19th to 21st October 2023

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in Physical Education, sport and recreation

Book of Proceedings

Niš, 2023.

University of Niš

Faculty of Sport and Physical Education

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„FIS COMMUNICATIONS 2023"

in physical education, sport and recreation

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FOREWORD

Dear authors it is with great pleasure that I introduce the Proceedings of the XXIV International Scientific Conference “FIS COMMUNICATIONS 2023” held in Niš, October 19 - 21, 2023. This comprehensive compilation stands as a testament to the remarkable diversity and intellectual richness of the global community engaged in the fields of sport science, exercise science, physical education, recreation, sports medicine, and related disciplines.

In this year's conference, we have the privilege of presenting 57 articles authored by 158 scholars and researchers from an impressive 14 countries. This global representation is a reflection of the diverse and multifaceted nature of our academic community, which thrives on the exchange of ideas and expertise from every corner of the world. As we navigate the rich tapestry of research within this book, we are reminded of the boundless possibilities and unifying power of science.

The articles presented here represent the spectrum of research that forms the foundation of our academic pursuits. Whether delving into the intricacies of human physiology, exploring the nuances of psychological aspects in sports, devising innovative exercise interventions and methods, or advancing the frontiers of sports medicine, these abstracts reveal the breadth and depth of our collective knowledge. They emphasize not only our current understanding but the promise of the future as well. These articles, the result of countless hours of dedication and perseverance, illustrate our unwavering commitment to exploring the potential of human performance and promoting health and wellness through sports and exercise.

Once again, thank you to all the authors, co-authors, reviewers, organizers, and attendees who have made this conference a resounding success. May these articles continue to inspire, educate, and drive progress in the fields we hold so dear.

Sincerely,
Nenad Stojiljković, PhD
Chair of the Scientific Committee
XXIV International Scientific Conference “FIS COMMUNICATIONS 2023”
Niš, October 19 - 21, 2023

CONTENTS

Plenary Session

TALENT IDENTIFICATION AND DEVELOPMENT - PERFORMANCE OR POTENTIAL?

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The organized sport is one of the most important opportunities of social participation of the adolescents. In spite of the emergency of a social alarm about a sedentary way of life and paediatrics obesity, the statistics of sport participation continue to give information about a increased volume of people practicing. Among the most popular sports, soccer is the predominant choice, with about 150 million players around the world with positive annual variations and in all of the age-groups.

Meanwhile, the applied research on youth soccer has also showed an abundant and growing production. The more studied topics in the research are based in questions related with talent, readiness and soccer selection.

The growing popularization of soccer and the increasing demand in the long term sport preparation results in the need of answers to new problems related with the prognosis of the sport performance, the adjustment of the training and match contents to the growth characteristics, maturation and young athletes' development, the control of the incidence of sport injuries and the predict variables of the injuries and the description of the players with different sport trajectories.

Talent identification and development is a dedicated topic in the research in sport sciences, partly, for the capacity to request concepts and methodologies in domains as different as the sport medicine, genetics, sport psychology and other disciplines. The analysis of the programs of sport preparation evidences a huge variation associated with the number of age-groups, the duration of the age-groups, the beginning of the formal competitions and their organization and stages of the sport selection. Different sports assume different models being the organization relative to male and female an additional source of variation. However, in all the cases, the chronological age constitutes the agglutinant element of the long-term programs of sport preparation. There is a need to complement the organization of the sport career based in information that considers the substantial biological variation that happens inside the same age-group. This consideration has not been contradicting with other sport agents, once the problem locates, above all, at the operational level. Even FIFA has been sensitive to the discussion of the problem.

Although the concept of biological maturation exists, the scientific and technological progresses make available a group of somatic, sexual and skeletal indicators, each one of them with different potentialities and limitations with an increased capacity to use in sample with more participants and out of the context of investigation. The determination of the stages of the secondary sexual characters promotes the invasion of the privacy of those observed. On the other hand, the methods as the radiological exams are revealed extremely difficult to become massively used. Alternatively, the percentage of predicted adult stature seems to be of easy utilization, having, however, a possible question about the validity of the formulas out of the original population.

There is a strong link between maturational development and growth and performance. Organizing age-groups using the criteria of chronological age leads to a big difference in size, composition and performance, and adolescence is the period when these differences are more visible and the ages between 13 and 15 years old seems to be the most heterogeneous period. In the same age group, the subjects maturationally more advanced are in general heavier and taller than their peers of the same chronological age since childhood until the end of adolescence. However, adults don't usually show the same differences when the same comparison is made. This situation can be explained by the catch up phenomenon in the late mature individuals.

The initial process to identify promising soccer players is multidimensional and the literature in the area show that growth and maturation are two important concepts to better understand the identification, selection, and development processes of young athletes. Usually young soccer players tend to be above the mean for height and mass and tend to be advanced in biological maturity status with increasing age during adolescence and in elite development programs. Worst results is been reported for body size and functional performance in young soccer players who were not selected to play in more demanding competitions or who dropped out from sport. The same trend was visible in academy players to whom were not proposed a professional contract. Despite of the lack of evidence that the anthropometrical, maturational and physical characteristics in the beginning of the process are not direct associated with the exceptional performance in the adulthood it is of interest to understand that these indicators may open the doors of academies and others training centers of excellence promoting better conditions and better coaching to the selected players. Recently were not found decennial differences in the entrance profile of soccer players in a club academy. This finding suggests that soccer promoting strategies are being maintained despite of the increased demanding in the anthropometric characteristics of professional players and demands of the actual professional soccer competitions.

DUAL CAREER OF ATHLETES

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Since the 2004 European Year of Education through Sport (EYES 2004), the talented and elite athletes' right to pursue their educational and a professional career in combination to their sporting career (e.g., dual career) has been supported from the White Paper on Sport (European Commission, 2007) to the implementation of the EU Guidelines on Dual Careers of Athletes (European Commission, 2012). To establish a platform for an effective dialogue between educational bodies (e.g., universities, high schools, sports schools), sport organizations (e.g., clubs, sport federations, National Olympic Committees), governmental organizations, and for profit companies, dual career is among the priorities of the ERASMUS+Sport funding, which fosters also the development of research and promotes the development of a European dual career culture (Capranica & Guidotti, 2016; Capranica et al., 2015; Guidotti et al., 2015; Guidotti et al., in press; Stambulova & Wylleman, 2019). During the past 10 years student-athletes have been the focus of dual career projects and research, whereas in 2021 the European policies in sports have extended the dual career to all the sportspersons (e.g., coaches, physical trainers, referees, sports managers, and volunteers), who are often challenged to combine their professional and sports careers (MacDonncha et al., 2023).

This presentation will provide an overview of the past and present implementation of the European dual career and will offer an analysis of projects carried out between 2014 and 2022 under the ERASMUS+ programme of the European Commission. In highlighting the focus on the different dual career dimensions (Capranica & Guidotti, 2016), and the characteristics of the established partnerships, potential gaps will be highlighted to guide future actions fostering long-term impact and ensuring sustainability.

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NEUROSCIENCE IN SPORTS - THE INFLUENCE OF MOVEMENT ON THE DEVELOPMENT OF COGNITIVE ABILITIES

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UDC 796.012:159.922

Physical activity significantly impacts the enhancement of cognitive capabilities. A plethora of studies indicates that consistent exercise can yield improvements in various cognitive functions, including attention, concentration, working memory, information processing speed, and problem-solving skills. Additionally, emerging research highlights that a lack of physical activity is associated with the reduction of deep brain regions, particularly the basal ganglia, which may result in adverse effects on cognitive abilities.

Engaging in movement promotes increased blood flow and oxygen delivery to the brain, leading to improved brain function, enhanced learning capacity, memory, and cognitive processes. Furthermore, physical activity influences the release of various neurotransmitters and neurotrophic factors within the brain, primarily dopamine and serotonin, known for their associations with improved attention, mood, and motivation. Additionally, exercise stimulates the production of brain-derived neurotrophic factor (BDNF), a critical element in neuronal growth, survival, and connectivity.

Incorporating tasks involving mental classifications and sequences, such as problem-solving during physical activities, becomes a vital aspect of contemporary sports training, as well as educational settings, including kindergartens and schools.

Ultimately, regular physical activity, encompassing movement and exercise, emerges as a valuable strategy to support the optimal development of cognitive abilities across all age groups.

Keywords: movement, neurogenesis, neurotransmitters, cognitive abilities.

Session 1

BREASTSTROKE ELITE SWIMMERS: AGE-PERFORMANCE COMPETITIVE CAREER QUANTITATIVE MODEL PROFILING

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UDC 797.212.2

ABSTRACT

The modeling procedure represents the process of objectifying the most likely outcome of the observed phenomenon. One of the problems in the sports training system is defining the potential for peak performance and career duration of an swimmer. The main aim of this study is career performance profiling in elite breaststroke swimmers of both gender in 50m pool. Non-experimental research was conducted. For the purposes of selecting the subjects for this research, the specific criteria was chosen. The sample consisted of: 31 males, and 23 females. Best annual Performance (time) vs Age relation, as an absolute model relation and 2). Delta values of Best annual Performance (%) vs Age relation, as a relative (standardised) career performance trajectory was calculated using the polynomial equation. All the defined Age vs Performance models were highly statistically significant as an explanation of the common variance of the examined space at the level of R^2 - 96.80% for 50m female to 99.79% for 100m male. In relation to men, the results showed the following: for the selected sample, the peak career performance at 50, 100 and 200m occur in the age of 31.9, 23.5 and 24.3 years, at the level of result values of 26.99, 1:00.85 and 2:09.60 min:sec, respectively. Considering female swimmers, for the selected sample, the peak career performance at 50, 100 and 200m occur in the age of 29.5, 30.3 and 31.2 years, respectively, at the level of result values of 30.48, 1:06.73 and 2:23.74 min:sec. Based on the obtained results, it can be concluded that the elite result in the breaststroke, as a biological potential of the body for the Peak Performance for 50, 100 and 200m at elite male and female swimmers can be obtained at chronological age from 23.5 till 31.9 years. The level of 99% of the career peaking, can be maintained in a time span of 7.5 to 8.6, and 4.4 to 7.5 years for male and female swimmers, respectively, regardless to distances.

Keywords: Swimming, breaststroke, peak performance, age, carier

INTRODUCTION

Generally, procedure of the modelling represents the process of objectifying the most likely outcome of the observed and analysed phenomenon. In elite sports system, exercise monitoring with the necessary analyses is a one of essential part of the training process (Boullosa et al., 2023).

In addition to the analysis of training structure and monitoring of training effects, within the performance analysis method, it is necessary to analyze systemic and strategic facts in relation to the phenomenology of the effects of long-term and multi-year effects of training on the development of athlete's performance.

There is more and more scientific evidence that the approach of individualizing the effects of training on improving sports performance is the direction in training science that optimizes the training process itself (Impellizzeri et al., 2019; Šiljeg et al., 2023; Perazzetti et al., 2023). The individual effect of training load components on adaptation processes, and the definition of methods for evaluating such effects on sports performance is one of the research directions in the future (Gabbett et al., 2017).

In the previously published papers it was demonstrated that the longitudinal performance assessment is helpful for coaches to define realistic season goals and training methods, and longitudinal assessment can therefore be applied by purpose of tracking the swimmers' performance status, considering for a deffined period of time, analyzing its dynamics between annual season, or at different competitions (Costa et al., 2010).

A clearly defined pathway of progression to elite level swimming performance is a key component of a comprehensive talent development programme. The career progression profiles of top athletes could also be used to assist coaches with planning towards the long-term goal performance targets for younger athletes. Performance changes at any stage of a swimmer's career are likely due to complex interactions between genetic and environmental variables (as aerobic and anaerobic abilities, muscle strength and power, motor skill acquisition, psychological development) (Allen et al., 2014). Generally speaking, the process of growth and maturation is a non-linear process, and the dynamics of changes at the individual level must first be generally modelled, in order to be able to define and compare individual characteristics for swimmers (Šiljeg et al., 2023).

One of the problems in the sports training system is the recognition of the chronological age-result potential for top achievements as a function of the duration of the career of top athletes. The aim of this work is to define the characteristics of the age-performance model in elite breaststrokers of both genders as a function of swimming distance in 50m pool.

METHODS

For the purposes of this research, a non-experimental research was conducted using secondary sources of databases. All results are taken from the open source database of specialized swimming results - swimrankings (https://www.swimrankings.net/).

Subjects

The research sample consisted of: 31 males (29.2±2.2 yrs., FINA points 50m = 920±28, 100m = 905±36, 200m = 936±38), and 23 females (29.6±2.2 yrs., 50m = 901±33, 100m = 900±36, 200m = 931±36). The female sample was made up of swimmers from 15 and male sample swimmers from 17 different countries around the world.

Procedure

The criteria for selecting respondents for this research were the following criteria: at least one career result worth up to 900 World of Aquatics ($W_{of}A$) points regardless of distance (50, 100 or 200m breaststroke); swam at least once with a score of 850 $W_{of}A$ points but at two different distances (50, 10 or 200m breaststroke); recorded results for at least 12 consecutive seasons in the Swimrankings database; a chronological age of at least 28 and 27 years for men and women respectively in the 2023 competitive season.

Procedure

Modeling

As a first procedure, two basic relations were calculated using the polynomial equation as two basic models as well: 1). Best annual Performance (time) vs Age relation, as an absolute model relation and 2). Delta values of Best annual Performance (%) vs Age relation, as a relative (standardised) career performance trajectory (Allen et al., 2014). In this way, it was possible to synthesize quantitative data of the explored relations from the defined equation models.

Statistical analysis

All data were analysed using descriptive statistics, and within it the following were calculated: average value (Mean) and standard deviation (SD). All examined relationships of swimming performance as a function of age were defined using polynomial specification equations. All results are presented in numerical form, and statistical software Microsoft EXCEL 2016 (Microsoft©) was used for their calculation.

RESULTS

Figure 1 shows the defined Best Annual Performance (time) – Age models, as absolute relations, while Figure 2 shows the delta values of Best Annual Performance (%) – Age models, as relative relations, for female swimmers considering 50, 100 and 200m distances. Considering female sample all defined models are highly statistically significant (R^2 = 98.23 to 99.10% for 100 to 200m for absolute, and 96.80 to 99.32% for 50 to 200m for relative models, respectively).

Figure 1. Performance – Age absolute models for female swimmers considering competitive distances

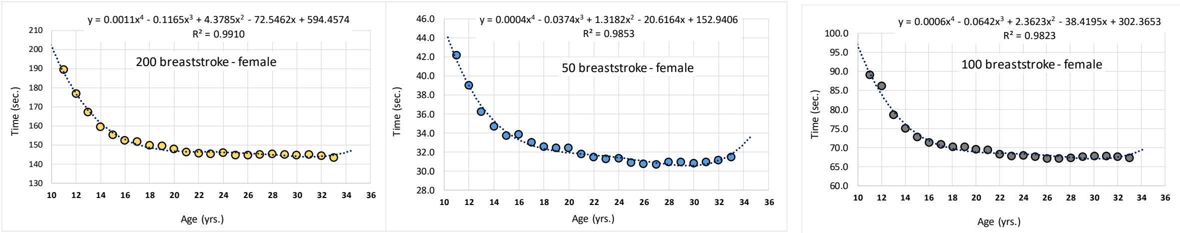


Figure 2. Performance – Age relative models for female swimmers considering competitive distances

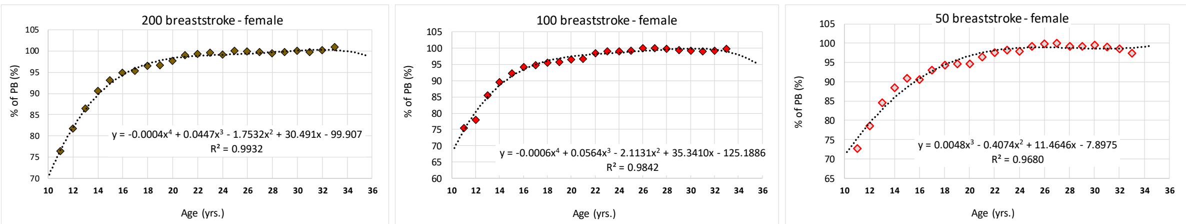


Figure 3 shows the defined Best Annual Performance (time) – Age models, as absolute relations, while Figure 4 shows the delta values of Best Annual Performance (%) – Age models, as relative relations, for male swimmers considering 50, 100 and 200m distances. Considering male sample all defined models are highly statistically significant (R^2 = 99.56 to 99.78% for 200 to 100m for absolute, and 99.33 to 99.79% for 50 to 100m for relative models, respectively).

Figure 3. Performance – Age absolute models for male swimmers considering competitive distances

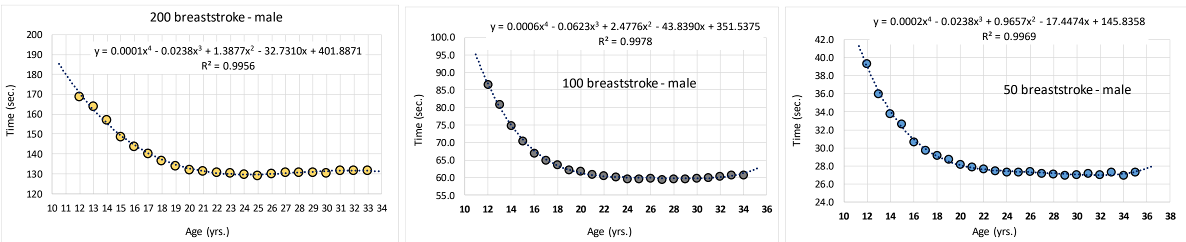
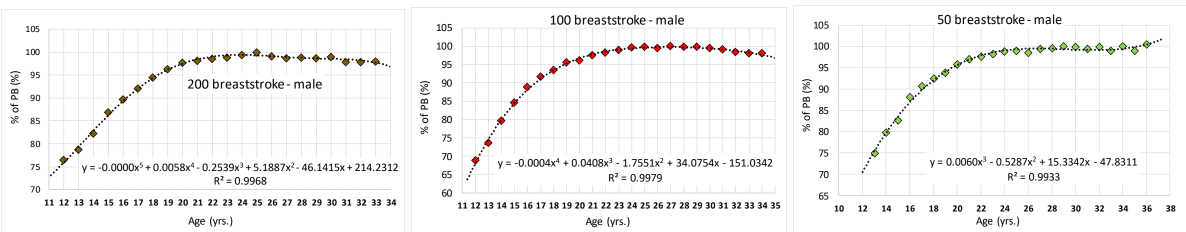


Figure 4. Performance – Age relative models for male swimmers considering competitive distances



The results of defined model basic descriptive statistics for the variables according to gender and swimming distances are at Table 1. Based on the obtained results, it can be concluded that the age range for the potential to achieve peak performance is in the range of 23.5 till 31.9 years of life for men, i.e. from 29.5 till 31.2 years of life for women. Also, the time period ("Window" Performance Time Frame) for achieving peak performance of 99% of Peak Performance (PP) is in the range of 7.5 to 8.6 yrs. for men, i.e. in the range of 4.4 to 7.5 yrs. for female breaststroke swimmers (Table 1).

Table 1. Basic central tendencies descriptive statistics for the modeled variables according to gender, performance, age and distances groups

	Male			Female		
	200m	**100m**	**50m**	**200m**	**100m**	**50m**
Peak Performance (PP)	02:09.60	01:00.85	26.99	02:23.74	01:06.73	30.48
PP age (yrs.)	24.3	23.5	31.9	31.2	30.3	29.5
99% Lower Limit PP age	21.3	20.5	26.9	27	27.2	27.1
99% Upper Limit PP age	28.8	29.1	34.5	33.5	32.7	31.5
PP Window time Frame (yrs.)	7.5	8.6	7.6	7.5	5.5	4.4

DISCUSSION

Based on observed variable dependencies, as a model, specification equations were defined on the basis of which it was possible to calculate (synthesize) the quantitative (numerical) values of the ages parameters of the swimmer's peak performance. In relation to the results of the current study, Peak Performance (PP) is defined at the level of results of 2:09.60, 1:00.85 and 26.99 min:sec:hundre, at males, and at the level of results of 2:23.74, 1:06.73 and 30.48 min:sec:hundred for 50, 10 and 200m breaststroke distance for female swimmers (Table 1). In relation to the $W_{of}A$ points, the given values of PP represent an analogy of 922, 817 and 889, i.e. the overall average value of the swimming result of 876 points for men, as well 903, 816 and 823, i.e. the overall average value of the swimming result of 845 points for female swimmers.

For all the defined Age vs Performance models were highly statistically significant regardless to gender (Figures 1 to 4), and in relation to males and females, the results showed the following: for the selected male swimmer sample, the peak career performance at 50, 100 and 200m occur at 31.9, 23.5 and 24.3 years of life, while for female sample was at 29.5, 30.3 and 31.2 years of life (Table 1). The potential of sports career performance at the level of 99% of peak for 50, 100 and 200m is realized in the range of 26.9 - 34.5, 20.5 - 29.1 and 21.3 – 28.8 years of life. "Window" performance time frame, as a measure of most probable longevity for elite performance achievement potential, was is in the range of 7.6, 8.6 and 7.5 yrs. for men, i.e. in the range of 4.4, 5.5 and 7.5 yrs. for female breaststroke swimmers considering upper and lower limit for achieving of 99% of Peak Performance (PP) at 50, 100 and 200m breaststroke distances (Table 1).

It was established earlier that top swimmers hold their performance peak for approximately 2.5±1.5 years, irrespective of event, except supremely talented swimmer who are able to win medals whilst not at peak performance. It seems that they can maintain longer time their sub-peak, but still greater performance levels in comparison to their competitors (Allen et al., 2014).

Although this paper did not look at the age of Olympic winners, research published 45 years ago found that for the period 1948 to 1980, the age of Olympic freestyle winners was about 20 and 18 years for men and girls, respectively (Schulz & Curnow, 1988). For the period from 1980 to 2010, i.e. for the period thirty years after, it was faund that the average age of the top ten best-ranked freestyle swimmers in the world is about 21 years old, which shows that top swimmers are getting older, that is, that they reach their peak performance later and later (Berthelot et al., 2012).

This trend of changing the age of swimmers (age increasing) was confirmed in the research published by Barbosa and co-workers (Barbosa et al., 2012) in which it was determined that the average age of swimmers participating in the OG in Beijing, regardless of the discipline, is in the range from 22.99±4.51 for 50m freestyle to 24.29±3.75 for 100m backstroke, for male, and from 20.43±2.93 for 200m backstroke to 22.83±4.22 for 100m freestyle for female swimmers, respectively. In relation to breaststroke disciplines, male swimmers were of average age at 23.22±3.51 and 22.96±2.75, for 100m and for 200m, and female at 21.63±3.37 and 21.60±3.43, respectively.

Previously published data proved that, in relation to the breaststroke technique, the peak performance of male swimmers is realized about 2 years later than that of female swimmers, as well as that male and female swimmers in shorter disciplines (50m) are older than those in longer sections. Current research has also shown that male and female swimmers reach their career peak (PP) in the 50m at the age of around 30 years. The only difference between the current and previously published data is that in this work it was determined that peak performance in men on the 100 and 200 m distances occurs earlier than in women (male – 23.5 to 24.3, female – 30.3 to 31.2, Table 1). The reason for this fact remains to be determined in future research, but on general level phenomenon can be explained by improving training technology (optimizing the training load and applying more effective specific training methods), better medical treatments (injury prevention, supplementation methods), as well as better motivation of swimmers in relation to the material aspect of continuing their career.

CONCLUSION

Based on the obtained results, it can be concluded that the elite result in the breaststroke, as a biological potential of the body for the Peak Performance for 50, 100 and 200m can be obtained at chronological age of 31.9, 23.5 and 24.3, and 29.5, 30.3 and 31.2, for male and female swimmers, respectively. The level of 99% of the career peaking, can be maintained in a time span of 7.5 to 8.6, and 4.4 to 7.5 years for male and female swimmers, respectively, regardless to distances.

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EMPLOYMENT OF ATHLETES AFTER ENDING THEIR PROFESSIONAL CAREER

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ABSTRACT

The transition from a professional sports career to post-retirement life is a multifaceted process that profoundly influences athletes both psychologically and socially. This article presents a comprehensive exploration of the relationship between athletes' careers, their personalities and motivations. Additionally, it investigates the strategies and opportunities available to athletes for effectively utilizing their skills and experience. This study primarily focuses on the employment of athletes after leaving their professional sports careers and examines the specific career options available in the mainstream workforce post-retirement. It also examines whether athletes receive support during this significant life change and provides insights into their psychological well-being during and after their careers. To investigate these aspects, we employed qualitative research methods, with a particular emphasis on semistructured interviews. These interviews were exclusively conducted with former professional athletes. The findings of this research highlight that professional athletes often experience profound personal development during their sports careers, with enhanced qualities such as discipline, perseverance, leadership skills, and teamwork. These attributes often influence their career choices after retirement. Athletes also emphasize the importance of mental resilience and fair play, which are cultivated through their sports experiences. While athletes enjoy a range of positive influences from their sports careers, some challenges emerge, such as physical strain and the limitation of personal life. Nevertheless, the ability to set and pursue goals is a skill athletes acquire through sports, which they apply to other areas of their lives. Furthermore, this research reveals the diverse career paths that athletes embark upon after retiring from their professional sports careers, including roles in sports management, coaching and various professional fields. In conclusion, this study the process of athletes transitioning to post-retirement life, highlights the impact of a sports career on their personal and professional lives.

Keywords: Professional sport, sports career, empleyment after sports career

INTRODUCTION

Sport is a fascinating and ubiquitous phenomenon that involves people of all ages all over the world. It can be a source of fun and enjoyment, but not only that. Sport can be a job opportunity and a source of income, a source of fame and satisfaction. Sport enables individuals to excel while facing great disappointments. It also has a great influence on the industry and there are many organizations and events that are associated with it (Svoboda, 2007). A different view of professional sport can be defined as the practice of sporting activities and the generation of income mainly from this activity. Therefore, it is necessary for the designation of an individual as a professional sportsman to include his income in taxes. This means that only individuals who are engaged in sport and whose main income is from sport can be considered professional athletes (Topinka, 1999). According to Sekot (2008, p. 171), professional athletes differ from the general population in several ways, including higher income. However, their careers are usually shorter than those of the general person, who may work even at an advanced age. That elite sport has a highly positive impact on sport in general is quite clear, if only because it involves increasing physical fitness and improving health. Even so, elite sport can be viewed negatively. This is because it detracts in a way from active exercise. This is due to the fact that it gives society the opportunity to look at sport from the spectator's point of view and thus, fulfill the needs for sport (Dušek, 2009). The fact that elite sport has a highly positive impact on sport in general is quite clear, just by the fact that it increases physical fitness and improves health. Even so, elite sport can be viewed negatively. This is because it detracts in a way from active exercise. This is due to the fact that it gives society the opportunity to look at sport from the spectator's perspective and thus, fulfill the needs for sport (Dušek, 2009). The personality of the athlete is a very interesting and often researched topic and is viewed from different angles. For example, the O'Sullivan et al. (1998) study focused on comparing the personality traits of male and female athletes who participated in hockey or lacrosse. The athletes in the study were compared to the general population. The main finding was that regardless of gender, all athletes were more active than the general population and were less prone to nervousness. For the athletes, it is a great advantage that they are more likely to have developed this ability to a large extent, since in sport there are a large number of situations to which the athlete has to adapt. Adaptation, however, does not only need to be activated in such strict changes, such as just ending a career, but also in less significant situations, such as changing positions or moving to another job (Koubek, 2002). Motivation is also an important part of sport. If motivation is not sufficiently activated one is not able to achieve maximum performance either in training or in actual competitions. The intensity of effort and the goal set are essential for proper functioning (Hodge, 2004). There can be many factors that can influence the end of a sporting career. A big factor here is whether there are voluntary factors, where the athlete voluntarily ends his or her career, and factors that interrupt the athlete's career involuntarily. On these aspects, also depends a lot on how the athlete copes with the end. Very often, it also occurs that the end of a career does not result in only one reason, but often there is a situation where multiple reasons are bought together, which then lead to such a strict solution as to end a professional sports career definitively (Stambulova, 2010, p. 95).

METHODS

The main method of data collection was a semi-structured interview, which had a given structure, but the respondents were able to partially control the direction of the discussion.

The respondents were selected according to certain requirements that we had set in advance. We interviewed former athletes who had been involved in sport for a long time and who fulfilled the above-mentioned characteristics of a professional athlete. Our other condition was that they were currently engaged in a profession and not living off the money earned from their sporting career. We selected respondents who were able to answer our questions from their own experience. We set 3 research questions:

RQ1: How does the federation/association take care of its athletes after their professional sports career?

RQ2: How does sport affect individuals in later stages of life?

RQ3: In which sector have athletes found a career?

Subjects

The study included a diverse sample of retired athletes who had participated in various sports disciplines at the professional level. The subjects were selected from different regions and backgrounds to ensure a broad representation of experiences. We analyzed the responses of 9 respondents from different sports. 5 respondents came from a basketball background, and one respondent each from hockey, athletics, climbing and motorcycle racing. The respondents were represented by 5 women and 4 men. Average ending of their career was in 30,3 years of age.

Procedure

During the data collection, 15 respondents were contacted and 9 of them gave us an interview because the others were very busy or had personal problems. Relationships between professional athletes are often very positive and most of those interviewed were willing to give us an interview. We arranged a meeting time with each respondent, which we adjusted to their availability. And also on the spot, the meetings mostly took place in cafes, in case a personal meeting was complicated we arranged the meeting by on-line call. With the consent of the interviewees, we recorded the interviews on a dictaphone, for time reasons, as transcribing the interviews would be lengthy and to preserve their authenticity. We had prepared the questions to be asked of the interviewees in advance, but in some cases we had to improvise according to the situation. For example, we changed the wording of a question, did not ask a question or added an extra question.

Statistical analysis

In the data analysis, we labelled individual interviews and respondents with numbers to preserve the anonymity of the respondents. As mentioned earlier, we recorded the interviews on a tape recorder and then transcribed them to make them easier to analyze. To analyse the data, we used the coding method, which consists in dividing the different parts of the text into certain units that have a certain degree of compatibility. These are words, characteristics, sentences, statements, etc. Then the individual parts are marked with specific codes. These interviews were divided into parts and then categorized for further analysis of the results.

RESULTS

The results revealed several key findings. Retired athletes frequently cited their sports careers as having a significant impact on their personal development, enhancing qualities such as discipline, perseverance, and leadership skills. These qualities often influenced their post-retirement career choices. This article examines the impact of sport on the lives and personalities of athletes through an analysis of the views and experiences of nine respondents who have played different sports in the past. The research included questions regarding the impact of sport on the respondents' personality, values, skills, and goals, as well as their current involvement in sport. The results of the study indicate that sport has a significant impact on the life course of athletes and their personality traits. Respondents reported positive influences such as improved self-esteem, discipline, time management skills, and the ability to work as part of a team. They also stress the importance of mental resilience and fair play that sport develops. On the other hand, some respondents mention the negative aspects of sport, such as the limitation of personal life and physical strain. The goals of playing sport emerged as important for the development of athletes. Respondents emphasise that the ability to set goals and work towards achieving them is a skill they have acquired through sport and apply in other areas of their lives. Some see goals as a philosophy or long-term direction rather than as specific tasks. Currently, some respondents are still actively involved in sport, whether in the form of regular exercise, playing sport at a lower level, or supporting sporting events as coaches. Sport remains an important part of their lives and brings them joy, health and companionship. Overall, sport has a significant impact on the personal and professional lives of athletes and brings with it both positive and negative aspects. Respondents recognise the benefits of sport, whether it is in terms of skill development or value creation, and enjoy the fact that sport remains part of their lives after their professional careers have ended.

DISCUSSION

The discussion section delves into the implications of these findings. It explores the importance of recognizing the unique qualities that athletes bring to the workforce and highlights the value of their skills in sports management roles. Additionally, it examines the psychological challenges faced by retired athletes and discusses the need for tailored support and career transition programs. When we see the research question 1, we can see that there is almost no one supported directly from the sports association. As we have already mentioned, we are of the opinion that a federation/association should take an interest in its athletes even after their careers are over. They could use the potential of the experience that the athletes have. Alternatively, the athletes could bring them interesting insights. Unfortunately this is not the case in most cases. Almost all of our respondents answered that they had not been helped in any way. Respondent 4 claims that a big problem of the Czech federation is the lack of interest in its athletes. Respondent 2, however, has experience in cooperating with the federation. It was after an initiative from her side, but that counts too. They are working together on a specific project. Respondent 9 is also part of the Czech Basketball Federation as an assistant coach of the youth national teams. According to Taylor and Lavallee (2010), sports coaches, managers, clubs, federations and associations are interested in athletes during their active careers, but once they leave the sporting sphere, their interest wanes. More attention should be paid to this issue. The statements of the respondents confirm this statement. To summarise this research question, in most situations the federation/association is not interested in its athletes in any way. However, we can speculate that if the athletes had reached out on their own, it is possible that help would have been provided.

When we continue to the research question 2, we can see the deep impact of doing sport. Even when we asked this question to the respondents, we knew that there would be a lot of mention of findings that are influenced by sport. Words such as discipline, mental toughness, endurance, adaptability, performance were very often repeated. They also put a lot of emphasis on collectivity, which is also important for later life, with the associated respect and perception of others' opinions. we really liked the statement of respondent 2, who started to consider her height as a benefit thanks to sport and became more confident. This confirms also Peric and Dovalil's (2010, p. 17) statement according to which, it is difficult to summarize the personality of an athlete in a model that can be said to apply to everyone in general. It can, however, be documented that the personality of an athlete is characterized by certain traits. For example, a degree of self-confidence, determination, efficiency, teamwork, respect, patience, and equanimity. These qualities were also mentioned very often by respondents in our work. It is understandable that some statements are also negative. For example, injuries, which are very common in sport, and wear and tear on the body. It is also worth mentioning that sport has taken a large amount of athletes' time. Sport has not only affected the qualities and strengths that athletes have, but also the environment in which they live. The large number of acquaintances and friends that sport has brought them. Many experiences and learning about new places, languages, cultures and destinations.

The last research question follows the employment after leaving the professional sports career. It can be assumed that athletes will look for subsequent employment in the field of sport after the end of their professional career. This is because they would make the most of their experience. Respondents who followed this fact found employment as managers and sports agents. There also appeared to be respondents who have a primary profession somewhere, but in their spare time they find employment in the field of sport. Specifically, employed in an IT firm or owning their own business and coaching mentees into it. Respondents 2 and 7 also appear on television in relation to commentating. Some of the respondents have found employment in the field they have studied. Respondent 9 is employed as a truck driver, which we find very interesting and unusual. Respondent 2 is a phenomenon that we must always follow our dreams, regardless of the circumstances. At the moment, everything is pointing towards becoming a mentor. Návratova and Vašek (2015) argue that athletes are exposed to many experiences during their sporting career that should be used in their search for a new profession. They could apply themselves as coaches, managers and so on. This fact also appears among the respondents, but it is not the rule. This implies that even though they have been involved in sport all their lives, they will always find a job somewhere in the end.

CONCLUSION

In conclusion, this study sheds light on the multifaceted process of athletes transitioning to post-retirement life. It emphasizes the enduring influence of a sports career on athletes' personal and professional lives and underscores the importance of strategic planning for athletes seeking alternative career paths. Understanding these dynamics can inform sports organizations and managers in effectively supporting and harnessing the potential of their retired athletes. The aim of the article was to find out interesting findings about the lives of athletes after their professional careers. Therefore, in order to better understand this specific life, we set research questions to which we sought answers, just by using the statements of the respondents. The questions were designed to find out where the athletes found employment after the end of their sporting career and what the transition was like psychologically. The next question was to delineate the typical traits that athletes are characterized by just because of sport, or how they themselves perceive that sport has affected them. Our questions also aimed to find out whether individuals are currently engaged in a profession in which they apply their experiences from sport, or in what way. It was also important to ask whether the federation/association is interested in its athletes after their sporting career or whether they have to find their own way. Thanks to the answers of the respondents, we were able to find out the answers to the research questions and also successfully fulfilled the set objectives for this paper.

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DIFFERENCES IN PLANTAR FLEXOR STRENGTH CHARACTERISTICS IN YOUNG FEMALE VOLLEYBALL PLAYERS MEASURED DURING TWO TYPES OF CONTRACTIONS: CLASSIC AND IMPULS

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ABSTRACT

The aim of this work is to determine the differences in the mechanical characteristics of the muscle force of the plantar flexors obtained in two different models of muscle strain: classical and impulse methods, in young female volleyball players and control group. (abstract could be in a form of structured abstract). Non-experimental research was conducted using laboratory testing methods. The measurement was carried out using the dynamometry method. 31 subjects participated in the research, (14 young female volleyball players (OK DIF Akademia, Belgrade) and 17 randomise selected different sports and physically active control group of young females. The plantar flexors were tested in accordance with the standardized procedure. A five variables were measure per each test model (Classic vs Impuls) and per tested group (Volleyball vs Control): F_{max} – maximal force, RFD_{max} - maximal explosive force; $RFDF_{max}$ – basic explosive force; tF_{max} – the time required for the achievement of maximal force; and $tRFD_{max}$ – time required for the achievement of maximal explosive force. The percentage difference - delta (Δ) between test model according to subsample group represented an analysed variabled (Index_RFD_{max}, F_{max}_delta, RFD_{max}_delta, $RFDF_{max}$_delta, tF_{max}_delta, and $tRFD_{max}$_delta). Based on the obtained results, it can be claimed that statistically significant differences between the deltas (Δ in %) were established for the variables: Index_RFD_{max}, tF_{max}_delta and $RFDF_{max}$_delta at $p = 0.045$, 0.000 and 0.000, respectively. The results of this study indicate that the measurement of the different characteristic/mechanical dimensions of strength manifestation - Fmax and RFDmax from the metrological aspects needs different testing procedure i.e. specific instructions during the testing process. Research has given initial results that indicate that training can influence the improving the manifestation of rapid and strong contraction (RFD), and a given contractile ability has its own measure of trainability (Index_RFD_{max}).

Keywords: Volleyball, dynamometry, plantar flexors, muscle contractile ability

INTRODUCTION

Muscle strength is a functional ability where, due to voluntary or involuntary neural activation of the muscle, its tone increases. In this way, the muscle functionally opposes the situation of increased external load (Suchomel et al., 2016). From a mechanical aspect, muscle tone can be measured with specialized instruments (for example - dynamometers) and in sports metrology there are standardized measurement procedures for quantifying the characteristics of muscle strength (Ivanovic and Dopsaj, 2013).

The basic procedure for measuring muscle strength is the application of standardized tests under conditions of maximal isometric effort (quasi-movement simulation) of the measured muscles or specific muscle groups. The current theoretical concept of measuring contractile characteristics (isometric) strength defines the measurement of the following mechanical dimensions that characterize the manifested muscle contraction (Dopsaj et al., 2019): maximal muscle force (F_{max}), as a measure of the achieved maximal muscle tone; parameters of the gradient of muscle force increase, or rate of force development (RFD), as a measure of ability of muscle to produce strength explosiveness; and the parameters of maintain a certain level of muscle force in a function of the required time interval, as a measure of strength endurance ($I_{mp}F$).

In most sports and sports disciplines, performing maximally fast movements is the dominant movement pattern, such as in sprinting, various jumps, changing direction of running (agility), punches and throws in martial arts, etc. In this sense, abilities as a manifestation of muscle contractions and the achieved necessary force level in a specific movement is limited to 50 to 250 ms (Andersen & Aagaard, 2005). In fact, RFD is a key factor in rapid movements where a short contraction time may not allow maximal muscle force to be reached (Rodríguez-Rosell et al., 2018)

Reaching F_{max} in isometric conditions requires a time that requires muscle contraction strain lasting up to 1-2 or even 3 seconds (Wilson and Murphy, 1996; Ivanović and Dopsaj, 2013; Majstorović et al., 2020). Therefore, the measurement of RFD_{max}, which determines the gradient of force increase in the early phase of muscle contraction, i.e. in the time interval up to 250 - 300 ms (Andersen & Aagaard, 2006; Maffiuletti et al., 2016) during testing according to the classic testing model (in which dominantly determines the value of F_{max}) can give false results of the real ability of the muscles to realize the real capacities of the RFD_{max} value.

The aim of this work is to determine the differences in the mechanical characteristics of the muscle force of the plantar flexors obtained in two different models of muscle strain: classical and impulse methods, in young female volleyball players and control group.

METHODS

For the purposes of this manuscript, non-experimental research was conducted using laboratory testing methods. The measurement was carried out using the dynamometry method. Testing was performed using the test-retest method, with three test attempts by testing models (classical and impulse) separated by a 2-minute pause. Procedures of testing were applied randomly in relation to the subjects and applied testing models. The plantar flexors were tested in accordance with the standardized procedure (Majstorović et al., 2021; Borisavljević et al., 2023). The study was carried out in accordance with the postulates of the Declaration of Helsinki (Christie, 2000) and with the approval of the Ethics Committee of the Faculty of Sports and Physical Education, University of Belgrade (ethics committee permit number 484-2).

Subjects

31 subjects participated in the research, where 14 were female volleyball players (OK DIF Akademia, Age = 16.4 ± 0.7 years, BH = 171.4 ± 6.1 cm, BM = 61.5 ± 7.1 kg, BMI = 20.89 ± 1.47 kg/m^2) and PBF = 21.97 ± 3.74 % and 17 randomise selected different sports and physically active control group of young females (Swimmers – 4, Dance – 4, Diving – 4, Gym – 4, Age = 16.9 ± 1.3 years, BH = 164.9 ± 6.2 cm, BM = 56.7 ± 7.2 kg, BMI = 20.75 ± 1.74 kg/m^2), and PBF = 21.97 ± 3.74 %.

Procedure

To test the mechanical characteristics of plantar flexor strength, a standardized procedure was used with standardized equipment (Sports Medical Solutions, All4gym d.o.o., Serbia). In previous research, a high statistically significant reliability of RFD_{max} measurement for the classical testing model (ICC = 0.912 – 0.949) and for the impulse testing model (ICC = 0.909) was proven (Majstorović, et al., 2021; Dopsaj et al., 2023). All tests were conducted at the Faculty of Sports and Physical Education, University of Belgrade, in the methodological research laboratory (MIL).

Plantar Flexors Test (PF)

The test was performed by having the subjects sit on a chair with their knees bent and their feet placed on the floor, so that the thighs were parallel to the floor and the knees pointed in the direction of the toes. The subjects sat with their backs straight on 2/3 of the chair. For the classic testing model, a verbal instruction was given: "push the structure maximally strong and fast and hold for 1 to 2 seconds", while for the impulse testing model for the application of impulse contraction, the following verbal instruction was given: "maximally explosively but strongly and quickly push the structure " (Majstorović, et al., 2020; Borisavljević et al., 2023; Dopsaj et al., 2023).

Variables

A five variables were measured per each test model (Classic vs Impuls), as well as for tested group (Volleyball vs Control): F_{max} – plantar flexor maximal force ($F_{max}\_PF_{Class}$; $F_{max}\_PF_{Imp}$), expressed in N; RFD_{max} - maximal explosive force ($RFD_{max}\_PF_{Class}$; $RFD_{max}\_PF_{Imp}$), expressed in N/s; $RFDF_{max}$ – explosive force realised at maximal force ($RFDF_{max}\_PF_{Class}$; $RFDF_{max}\_PF_{Imp}$), expressed in N/s; tF_{max} – the time required for the achievement of maximal force ($tF_{max}\_PF_{Class}$; $tF_{max}\_PF_{Imp}$), expressed in milliseconds (ms); $tRFD_{max}$ – time required for the achievement of maximal explosive force ($tRFD_{max}\_PF_{Class}$; $tRFD_{max}\_PF_{Imp}$), expressed in milliseconds (ms). The percentage difference - delta (Δ) of all originaly investigated variables (Index_RFD, F_{max}_delta, RFD_{max}_delta, $RFDF_{max}$_delta, tF_{max}_delta, and $tRFD_{max}$_delta) for the applied PF test between the impulse and classical models considering groups was calculated using the formula (1):

$$((\text{Impulse}-\text{Classical})/\text{Impulse}) \bullet 100 \qquad (1)$$

Statistical analysis

All data were analysed using descriptive statistics, and within it the following were calculated: average value (Mean), standard deviation (SD), coefficient of variation (Cv%) confidence interval at the level of 95% (CI 95%), minimum (min) and maximum (max) value of variables. One-way analysis of variance (ANOVA) was used to determine differences between variables, followed by the t test for independent samples. Statistical significance (alpha level) was set at $p < 0.05$. Statistical analysis was performed using IBM SPSS statistical software, version 23.0 (IBM Corp.).

RESULTS

Table 1. Descriptive statistics for the examined variables according to groups and testing model

		F_{max} (N)	RFD_{max} (N/s)	tF_{max} (s)	$RFDF_{max}$ (N/s)	$tRFD_{max}$ (s)
Control	Classic	2822±481	12525±2823	1.075±0.537	3073±1100	0.146±0.019
	Impuls	2387±420	13735±3009	0.360±0.075	6850±1692	0.135±0.015
	Δ (in %)	*-15.40*	*9.66*	*-66.52*	*122.87*	*-7.38*
DIF Academy Volleyball	Classic	3312±504	14598±2987	1.717±0.608	2200±1012	0.138±0.017
	Impuls	2816±340	17004±2868	0.309±0.067	9452±2188	0.130±0.014
	Δ (in %)	*-14.99*	*16.48*	*-81.98*	*329.60*	*-5.57*

Table 2. Descriptive results for the examined differences between variables in function of the testing models

Clasic vs Impuls Model testing	Tested Groups	Mean	Std. Dev.	cV%	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
$Index\_RFD_{max}$	Control	1.101	.086	7.81	1.057	1.145	0.99	1.33
	DIF Academy	1.179	.121	10.26	1.109	1.248	1.02	1.46
F_{max}_delta	Control	-14.81	10.31	69.62	-20.11	-9.51	-42.00	-0.41
	DIF Academy	-14.29	7.55	52.83	-18.65	-9.93	-30.04	-1.22
tF_{max}_delta	Control	-58.56	18.69	31.92	-68.17	-48.95	-89.55	-26.01
	DIF Academy	-80.00	6.91	8.64	-83.99	-76.01	-91.09	-67.82
$RFDF_{max}$_delta	Control	158.61	129.49	81.64	92.04	225.19	18.36	454.84
	DIF Academy	390.10	192.97	49.47	278.68	501.52	147.33	776.34
$tRFD_{max}$_delta	Control	-6.83	8.02	117.42	-10.95	-2.70	-17.05	10.34
	DIF Academy	-4.87	10.18	209.03	-10.74	1.01	-22.49	9.42

The results of descriptive statistics for the examined variables according to groups and testing model, with intra-variables differences are shown at Table 1. Differences between variables in function of the testing model, at the level of the examined sample groups, are shown in Table 2.

The results of the difference (ANOVA) for the examined groups and examined variables as a function of the applied testing model are shown in Table 3. Based on the obtained results, it can be claimed that statistically significant differences between the deltas (Δ in %) were established for the variables: Index_RFD_{max}, tF_{max}_delta and $RFDF_{max}$_delta at p = 0.045, 0.000 and 0.000, respectively.

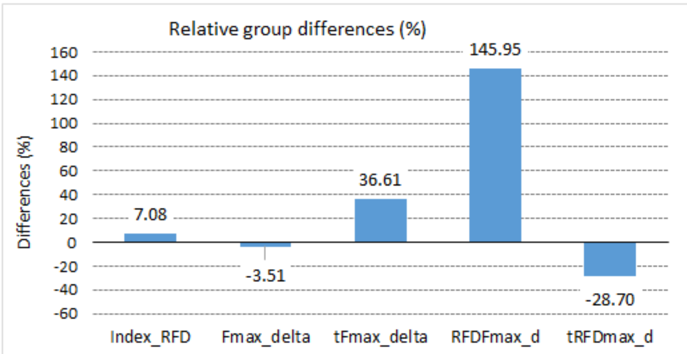
Table 3. ANOVA results with groups differences

ANOVA for Δ variables	Between Groups / Within Groups	Sum of Squares	df	Mean Square	F	Sig.
Index_RFD_{max}	BG	.05	1	.05	4.38	**.045**
	WG	.31	29	.01		
F_{max}_delta	BG	2.06	1	2.06	.03	.877
	WG	2442.52	29	84.23		
tF_{max}_delta	BG	3529.34	1	3529.34	16.49	**.000**
	WG	6208.27	29	214.08		
$RFDF_{max}$_delta	BG	411405.52	1	411405.52	15.86	**.000**
	WG	752381.48	29	25944.19		
$tRFD_{max}$_delta	BG	29.53	1	29.54	.36	.553
	WG	2375.77	29	81.93		

Figure 1 shows the results of the difference (expressed in %) between the different testing model variables in relation to the examined groups. The results showed that the difference between the ability to create maximal explosiveness (RFD_{max}) in the classical and impulse model of contraction between the control and experimental (DIF Academy Volleyball) groups was at the level of 7.08% considering greater explosiveness for impulse contraction in volleyball players, till the 145.95% of differences for basic RFD value ($RFDF_{max}$).

Figure 1. Relative values of inter-group differences between testing models results (Classic vs Impulse)

Index_RFD_{max}	Control	**1.101**
	DIF Academy	**1.179**
F_{max}_delta	Control	-14.81
	DIF Academy	-14.29
tF_{max}_delta	Control	**-58.56**
	DIF Academy	**-80.00**
$RFDF_{max}$_delta	Control	**158.61**
	DIF Academy	**390.10**
$tRFD_{max}$_delta	Control	-6.83
	DIF Academy	-4.87



DISCUSSION

The results showed that between differently trained populations of young women, considering to the differences between the mechanical manifestation of muscle contraction measured in different types of maximal strain - classical and impulse, there is a statistically significant difference in three contractile characteristics, as well as: Index_RFD_{max}, as a measure of the difference in maximal explosiveness manifested in classical and impulse model of maximal muscle strain (F = 4.38, p = 0.045, 7.08% of inter-group differences); tF_{max}_delta, as a measure of the difference in time need to reach maximal force manifested in classical and impulse model of maximal muscle strain (F = 16.49, p = 0.000, 36.61% of inter-group differences); and $RFDF_{max}$_delta, as a measure of the difference in basic measure (level) of explosivity manifested in classical and impulse model of maximal muscle strain ($F = 15.86$, $p = 0.000$, 145.95% of inter-group differences, Table 3 and Figure 1, respectively).

Comparing the results of this study with previously published ones, it can be argued that they are in agreement because other researchers have also proven that (Christ et al., 1993; Sahaly et al., 2001) RFD is statistically significantly higher when the instruction "contract fast" (Impulse Testing Model) was used during strength testing in relation to "contract strong" (Classical Testing Model).

In a previous study (Dopsaj et al., 2023) where well-trained young adult men were tested in the same methodology model, the following statistically significant differences between classical and impulse contraction for PF were determined: -21.37% for F_{max}_delta, 14.00% for Index_RFD_{max}, -145.95% for tF_{max}_delta, as well as -5.12% for $tRFD_{max}$_delta. The presented facts also support the currently obtained results, where during impulse contraction at lower maximal force levels, and for shorter time intervals, subjects reaches higher values of the explosive contractile component. In other words, it is obvious that during the examined models of contractions (Classical vs Impulse) muscle is under control of different neuro-mechanical, i.e. neuro-physiological CNS components which have dominant roles in controlling the expression of mechanical characteristics of muscle force.

Also, this research gave initial results that indicate the fact that training can influence the improvement of a given ability to achieve greater explosiveness, because it has been proven that the given ability of volleyball players (Plantar Flexor explosiveness) at a specifically trained muscle group (fast jumping movements) is better developed than at control group of female athletes from other sports (with 15% less force, and in 82% less time, volleyball players achieve a 16.5% higher level of maximal explosiveness, while female athletes from the control group achieved a 9.7% higher level of explosiveness, Table 1). In this way, it was initially shown that the given ability has its own measure of trainability, that is, that it can be trained, i.e. improve with systematic and planned exercise.

Also, the results indicate a methodological fact, that the measurement of the different characteristic/mechanical dimensions of strength manifestation - F_{max} and RFD_{max} needs different, specific instructions during the testing process. Analyzing the time parameters of the manifestation of the given contraction models, it can be claimed that the impulse contraction was realized in an average time interval from 0.360 ± 0.075 seconds for the control, and from 0.309 ± 0.067 seconds for the group of tested volleyball players, while the time interval for the classic contraction was in ranging from 1.075 – 1.717 for the control group and female volleyball players in average, respectively (Table 1). Hypothetically observed and from the metrological aspect of testing, it can be concluded that as the time span of realization of impulse contraction in young volleyball players, values from 0.242 till 0.376 can be taken as an initial standard, i.e. for other sports where maximally fast jumps are not the dominant motor pattern from 0.285 till 0.435, in in relation to the muscle group PF.

The established statistically significantly difference of higher maximal explosiveness that is achieved during the impulse method of testing is most likely a consequence of the phenomenon of consciously encouraging faster discharge frequencies of motor units at the impulse contraction testing task, which from a physiological aspect affects the difference in the manifestation of greater explosiveness in the early phase of contraction compared to the classical method of isometric testing (Maffiuletti, et al. 2016).

CONCLUSION

This research has given initial results that indicate the fact that training can influence the improving the manifestation of rapid and strong contraction (RFD) as a given contractile ability in which higher explosiveness values are achieved for shorter time. From the methodological aspect, we can conclude that a given contractile ability has its own measure of trainability (Index_RFD_{max}).

Finally, the results of this study indicate that the measurement of the different characteristic/mechanical dimensions of strength manifestation - F_{max} and RFD_{max} from the metrological aspects needs different testing procedure i.e. specific instructions during the testing process.

In the following research, it is necessary to determine the characteristics of the differences between the examined test models and on other muscle groups, but also in relation to gender, age and type of sport, that is, it is necessary to determine the limits of the level of adaptation under the influence of different training loads.

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EFFECTS OF PHYSICAL ACTIVITY ON THE BALANCE OF OLDER ADULTS

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ABSTRACT

This research aims to collect relevant studies related to the effects of physical activity on the balance of older adults.The objective of this study is to determine the impact of physical activity on the balance of older adults. To collect data on the effects of physical activity on the balance of older adults, the following electronic databases were utilized: PubMed/Medline, PEDro, SCIndex, ScienceDirect, Google Scholar, journals in the field of sports sciences, as well as relevant literature that could address the research question. The following keywords were used during the search: *Exercises of balance, proprioception, exercise in the water, balance of the elderly.* It was concluded that multidimensional exercise has a positive influence on the balance development of older adults. Proprioceptive physical activities have the most significant impact on balance control among older adults. Research on aquatic exercises indicates that lower body water-based or land-based exercise programs contribute to balance improvement. High-intensity strength training can safely and effectively strengthen the lower limb muscles, leading to significant enhancements in balance and a reduced risk of falls among older adults. In summary, physical activity has numerous positive effects on preserving the health and quality of life of older individuals. Future studies should be well-designed and provide detailed and precise reports.

Keywords: Exercises of balance, proprioception, exercise in the water, balance of the elderly.

INTRODUCTION

Modern living and working conditions, influenced by technological advancements, have shifted human activity from physical to intellectual, resulting in minimal daily physical activity. Intellectual work has led to a sedentary lifestyle, reducing physical activity and thereby jeopardizing human health and the normal functioning of organs and organ systems (Đurašković, 2009). Physical activity, as a specific form of "stress," elicits complex biochemical, physiological, psychological, and functional reactions within the body that are interconnected. Adaptation to workload primarily refers to the body's ability to perform physical work of a certain volume and intensity that was previously unavailable (Đurašković, 2009).

Research has shown that approximately one-third of individuals aged 65 and older experience falls each year, and injuries such as fractures of the arm, leg, or hip, or acute tendon strains resulting from falls, can significantly impact an older person's life by limiting mobility and hindering independent living. Balance exercises, combined with strength training, can prevent falls by improving stability both at rest and in motion. Many take balance for granted, but for many individuals, maintaining balance can be a challenge (Pavić, 2015).

When a young child falls, they simply get up, shake it off, and continue, but when an older adult falls, there can often be negative consequences. Broken bones or head injuries can limit mobility, erode self-confidence, create a fear of falling, and reduce an individual's independence (Means, Rodell & O'Sullivan 2005).

Although balance training is the cornerstone of fall prevention programs, any exercise that enhances endurance, increases muscle strength, and improves flexibility can have the same effect (Orr, Raymond & Singh, 2008).

According to Douris et al (2003), balance exercises can be done anytime, anywhere, and as frequently as people are capable of. In the beginning, it's advisable to have a solid support to grab onto in case stability is compromised. A chair or standing next to a wall can serve this purpose.

Balance can be described as the ability to maintain a specific body or body part position when in contact with a stationary or moving surface. Static and dynamic balance are distinguished. Static balance involves controlling postural movements, i.e., maintaining a static body position and an upright stance when standing still. Dynamic balance is the ability to appropriately respond to changes in balance and predict changes in body movement. Dynamic balance is crucial for walking, which means being mobile, independent, and having a better quality of life (Mekić & Mavrić, 2016).

A group of authors (Kasović, Vlašić & Antolić, 2007) suggests that a particularly vulnerable group of older people is those residing in homes for the elderly and disabled, due to the ongoing reduction in their physical activity, increasing immobility, and growing dependence on others.

The subject of this research is to collect relevant studies related to the effect of physical activity on the balance of older adults.

The aim of this study is to determine the impact of physical activity on the balance of older adults.

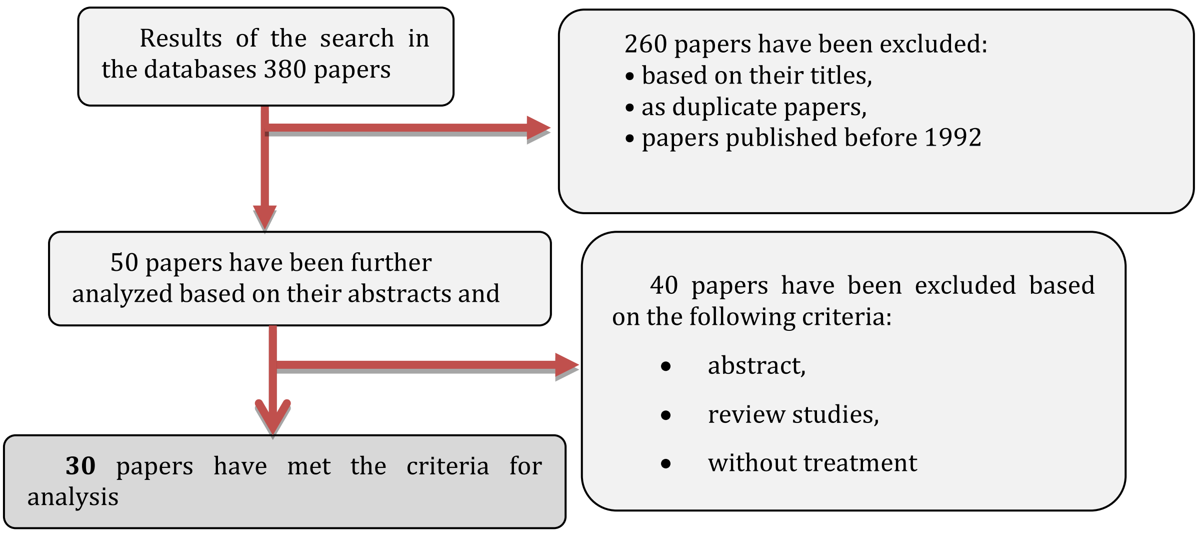
METHODS

To collect data on the effects of physical activity on the balance of older adults, the following electronic databases were utilized: PubMed/Medline, PEDro, SCIndex, ScienceDirect, Google Scholar, journals in the field of sports sciences, as well as relevant literature that could address the research question. The following keywords were used during the search: Exercises of balance, proprioception, exercise in the water, balance of the elderly.

Procedure

The selection of studies was based on titles and keywords. Two selection criteria were applied. The first criterion pertained to the research topic, focusing on the effects of physical activity on the balance of older adults. The second criterion was the analysis of studies published from 1992 to 2009. During this specified time frame, thirty original scientific papers closely related to the research topic and meeting all criteria for further consideration were identified. The process of collecting the studies is presented in Figure 1. In the time frame from 1992 to 2009, studies that were most closely related to addressing the given research topic were included.

Figure 1. *Procedure for collecting, analyzing, and eliminating identified scientific papers*:



RESULTS

The table provides information about authorship, listing the lead author and publication year, while co-authors are referenced. Basic information about the number of participants, age categories, and gender within the sample of participants is included. In the "Research Results" column, the results of the authors and partial conclusions are presented, from which we have drawn personal conclusions for further analysis. The table displays thirty original scientific papers from the period of 1992 to 2009.

Study	Sample of participants			Research results
	number	aged	gender	
Shumway et al. (1996)	105	65	male/ female	The first group served as the control group (n=21), the second group (n=52) engaged in full-spectrum endurance exercises, and the third group (n=32) followed a partial endurance exercise routine. The second and third groups achieved better results than the control group in terms of balance and mobility. Additionally, both the second and third groups exhibited a lower risk of falling compared to the control group. The group that engaged in full-spectrum endurance exercises showed the most significant reduction in fall incidents.
Buchner et al. (1996)	105	68-85	male/ female	The first group (n=25) implemented strength training, the second group (n=25) engaged in endurance training using a bicycle, and the third group (n=25) combined strength and endurance training. There was no significant impact of exercise on walking, balance, physical, or health status. However, exercise had a protective effect on the risk of falling.
Madureira et al. (2007)	66		female	The participants were randomly divided into two groups: "GROUP 1," which underwent balance training, and "GROUP 2," which did not receive training. Using the Berg Balance Scale (BBS), Clinical Test of Sensory Interaction on Balance (CTSIB), and the Timed Up and Go Test (TUGT), this longitudinal prospective study demonstrated that the use of training was effective in improving functional and static balance, mobility, and fall frequency in older women with osteoporosis.
Judge et al. (1992)	38	62-75	female	The first group (n=12) underwent combined training, while the second group, serving as the control group, received flexibility training (n=9). The first group engaged in training three times a week, which included knee joint extension exercises and seated leg press machine exercises, followed by 20 minutes of brisk walking and simple Tai Chi movements. The second group focused on flexibility training, including postural exercises. The average displacement of the center of pressure improved by 17% in the first group and showed no significant change in the second group.
Wolf et al. (1996)	200	76	male/ female	The study involved three groups (TC, BT, and ED) with a duration of 15 weeks. The primary outcomes were measured before and after the intervention, as well as at a 4-month follow-up. Falls were continuously monitored throughout the study. Fear of falling was reduced after the intervention in the TC group compared to the ED group (p = .046 and p = .058, respectively). After adjusting for fall risk factors, the TC group was found to reduce the risk of multiple falls by 47.5%.
Rubenstein et al. (2000)	59		male	They were randomly divided into a control group and an exercise group in a 12-week program. The exercise regimen consisted of 90 minutes of exercise three times a week, focusing on increasing strength and endurance, as well as improving mobility and balance. Exercise where no significant impact was achieved was on balance. These results suggest that physical activity can improve endurance, strength, and gait in older individuals with health conditions. Furthermore, increased physical activity is associated with reduced fall rates.
Wolf et al. (1996)	72		male/ female	In contrast to computerized balance training, Tai Chi does not seem to improve balance measures. However, Tai Chi exercises have been shown to delay falls in older individuals. Interestingly, this effect does not appear to be directly associated with improvements in balance.

Schlicht et al. (2000)	24	61-87	male/ female	These results suggest that strength training alone may not improve balance but can enhance walking speed. The relationship between gaining strength and the risk of falls remains unclear. The data will reinforce the idea that intensive strength training is a safe and effective way to increase muscle strength in this population.
Gauchard et al. (1999)	40	60	male/ female	Nineteen healthy individuals were divided into three groups: proprioceptive exercise (Group I), bioenergetic exercise (Group II), and a control group (Group III) that engaged in regular walking. The control group exhibited the poorest balance and muscle performance. Group I participants showed the best balance with average muscle strength. In Group II, muscle strength significantly increased, but balance was poor. Proprioceptive exercises appear to have the most significant impact on balance.
Kaneda et al. (2008)	30	60	male/ female	Participants were given exercises, either deep water running exercises (DVRE, n=15) or regular water exercises (NVE, n=15). The findings of this study indicate that the deep water running exercise program is significantly more effective than normal water exercises in improving balance abilities in older individuals.
Campbell et al. (2005)	233	80	male/ female	In a randomized controlled study comparing an individually tailored physical therapy program (Group I, n=116) to usual care (control group, n=117), it was found that individual strength and balance exercise programs improved physical function and increased effectiveness in reducing falls and injuries in women aged 80 years and older.
Kevin et al. (2005)	205		male/ female	Participants in the first group (n=122) significantly outperformed those in the control group (n=83). Our intervention can improve functional performance and protect against falls and fall-related injuries in older individuals.
Lord et al. (2002)	669	75-93	male/ female	Sitting to Stand (STS) is often used as a measure of lower extremity strength in older individuals and those with weaknesses. However, recent research results suggest that this test is influenced by factors related to balance and mobility. Findings indicate that in older individuals, the STS test is influenced by multiple physiological and psychological processes and represents a specific skill rather than a measure of lower extremity strength.
Bird et al. (2009)	32	66,9	male/ female	The research investigates balance in older individuals participating in a resistance and flexibility training program. Resistance training resulted in a significant increase in strength that was not observed in flexibility training. Balance was significantly improved after both resistance and flexibility training. However, further research is needed to determine the mechanisms responsible for these improvements.
Swanenburg et al. (2007)	24	65	male/ female	The three-month program, consisting of strength, coordination, balance, and endurance training, led to a significant reduction in the risk of falls, increased muscle strength, and an increase in activity levels observed in the experimental group compared to the control group. Furthermore, there was an 89% reduction in reported falls in the experimental group compared to the control group.
Faber et al. (2006)	278	85	male/ female	The fall frequency rate was higher in the first group compared to the balance exercise program (IB) group and the control group, but this difference was not statistically significant.
Hong et al. (2000)	58	66-67	male	Twenty-eight Tai Chi (TCC) practitioners, who had been practicing Tai Chi exercises were compared with 30 sedentary males serving as the control group. +Long-term regular Tai Chi practice has favorable effects on balance, flexibility, and cardiovascular fitness in older individuals.
Barnet t et al. (2003)	163	65	male/ female	These findings suggest that participation in a weekly group exercise program with accompanying home exercises can improve balance and reduce the risk of falls in older individuals.
Topp et al. (1993)	55	71	male/ female	Participants were instructed to complete three strength training sessions per week for 12 weeks using elastic bands. After the test, participants showed slower walking speed, improved balance, and enhanced ability to walk backward, although none of these post-test measures significantly differed from the control group.

Douris et al. (2003)	11	75-83	male/ female	Performed a similar set of lower body exercises (2 times a week for 6 weeks), but one group did the exercises in the pool, while the others did them on land. The results, as measured by the Berg Balance Scale (BBS), showed significant improvements in BBS scores between the pre-test and post-test, regardless of the treatment intensity. Whether the exercises were performed in water or on land, they led to improved balance.
Woo et al. (2007)	180	65-74	male/ female	The aim was to investigate the impact of Tai Chi (TC) exercises and resistance training exercises (RTE) on bone density (BMD), muscle strength, balance, and flexibility in older adults. There were no significant differences observed in balance, flexibility, or the number of falls between any of the interventions or the control group after 12 months.
Ming-hsia et al. (1993)	24	651-90	male/ female	Subjects were randomly divided into an experimental group (n = 12) and a control group (n = 12). The subjects' training showed a significant improvement in balance after training in five out of eight training conditions (p <0.006). When tested four weeks after the completion of training, subject (a) fell less when minimized to somatosensory inputs from the ankle/foot, and subject (b) stood more on one leg compared to the control group (p <0.001).
Harmer et al. (2004)	256	70-92	male/ female	It was investigated whether functional balance improves through Tai Chi intervention in relation to a subsequent reduction in falls among older adults. Tai Chi participants demonstrated improvement in measures of functional balance. The improvement in functional balance through Tai Chi training is associated with a later reduction in the frequency of falls in older adults.
Wolf et al. (2001)	94	75	male/ female	A short individualized exercise program can improve functional balance in people aged 75 and older. This improvement was maintained for at least one month but disappeared after one year.
Kammerlind et al. (2001)	23		male/ female	Balance training in older individuals with dizziness and instability can improve both issues and enhance balance.
Ballard et al. (2004)	40	65-89	female	The exercise program resulted in increased balance and leg strength but did not result in a significant difference in falls during the follow-up period..
Hess et al. (2005)			male/ female	The aim of the study was to assess the effect of a 10-week, high-intensity lower extremity muscle strength training program to improve balance in older adults. High-intensity strength training can safely and effectively strengthen lower extremity muscles in impaired older adults, resulting in significant improvements in balance and a reduced risk of falls.
Rhonda et al. (2005)	112	69	male/ female	The study investigated the 8-12 weeks of strength training at 20%, 50%, or 80% of their maximal strength, or no training (CON group). Strength training improved balance, particularly when using lower loads and a high-velocity regimen, in older adults with initially lower muscle strength and slower contractions.
McAuley et al. (2002)	44	60	female	Fifteen participants regularly practiced proprioceptive physical activities (Group I), 12 regularly practiced bioenergetic physical activities (Group II), and 18 participants in the control group engaged in regular walking (Group III). Proprioceptive exercises appeared to have the best influence on balance regulation and precision.
Taggart (2002)			female	The aim of the study was to determine the effects of Tai Chi exercise in older women. Regression analysis showed statistically significant improvements in balance (p < .001), mobility (p < .05), and fear of falling (p < .001). Three months of twice-weekly, 30-minute Tai Chi classes were associated with statistically significant improvements in balance and a reduction in the fear of falling in this sample of older women.

DISCUSSION

A reduced ability to maintain balance can be associated with an increased risk of falling, particularly in older individuals. Falls in older adults often lead to injuries, a loss of confidence, a higher likelihood of illnesses, and premature death.

Table 1 provides an overview of scientific studies that investigate the impact of physical activity on improving balance in older individuals. The table demonstrates that the studies have been presented and analyzed according to five groups of parameters: reference, participants' age, number of participants, participants' gender, and measurement results.

A total of 30 studies were included in the review, with a combined total of 3240 participants, the majority of whom were women and on average over 60 years old. In the study by Helen M. Taggart (2002), the number of participants and their age were not emphasized, but it is known that the participants were female, and the conclusion is that Tai Chi exercises can be an acceptable form of exercise for older women. In the work by Hess & Woollacott (2005), the number of participants and their age were not specified, and the research was conducted to assess the impact of a 10-week program of high-intensity strength training of the lower extremity muscles on the balance of older adults. The study by Lord et al. (2002) had the largest number of participants, with 669 individuals, while the study by Douris et al. (2003) had the smallest number of participants, with 11 individuals.

Five different studies by various authors were found to analyze strength training and its impact on balance. Research on the impact of physical activity on the balance of older individuals applied a strength training program by authors such as Buchner et al. (1996), Schlicht et al. (2005), Topp et al. (1993), Rhonda et al. (2005), and Ballard et al. (2004).

Two studies were found that analyzed aquatic exercise training and its impact on the balance of older individuals: Douris et al. (2003) and Kaneda et al. (2008).

Two studies were found that analyzed proprioceptive training and its impact on the balance of older individuals: Gauchard et al. (1999) and Gauchard et al. (2002).

There were seven studies found that analyzed the effects of Tai Chi programs on the balance of older individuals: Taggart (2002), Judge et al. (1992), Wolf et al. (1996), Harmer et al. (2004), Jean Woo et al. (2007), Wolf et al. (1996), and Hong et al. (2000).

Furthermore, studies that analyzed the effects of multidimensional exercises on the balance of older individuals were conducted by the group of authors Shumway-Cook et al. (1996).

In the study by Barnett et al. (2003), a group exercise program was implemented. Participants were assessed using the Berg Balance Scale (BBS), the Clinical Test for Sensory Interaction on Balance, the Dynamic Gait Index, postural sway with eyes open and eyes closed, and coordinated stability. Based on the results, it can be concluded that strength training alone does not significantly improve long-term balance.

It was concluded that the effect of multidimensional exercises on the balance of older individuals has a positive impact on balance development. The effect of proprioceptive physical activities on balance control in older individuals has the greatest impact on balance control in this group. Research on the effects of aquatic exercises on balance shows that lower extremity water exercise programs, whether in water or on land, lead to improved balance.

High-intensity training can safely and effectively strengthen the lower extremity muscles, resulting in significant improvements in balance and a reduced risk of falling in older individuals. Some authors argue that the effects of Tai Chi Kuan exercises cannot be directly associated with measures of improved balance. However, other authors believe that long-term regular Tai Chi Kuan (TCC) practice has favorable effects on balance and flexibility in older individuals.

Based on the results, it can be recommended to include high-intensity strength training and proprioceptive physical activity training in older individuals, as they have been shown to have the most significant impact on balance control in older individuals. The review has established that physical activity has statistically significant positive effects on balance compared to regular activities in older adults.

The effects of physical activity on the balance of older individuals have been observed in their ability to stand on one leg with both eyes open and closed, walk backward, and increase walking speed.

Future studies should be well-designed and provide detailed and precise reports. Ideally, research should follow participants for one year after their participation to assess long-term effects, rather than solely focusing on immediate post-intervention results in improving balance in older individuals.

CONCLUSION

Based on the analysis of results and conclusions drawn by the authors in the mentioned studies, it can be concluded that balance can be successfully improved in older individuals who engage in moderate physical activity and everyday life activities. The most significant impact on improving balance comes from resistance training, where proper load dosage is crucial. High-intensity strength training can safely and effectively strengthen the lower extremity muscles, resulting in significant improvements in balance and a reduced risk of falling in older individuals. Research on the effects of various exercise programs on balance remains highly relevant. Other exercise programs applied in the analyzed studies also have certain positive effects on balance development. Some authors believe that deep-water exercise programs are more effective than regular water exercises in improving balance. Recent research conducted by Gauchard, Gangloff, Jeandel & Perrin (2002) shows that bioenergetic activity improves postural control in simple tasks, and proprioceptive exercises have the greatest impact on balance control in older individuals.

This relevance allows proven balance-enhancing exercise programs for older adults to be successfully used in practice. In fall prevention, physical activity programs must be based on a multidimensional aspect of balance maintenance and focus on activating all relevant sensory systems in balance maintenance, such as the musculoskeletal system, visual, vestibular, and somatosensory systems. Long-term regular exercise has favorable effects on balance in older individuals. In addition to improving balance, there are other benefits of a combined exercise program that includes balance, endurance, strength, and flexibility exercises, such as:

• Faster reaction time - can help you quickly grab onto something stable if you start to fall.

• Improved coordination - can prevent falls and help you land more smoothly and gracefully, reducing the risk of injury upon falling. • More muscle mass - stronger and larger muscles can cushion a fall and protect bones and joints.

• Stronger bones - resistance exercises strengthen bones, making them more resistant to fractures.

• Better brain function - regular exercise helps maintain normal brain function as you age. Sharper thinking can help you avoid situations that increase the risk of falling.

Based on all the above, it can be concluded that physical activity has numerous positive effects on maintaining the health and quality of life of older individuals. When conducted correctly, tailored to age-related characteristics, and individual needs, there should be no contraindications or side effects that could jeopardize the health of the participants.

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STUDENT'S ATTITUDES TOWARDS ENGLISH LANGUAGE IN KINESIOLOGY: INSIGHTs THROUGH GENDER-RELATED DIFFERENCES

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ABSTRACT

The English language, which has attained a global status, plays an important role in modern times and is used in almost all fields such as science, engineering, education, information and technology, business, etc. Thus, it has the status of "English for specific purposes" (ESP), which means that it focuses on the linguistic and communicative requirements in a specific professional field and becomes an important force in English language teaching and research. Therefore, the aim of this study was to identify and explain gender related differences in student's attitudes towards necessity of English language. In doing so, by using 2 newly-constructed questions, N_1=48 male and N_2=53 female students of kinesiology were assessed for their attitudes towards the relationship between English language proficiency and finding a job 1) in Croatia 2) internationally. Used questions appeared to be a-priori valid using expert assessment and highly reliable ($r>0.92$; $p<0.05$). Using Mann Whitney U test, it was found ($p=0.34$; $p=0.53$) that male and female students have the same attitudes towards the applicability of English when looking for a job in Croatia or abroad. The results of this research indicate that the attitudes of male and female students on this issue are homogeneous. The absence of differences can be used as an additional indication for structuring learning materials for undergraduate and graduate students of kinesiology, physical culture and/or sports science. Although, many researches of the relationship between gender-related differences and English language learning acquisition abound in the publications, further studies should include similar reseach for other languages that are also prevalent today in the global sense.

Keywords: learning English, physical education, importance of English, interaction English – real life

INTRODUCTION

It is common knowledge that the English language has become an indispensable tool of international, even intranational, communication and that adequate oral and written proficiency is expected in most countries of the world (Wright, 1999; Neufeld, 1979). As members of the countries' educational systems are aware of the above-mentioned fact, there are compulsory courses on English language in all study programmes in Croatia, related to terminology and grammar usually used in practise (Vilke, 2007; Vičević Ivanović, Košuta & Patekar, 2021; Penjak & Duran, 2017). Studies on physical culture or kinesiology, for example, tend to promote oral and written skills, but are strongly focused on the context of physical culture or kinesiology.

It is important to say that language learning processes are usually long-lasting and require set of skills, various abilities and even motivation. Additionally, any kind of communication in the foreign language, especially oral presentations, requires daily practise and can be associated with an increase in anxiety and stress (Penjak & Karninčić, 2015; Kovač & Zdilar, 2017). On the other hand, it is important to question various issues arising from gender differences in foreign language learning and attitudes towards learning (Nikolov, Djigunović, 2006; Kayaoğlu, 2012; Ho & Ng, 2016) as they may have an impact on the quality of learning (Schwab & Lew-Williams, 2016). More precisely, it is well known that the analysis of aspects of foreign language learning usually points female superiority (Oga-Baldwin & Fryer, 2020; Saranraj, Khan, & Zafar, 2016). Regarding all abovementioned into account, the goal of this research is to inspect kinesiology student's gender related attitudes towards the necessity of learning English and its applicability in real-life settings - in physical culture and/or kinesiology.

METHODS

Subjects

Due to the aim of the study, a sample of N=101 (M=48; F=53; mean age 21.13 ±1.92 yrs) kinesiology students was used. All students passed the English for Sport exam in the second year of the undergraduate Kinesiology programme. In addition, the students were informed about the aim of the study and that they could discontinue the study without penalty. All measurements were carried out in full compliance with the Declaration of Helsinki.

Variables

All students were asked 2 questions on a Likert type 1-5 scale (1 – Strongly disagree; 5 – Strongly agree)

1) "Knowing English language will be useful to me in finding job in Croatia"
2) "Knowing English language will be useful to me in finding job abroad"

In further, questions were labelled as Q1 and Q2, respectively.

Procedure

To ensure the validity of the questions, prior to taking survey, several details about the questions were clarified with several experts who have more than 30 years of experience in foreign language teaching. Also due to identification of reliability issues, 12 male and 12 female students were asked to fill questionnaire after 14 days.

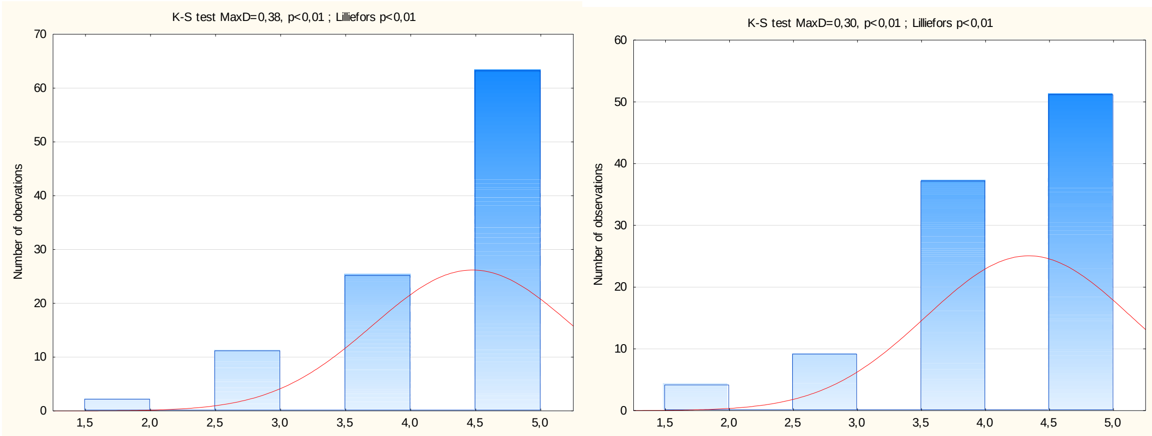
Statistical analysis

As a measure of reliability, the correlation coefficient between test and retest was used together with the t-test for dependent samples. Thus, prior to analysis, it could be determined that the measurement instrument was very reliable ($r > 0.92$ with $p < 0.05$; $t=1.37$ with $p > 0.57$). The normality of the data was tested with the Kolmogorov-Smirnov test together with the Lilliefors correction. Since the normality assumption was violated, the non-parametric Mann Whitney U test along with the continuity correction was used to test the significance of the differences between female and male students. Type I error was set at $\alpha=5\%$. All calculations were performed using the statistical analysis system Statistica 14.0.1.25 (TIBCO Software Inc. (2020). Data Science Workbench, version 14. http://tibco.com.)

RESULTS

Prior to the analysis, histograms were drawn and normality was inspected using Kolmogorov Smirnov test with Lilliefors correction (Histogram 1 & 2).

Histogram 1 and 2 (visualisation of data distribution for two questions)



Regarding the fact that normality of used variables was violated, nonparametric Mann Whitney U test, together with continuity correction was used to examine the significance of differences between female and male students. The results of the analysis of the differences are shown in Table 1.

Table 1: Significance of differences between female and male students using Mann Whitney U test (together with continuity correction) was used for examination of significance of differences between female and male students.

	Rank Sum Male	Rank Sum Female	U	Z	p	Z adjusted	p adjusted
Q1	2307	2844	1131.00	-0.96	0.34	-1.05	0.29
Q2	2356	2796	1179.50	-0.63	0.53	-0.73	0.47

Legend: Knowing English language will be useful to me in finding job in Croatia (Q1); Knowing English language will be useful to me in finding job abroad (Q2)

As shown in Table 1, contrary to expectations, there were no significant differences between male and female students for the two questions used (Q1 and Q2).

DISCUSSION AND CONCLUSION

The aim of the study was to obtain information on gender-related differences in attitudes towards the necessity of learning English, i.e. its usefulness in real life. Using the Mann Whitney U-test, contrary to expectations, it was found that male and female students have approximately the same attitudes towards the necessity and applicability of English when looking for a job in Croatia or abroad (Z=-0.96 with p=0.34; Z=-0,63 with p=0.53). Research in these areas usually indicates the identification of statistically significant differences between genders (Nyikos, 1990; Montero-Saizaja, 2021; Piniel, & Zólyomi, 2021). On the other hand, there was no significant meaning between students' attitudes towards English in relation to their gender, nationality and the subject areas in which they study (Soleimani & Hanafi, 2013). Moreover, students from different disciplines are known to have different attitudes towards English language learning in terms of areas of application and focus of learning skills, which shows that a single curriculum or teaching method is not appropriate (Ahmed, 2015). Additionally, the study (Kobayashi, 2002) problematises the common practise in questionnaire-based research that ends with the statistical identification of gender-related differences in attitudes without examining the potentially crucial factors that influence these differences. The results of this research indicate that the attitudes of male and female students on this particular issue are homogeneous. The absence of differences can be used as additional evidence for structuring learning materials for undergraduate and graduate students of kinesiology, physical culture and/or sport sciences.

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BARRIERS TO THE WORKING POPULATION'S PHYSICAL ACTIVITY

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ABSTRACT

The working population's physical activity has an enormous influence on their health. Despite the well-documented health benefits of physical activity for this population, the working population is not sufficiently physically active and faces a wide range of internal and external barriers. The aim of the study was to identify the differences in barriers to physical activity between working men and women, as well as the differences in barriers related to age. The sample of subjects consisted of 619 working adults (aged 20 to 65), of which 354 were men and 265 were women. The questionnaire developed by Mitic et al. (2010) was used to identify the barriers. Frequencies and percentages of responses were calculated, and differences between groups were determined by the χ^2 test. The data were processed using the SPSS 20 statistical package, and the level of statistical significance was p= .05. Significant differences were found in most barriers to physical activity between working men and women, in relation to age. The most frequently stated barriers were "I lack time", "I don't feel the need" and "I lack habits". Age-related barriers have been identified for men above the age of 40, but they begin for women at the age of 30. In relation to gender, a statistically significant difference was found in the barriers "I lack habits" (p= .050) and "There is a lack of place to perform it" (p= .044), with a higher proportion of women confirming the mentioned barriers. The study showed that there are differences in barriers to physical activity between men and women, and accordingly there is a need to offer different programs and exercise opportunities to reduce these barriers.

Keywords: barriers, physical activity, working population, workplace health, sedentary behavior.

INTRODUCTION

World Health Organisation defines physical activity as „any bodily movement produced by skeletal muscles that requires energy expenditure" (WHO, 2017). Active people, who regularly exercise, have a large number of benefits, including a lower risk of developing certain non-communicable diseases and a delay of morbidity and mortality in later life (Brunner, Welch, Shipley, Ahmadi-Abhari, Singh-Manoux & Kivimäki, 2017; Shin, Lee & Belyea, 2018). Physically active people reduce the risk of cardiovascular diseases including stroke, coronary heart disease, heart failure, diabetes, high blood pressure (Shakoor et al., 2023), as well as various types of cancer (Patel et al., 2019). In this age group, physical activity has additionally been found to have positive effects on mental health (Bondarev et al., 2021).

Middle age is an important phase of life and frequently the time when there are the most demands due to a variety of responsibilities in the home, in the workplace, and in the community. (Lachman, Teshale & Agrigoroaei, 2015). The lack of exercise among middle-aged persons is a result of their busy schedules and the lack of focus placed on physical activity (Kelly, Martin, Kuhn, Cowan, Brayne & Lafortune, 2016).

Today's pace of life combined with the defined assignments at the workplace creates a significant task that is reflected in the effectiveness of work execution. A large number of jobs in the modern world are mainly related to sitting at a desk (working at a computer) and limited movement during working hours (Hadgraft et al., 2016). Evidence indicates that sedentary behavior has become an integral part of the working population, arising as a result of technological progress and environmental changes where extended daily sitting time has become the norm in the office, home and transport (Al-Mohannadi, Albuflasa, Sayegh, Salman & Farooq, 2020). Apart from the previously mentioned facts related to the workplace itself, there are data that gender plays an important role in the representation of physical activity among employed people. Namely, women are less physically active than men, that is, employed women show a higher level of inactivity than employed men (Cook & Gazmararian, 2018).

Physically active people perform everyday tasks more easily precisely because their bodies are prepared for the given conditions. Also, the conditions, type and character of the work affect efficiency (Mariam & Mazin, 2019). Certain studies indicate that the inclusion of workers in physical activities at the workplace has various benefits for their health, primarily reducing anxiety and depression (Chu, Koh, Moy & Müller-Riemenschneider, 2014), reduction of back pain and musculoskeletal pain in general (Moreira-Silva, Teixeira, Santos, Abreu, Moreira & Mota, 2016) as well as reducing the number of sick days and increasing work performance (Wynne-Jones et al., 2014). Increasing the level of physical activity of employees in the workplace could provide great benefits to both employees and the companies they work in, as well as contribute to improving the health of the population.

However, the working population faces a large number of barriers that prevent them from being physically active, both at work and in their free time (Paudel, Owen & Smith, 2021).

Perceived barriers to physical activity have been established as an important factor in physical activity itself. Research has shown that there are both external and internal barriers to physical activities among working individuals (Schwetschenau, O'Brien, Cunningham & Jex, 2008). Also, barriers are not the same and can vary depending on gender, age, workplace, etc. Also, the habit and motivation of the individual for exercise can be a barrier (Shin, Lee & Belyea, 2018). The levels of inactivity in previous researches were related to the perceived barriers such as lack of time, lack of energy, workload and insufficient motivation, etc. (Hunter, Gordon, Bird & Benson, 2018; Al-Mohannadi, Albuflasa, Sayegh, Salman & Farooq, 2020; Ryde, Atkinson, Stead, Gorely & Evans, 2020).

Based on the above, the question arises whether there are barriers to physical activity among working men and women, or whether they differ in relation to gender and age. Therefore, the aim of this research was to determine whether there are differences in barriers to physical activity between working men and women, as well as to determine whether these barriers change with age depending on gender.

METHODS

Subjects

The research was conducted on a total sample of 619 respondents, of which 354 were men, and 265 women (Table 1). The interviewers went over the process and timeline of the survey with respondents before it was actually conducted. Participation in the study was voluntary and any respondent could withdraw at any time during testing. The research was approved by the Ethics Committee of the Faculty of Sports and Physical Education.

Table 1. Sample of respondents according to gender and age

Age	Male		Female		Total	
	n	%	n	%	n	%
20-29	88	24,9	49	18,5	137	22,1
30-39	95	26,8	83	31,3	178	28,8
40-49	101	28,5	93	35,1	194	31,3
50-59	59	16,7	40	15,1	99	16,0
60+	11	3,1	-	-	11	1,8
Total	354	100,0	265	100,0	619	100

The research was conducted in accordance with the Declaration of Helsinki and recommendations for research involving human subjects (Christie, 2000). Before the actual survey, the respondents' consent to participate in the study was requested.

After obtaining consent, all participants were invited to take part in the survey.

Procedure

For the purposes of this research, a survey questionnaire (Mitić et al., 2010) was used, which contained a total of 9 questions. All questions were of the closed-choice type, and each question was rated on a three-point Likert scale. In order to identify what can be a barrier to physical activity, each question contained the following answer options: "Yes", "Partially" "No".

Statistical analysis

The basic descriptive parameters for each group, as well as the parameters of the total sample and the sample by age are presented as absolute and relative frequency distributions. Only the fully completed question sheets were included into the data analysis. To determine the differences according to gender and age, a non-parametric Chi-square test (χ^2) was used. The level of significance was defined as 0.05. The Statistical Package for the Social Sciences (SPSS) for Windows was used to process the obtained data (Version 20.0) (Chicago, IL, USA).

RESULTS

Table 2 shows the basic parameters of the descriptive statistics of the surveyed sample of men and women.

Table 2. Descriptive statistics

	Male f (%)			Female f (%)		
Barriers to physical activity	**Yes**	**Partially**	**Not**	**Yes**	**Partially**	**Not**
I don't feel the need	128 (36,2)	100 (28,2)	126 (35,6)	118 (44,5)	61 (23,0)	86 (32,5)
I lack habits	157 (44,4)	119 (33,6)	78 (22,0)	142 (53,5)	80 (30,2)	43 (16,2)
My age bothers me	114 (32,2)	62 (17,5)	178 (50,3)	92 (34,7)	53 (20,0)	120 (45,3)
I lack time	181 (51,1)	116 (30,6)	57 (15,5)	143 (54,0)	81 (30,6)	41 (15,5)
Financial costs are considerable	129 (36,4)	89 (25,1)	136 (38,4)	108 (40,8)	60 (22,6)	97 (36,6)
Misunderstanding of milieu bothers me	104 (29,4)	54 (15,3)	196 (55,4)	90 (34,0)	32 (12,1)	143 (54,0)
Sports facilities are not available	120 (33,9)	98 (27,7)	136 (38,4)	108 (40,8)	66 (24,9)	91 (34,3)
There is a lack of organizers (of PA)	127 (35,9)	98 (27,7)	129 (36,4)	106 (40,0)	60 (22,6)	99 (37,4)
There is a lack of place to perform it	112 (31,6)	96 (27,1)	146 (41,2)	103 (38,9)	51 (19,2)	111 (41,9)

Legend: f – frequencies; % - percentage share

Based on the obtained results, it can be concluded that the largest number of working men (51%) states "I lack time" for the physical activities, as a barrier. The respondents stated "I lack habits" (44.4%) as the second barrier that most hindered them from engaging in physical activity. In third and fourth place are the barriers "Financial costs are considerable" (36.4%) and "I don't feel the need" (36.2%).

The results are similar when it comes to working women. The majority of working women (54%) state "I lack time", as well as "I lack habits" to engage in physical activity (53.5%). In third place is the barrier "I don't feel the need" to participate in physical activity (44.5%).

Differences in barriers in relation to age are shown in Table 3. Based on the obtained results (Table 3), it can be seen that the most important barrier to getting involved in physical activity, regardless of age, is "I lack time". Most men who answered *yes* to this statement were over 40 years old, 40-49 (53.5%), 50-59 years (62.7%), and 60+ (81.8%). Also, the largest number of respondents stated "I lack habits" to engage in physical activity. Respondents who answered affirmatively were, as in the previous case, over 40 years old, that is, 40-49 years old (40%), 50-59 years old (66.1%) and older than 60 years old (81.8%). The barrier that men over 40 also stated is " I don't feel the need". The findings show that men between the ages of 20 and 29 responded negatively to the statement "My age bothers me," indicating that it is not a barrier for them. The barrier that most men denied was "Misunderstanding of milieu bothers me". As many as 50% of men aged 20 to 29 and 44% of men aged 40 to 49 denied this statement.

The results of the χ^2 test showed (Table 3) that there are statistically significant differences in barriers to physical activity between working men in the following: "I don't feel the need" (p= .005), "I lack habits" (p= .000), "My age bothers me" (p= .000), "I lack time" (p= .015), "Misunderstanding of milieu bothers me" (p= .002), "Sports facilities are not available" (p= .001), "There is a lack of organizers" (p= .001) and "There is a lack of place to perform it" (p= .002).

The majority of women over 30 who responded to the survey stated "I lack habits" necessary to engage in physical activity, i.e. the age group 30-39 years (54.2%), 40-49 years (47.3%) and women aged 50-59 (65%). Also, women aged 30 to 39 and 40 to 49 stated "I lack time" for physical activity (59% and 54.8%). Women aged 30-39 stated as a barrier that "I don't feel the need" (54.2). 55% of young women between the ages of 20 and 29 who responded to the question indicated they did not have any trouble arranging their physical exercise. According to the findings, women between the ages of 40 and 49 reported they have a place where to engage in physical activity (40%) and that they are not bothered by the lack of understanding of their environment (50%). As many as 71% of women aged 20 to 29 answered „not“ to the previous statement.

The results of the χ^2 test showed that there is a statistically significant difference in barriers to physical activity between working women in the following statements: "My age bothers me" (p= .000), "Sports facilities are not available" (p= .028) and "There is a lack of organizers" (p= .014).

Table 3. Differences in barriers in relation to age

	Male f (%)						Female f (%)				
	Age	Yes	Partially	Not	χ^2	Sig.	Yes	Partially	Not	χ^2	Sig.
I don't feel the need	20-29	25 (28,1)	26 (29,2)	38 (42,7)	21,9	**.005****	16 (32,7)	12 (24,5)	21 (42,9)	8,5	.220
	30-39	28 (29,8)	29 (30,9)	37 (39,4)			45 (54,2)	19 (22,9)	19 (22,9)		
	40-49	35 (34,7)	26 (25,7)	40 (39,6)			38 (40,9)	21 (22,6)	34 (36,6)		
	50-59	33 (55,9)	16 (27,1)	10 (16,9)			19 (47,5)	9 (22,5)	12 (30,0)		
	60+	7 (63,6)	3 (27,3)	1 (9,1)			-	-	-		
I lack habits	20-29	31 (34,8)	28 (31,5)	30 (33,7)	35,5	**.000****	22 (44,9)	17 (34,7)	10 (20,4)	6,1	.339
	30-39	37 (39,4)	42 (44,7)	15 (16,0)			50 (60,2)	21 (25,3)	12 (14,5)		
	40-49	41 (40,6)	31 (30,7)	29 (28,7)			44 (47,3)	32 (34,4)	17 (18,3)		
	50-59	39 (66,1)	16 (27,1)	4 (6,8)			26 (65,0)	10 (25,0)	4 (10,0)		
	60+	9 (81,8)	2 (18,2)	0 (0,0)			-	-	-		
My age bothers me	20-29	20 (22,5)	5 (5,6)	64 (71,9)	52,8	**.000****	8 (16,3)	5 (10,2)	36 (73,5)	24,0	**.000****
	30-39	19 (5,4)	20 (5,6)	55 (15,5)			32 (38,6)	14 (16,9)	37 (44,6)		
	40-49	35 (34,7)	24 (23,8)	42 (41,6)			33 (35,5)	23 (24,7)	37 (39,8)		
	50-59	32 (54,2)	11 (18,6)	16 (27,1)			19 (47,5)	11 (27,5)	10 (25,0)		
	60+	8 (72,7)	2 (18,2)	1 (9,1)			-	-	-		

	20-29	36 (40,4)	29 (32,6)	24 (27,0)			22 (44,9)	16 (32,7)	11 (22,4)		
	30-39	45 (47,9)	33 (35,1)	16 (17,0)			49 (59,0)	25 (30,1)	9 (10,8)		
I lack time	40-49	54 (53,5)	36 (35,6)	11 (10,9)	18,9	**.015***	51 (54,8)	25 (26,9)	17 (18,3)	6,2	.398
	50-59	37 (62,7)	16 (27,1)	6 (10,2)			21 (52,5)	15 (37,5)	4 (10,0)		
	60+	9 (81,8)	2 (18,2)	0 (0,0)			-	-	-		
	20-29	22 (24,7)	26 (29,2)	41 (46,1)			12 (24,5)	16 (32,7)	21 (42,9)		
	30-39	35 (37,2)	25 (26,6)	34 (36,2)			35 (42,2)	19 (22,9)	29 (34,9)		
Financial costs are considerable	40-49	36 (35,6)	26 (25,7)	39 (38,6)	12,9	.112	41 (44,1)	19 (20,4)	33 (35,5)	8,6	.213
	50-59	30 (50,8)	11 (18,6)	18 (30,5)			20 (50,0)	6 (15,0)	14 (35,0)		
	60+	6 (54,5)	1 (9,1)	4 (36,4)			-	-	-		
	20-29	19 (21,3)	9 (10,1)	61 (68,5)			8 (16,3)	6 (12,2)	35 (71,4)		
	30-39	24 (25,5)	20 (21,3)	50 (53,2)			33 (39,8)	11 (13,3)	39 (47,0)		
Misunderstanding of milieu bothers me	40-49	27 (26,7)	14 (13,9)	60 (59,4)	24,1	**.002***	34 (36,6)	9 (9,7)	50 (53,8)	10,9	.113
	50-59	29 (49,2)	10 (16,9)	20 (33,9)			15 (37,5)	6 (15,0)	19 (47,5)		
	60+	5 (45,5)	1 (9,1)	5 (45,5)			-	-	-		
	20-29	21 (23,6)	23 (25,8)	45 (50,6)			13 (26,5)	21 (42,9)	15 (30,6)		
	30-39	30 (31,9)	36 (38,3)	28 (29,8)			36 (43,4)	22 (26,5)	25 (30,1)		
Sports facilities are not available	40-49	33 (32,7)	23 (22,8)	45 (44,6)	26,2	**.001***	41 (44,1)	15 (16,1)	37 (39,8)	14,2	**.028***
	50-59	31 (52,5)	15 (25,4)	13 (22,0)			18 (45,0)	8 (20,0)	14 (35,0)		
	60+	5 (45,5)	1 (9,1)	5 (45,5)			-	-	-		
	20-29	21 (23,6)	22 (24,7)	46 (51,7)			9 (18,4)	13 (26,5)	27 (55,1)		
	30-39	34 (36,2)	32 (34,0)	28 (29,8)			41 (49,4)	18 (21,7)	24 (28,9)		
There is a lack of organizers (of PA)	40-49	33 (32,7)	29 (28,7)	39 (38,6)	26,0	**.001***	36 (38,7)	20 (21,5)	37 (39,8)	15,1	**.014***
	50-59	34 (57,6)	11 (18,6)	14 (23,7)			20 (50,0)	9 (22,5)	11 (27,5)		
	60+	5 (1,4)	4 (1,1)	2 (0,6)			-	-	-		
	20-29	19 (21,3)	26 (29,2)	44 (49,4)			12 (24,5)	12 (24,5)	25 (51,0)		
	30-39	27 (28,7)	32 (34,0)	35 (37,2)			39 (47,0)	16 (19,3)	28 (33,7)		
There is a lack of place to perform it	40-49	32 (31,7)	21 (20,8)	48 (47,5)	24,9	**.002***	36 (38,7)	17 (18,3)	40 (43,0)	7,6	.272
	50-59	29 (49,2)	17 (28,8)	13 (22,0)			16 (40,0)	6 (15,0)	18 (45,0)		
	60+	5 (45,5)	0 (0,0)	6 (54,5)			-	-	-		

Legend: f – frequencies; % - percentage share; χ^2 – Chi-square test; Sig.- significance level; *p< .05, **p< .01

Table 4. Differences in barriers between men and women

Barriers to physical activity		Male f (%)	Female f (%)	Male vs Female χ^2	Sig.
I don't feel the need	Yes	128 (36,2)	118 (44,5)		
	Partially	100 (28,2)	61 (23,0)	4,702	.095
	Not	126 (35,6)	86 (32,5)		
I lack habits	Yes	157 (44,4)	142 (53,6)		
	Partially	119 (33,6)	80 (30,2)	5,844	**.050***
	Not	78 (22,0)	43 (16,2)		
My age bothers me	Yes	114 (32,2)	92 (34,7)		
	Partially	62 (17,5)	53 (20,0)	1,579	.454
	Not	178 (50,3)	120 (45,3)		
I lack time	Yes	181 (51,1)	143 (54,0)		
	Partially	116 (32,8)	81 (30,6)	,501	.778
	Not	57 (16,1)	41 (15,5)		
Financial costs are considerable	Yes	129 (36,4)	108 (40,8)		
	Partially	89 (25,1)	60 (30,6)	1,263	.532
	Not	136 (38,4)	97 (36,6)		
Misunderstanding of milieu bothers me	Yes	104 (29,4)	90 (34,0)		
	Partially	54 (15,3)	32 (12,1)	2,173	.337
	Not	196 (55,4)	143 (54,0)		
Sports facilities are not available	Yes	120 (29,4)	108 (40,8)		
	Partially	98 (27,7)	66 (24,9)	3,063	.216
	Not	136 (38,4)	91 (34,3)		
There is a lack of organizers (of PA)	Yes	127 (35,9)	106 (40,0)		
	Partially	98 (27,7)	60 (22,6)	2,229	.328
	Not	129 (36,4)	99 (37,4)		
There is a lack of place to perform it	Yes	112 (31,6)	103 (38,9)		
	Partially	96 (27,1)	51 (19,2)	6,252	**.044***
	Not	146 (41,2)	111 (41,9)		

Legend: f – frequencies; % - percentage share; χ^2 – Chi-square test; Sig.- significance level; *p< .05, **p< .01

The results of χ^2 (Table 4) showed that there are statistically significant differences in barriers to physical activity between working men and women in the following: "I lack habits" (Sig.= .050) and in the question "There is a lack of place to perform it" (Sig.= .044).

DISCUSSION

The aim of the research was to determine whether there are differences in barriers to physical activity between working men and women, as well as to determine whether these barriers change with age depending on gender. The results show that the barriers mentioned by the respondents are very similar between men and women, and the first place is that they don't have time, then they don't feel the need and they lack habits. The obtained results are consistent with the results of other studies that investigated this topic (Hunter, et al., 2018; Al-Mohannadi et al., 2020; Ryde et al., 2020). Insufficient time to participate in physical activity due to work schedule is a frequent barrier among this population. This barrier is most often stated by respondents of both sexes, in men over 40 years old, in women over 30 years old, who also point out that age is a barrier to engaging in physical activity. The results indicate that people of the mentioned age have more barriers than respondents of other ages, younger and older. In almost all of the tested barriers, mainly married men over the age of 40 state that they do not have time, that they lack habits, that they do not have the need, etc., that is, that they are the most obtuse barriers in this period. It is a period in life that requires business and family activities, when people build their personality at work, but also by building their role as parents (Lachman, Teshale & Agrigoroaei, 2015) and thus give the lowest priority to physical activity.

Also, the most frequently stated barriers in both sexes were that the respondents do not have need (with women stating this barrier statistically significantly more) and that they lack the habits of physical activity. Most of these statements were made by women aged 30-39. Men and women aged 40 to 49 mentioned these barriers with a slightly smaller percentage. The period of 30-39 years is primarily based on forming a family and assuming the role of a woman as a mother. There is information that working mothers are a risk group with a low level of participation in physical activities (Limbers, McCollum, Ylitalo & Hebl, 2020) and that most of them do not meet the guidelines of 150 min per week of physical activity (WHO, 2020). Obligations related to children and work prevent this population from having the habit and need to participate in physical activities. Accordingly, one study focused on working mothers, influencing their behavior modification, i.e. adopting the needs and habits for physical activity, playing videos of physically active mothers, as well as education and counseling for participating in them (Mailey & McAuley, 2014). They also held sessions outside of working hours while allowing for childcare while mothers attend education (Mailey & McAuley, 2014).

Women stated in the figher percentage that "There is a lack of place to perform it" as a barrier, which is consistent with other results (Shin, Lee & Belyea, 2018). It is necessary to inform women about exercise opportunities and provide them with information about easily available and accessible facilities such as outdoor gyms in the neighborhood, bicycle paths, safe walking paths, as well as other areas that are close to the place of residence. Additionally, information on how to exercise at home should be provided (Golden & Earp; 2012; Shin, Lee & Belyea, 2018). In this way, this barrier can be eliminated, especially for women.

This problem can be approached in both sexes of the working population of all age categories by organizing an exercise program with an instructor during certain breaks at work, taking into account the health status and ability level of each employee (Hunter, et al., 2018). In this way, in addition to all the benefits related to the health of employees, their productivity at work will also increase (Wynne-Jones et al., 2014; Mariam & Mazin, 2019). As the most common motivator for physical activity in the work of Spiteri, Broom, Bekhet, de Caro, Laventure & Grafton (2019), the working population emphasize health improvement. Therefore, health benefits should be promoted among employees in Serbia and the world should be raised about them among this population.

This population needs education on scheduling their responsibilities and pointing out the need for smart prioritization of time demands for work and life (Al-Mohannadi et al., 2020). In addition, in order to solve the problem of lack of time due to family and business obligations, fitness centers should also consider extended working hours to provide employees with limited time more opportunities to be physically active (Brown, Volberding, Baghurst and Sellers, 2014). Also, education on the application of exercise in a shorter duration (for example, 30 minutes) of high intensity can be helpful for this population (Ekkekakis, Vazou, Bixby & Georgiadis, 2016).

The above can help to further improve and encourage the working population to regularly participate in physical activities.

CONCLUSION

Based on the results, it can be concluded that both women and men emphasize similar barriers as to why they do not practice physical activity. They say they don't have time, don't feel the need, and lack habits. In relation to age, the most barriers were found in men older than 40 years, while in women it is from 30. In relation to gender, statistically significant differences were found in the barriers "I lack habits" and "There is a lack of place to perform it", with a higher share of women confirming the mentioned barriers. The working population spends a large part of the day at the workplace, therefore it can be crucial for reducing the number of barriers and increasing the level of physical activity. It is necessary to increase awareness of the benefits of physical activity, which will contribute to increasing the need for physical activity among employees. It is also necessary to promote and educate people about exercise at home, as well as in accessible places near their homes and sports fields. In this way, barriers that prevent the working population from being physically active can be eliminated and affect the increase in the number of people who will meet the guidelines of the World Health Organization on the frequency and duration of physical activity during the week.

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INFLUENCE OF EXTRA-CURRICULAR SPORTS ACTIVITIES IN STIMULING EXPLOSIVE FORCE AND CONCENTRATE CAPACITY AT PRIMARY SCHOOL CHILDREN IN A RURAL ENVIRONMENT

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ABSTRACT

The rural environment was and is constantly changing. Is it different from the urban one? Definitely YES! Values, possibilities, potential, interests are different. However, the village is no longer what it was 50 or 100 years ago. It is important that the latest development information and directions reach the village. Education has become the means by which the rural environment can be rapidly transformed in all fields. The mindset has changed and people have understood the advantage that education gives to those interested. The standard of living has increased and implicitly the study conditions have improved. The hypothesis from which we started was partially verified. The correlation of the values obtained in the 2 exposure force evaluation tests with the answers given to question no. 8 in the questionnaire showed that 78.57% of the subjects located in the first half of the ranking are those who practice extracurricular sports activities in free time. Following this correlation, we can state, based on the data obtained by us, for the studied sample, that the explosive force is influenced and can have significantly higher values in children who practice sports activities during extracurricular activities. The correlation of the results (quality element) obtained at the Dam Test with the answers given to question no. 8 in the questionnaire showed that only 14.28% of the subjects located in the first half of the ranking are those who practice extracurricular sports activities in free time. Following this correlation, we can state, based on the data obtained by us, for the studied sample, that there is no clear influence of the practice of sports activities, in free time, on the ability to concentrate.

Keywords: extra-curricular sports activities, explosive force, concentrate capacity, primary school children, rural environment

INTRODUCTION

There are children for whom physical activity is a way of life, just as others consider exercise a "necessary evil". Studies are not gratifying and confirm a decrease in sports activities in the daily schedule of children, especially those in primary education. The causes are multiple and it is enough to mention only the busy school curriculum, the lack of coordinated programs, the lack of playgrounds, the lack of financial resources, etc.

We are aware that the number of hours of physical education in school is insufficient for what Latin saying "mens sana in corpore sano" to be functional. For this reason, extracurricular sports activities are an alternative and a way to fill the "movement" deficit.

The aim of the work is to carry out a proper analysis of the correlation between the measurable values of the ability to concentrate attention, the explosive force and the extracurricular sports activity performed by subjects from the rural environment in their free time.

METHODS

The present paperwork starts from the following hypothesis: it is assumed that extracurricular sports activities are essential for the development of explosive strength and the ability to concentrate in fourth-grade students from rural areas.

We aimed to highlight in this paper a study on children's participation in extracurricular sports activities and the correlation of this information with the level of development of explosive force and the ability to concentrate at fourth grade children.

To validate the hypothesis mentioned above, the information obtained from a questionnaire with questions regarding the extracurricular activity of the subjects was correlated with the results obtained at the Toulouse-Pieron attention concentration test and with the results obtained at the 2 tests for measuring the explosive strength of the upper limbs (A) and to the lower ones(S).

Subjects

The study took place during the 2021 school year, at the "Emil Braiescu" Secondary School in Magura village, Bacau county, being a longitudinal study.

To verify the hypothesis, a number of 33 students, 19 girls (W) and 14 boys(M), were included in the experiment. Due to the absence from the 2 tests (ball throw and standing long jump) 5 girls and 1 boy could not be evaluated and in this way the total number of subjects included in the experiment was 27 (14 girls and 13 boys)

Procedure

The main purpose of the questionnaire was to determine, from the group of subjects available, those who carry out extracurricular sports activities as the main option for spending free time. In order to carry out the investigation, the subjects did not pass their identification data on the questionnaires, but for the efficient utilization of the information and the correlation with the results of the subsequent tests, each sheet received had, discreetly, an order number marked with a pencil. The attendance provided the (alternative) numbers and the name of the person who filled in, according to the attendance sheet in the catalog.

Performances in the two tests for measuring explosive force were performed under similar conditions meeting the requirements for all investigated subjects. The quantification of the explosive force involved the measurement of this value in the upper train and in the lower train through the two tests: the standing long jump (S) and the OINA ball throw (A), the values obtained by the subjects had to be correlated and used as a single value. For this reason, the Performances were transformed into points where the best performance received 27 points (= with the number of subjects) and the worst performance received 1 point. In case of equality of performances, no. maximum points of the respective position (n) in both subjects, and the next one down the list received no. of points offered to the previous position – no. of subjects with the same previous result (n-2 or n-3, etc.). In this way we were able to obtain a common ranking based on the values of the 2 correlated tests (tab. 2)

The Toulon-Pieron test had as its main objective the measurement of the ability to concentrate attention, an essential element in any learning process. A centralized table was made with the results obtained in which I presented the 3 elements (c-representing the correctly crossed out signs, g-representing the wrongly crossed out signs and o-representing the omitted signs) + the "qualitative" value of the test = Tc -Tg/Tc+To, which is the main element of this test.

The questionnaire as the main means of investigation answered several questions, and the correlations between the answers given could be the subject of another investigation.

Unfortunately, our topic was very clear, and our objective was to conduct a study on the influence of extracurricular sports activities in the development of explosive strength and the ability to concentrate in 4th grade children from rural areas. From this point of view, our analysis and discussion will focus on the values obtained in the tests (standing long jump, OINA ball throw and Toulon-Pieron) correlated with the answers given by the subjects to the main question and to the verification question.

Statistical analysis

Table no. 1. Ranking answers to main question 8 and check question 2

nr.	Name/ surname	sex	Question	
			2	8
1	P.A.M	M	nu	1
2	T.A.N.	W	nu	1
3	D.C.M.2	M	nu	2
4	D.M.G	W	nu	3
5	A.D.A.	M	nu	4
6	C.P.M.	M	nu	4
7	D.I.A.	W	nu	4
8	L.D.Ş.	M	nu	4
9	M.I.	M	nu	4
10	P.D.M.	M	nu	4
11	D.C.M.1	M	da	5
12	A.I.C.E.	M	da	5
13	B.A.D.	W	da	5
14	C.M.A.	W	da	5
15	C.R.M.	M	da	5
16	D.I.I.	W	da	5
17	F.Ş.A.	M	da	5
18	N.A.G.	W	da	5
19	N.D.A.	W	da	5
20	O.I.	M	da	5
21	P.A.M.G.	W	da	5
22	P.L.	W	da	5
23	R.V.R.	W	da	5
24	S.N.I.	M	da	5
25	A.I.M.	W	nu	6
26	C.D.A.M.	W	nu	6
27	H.E.Ş.	W	nu	6

Table no. 2. Explosive strength test value ranking (marks quiz options)

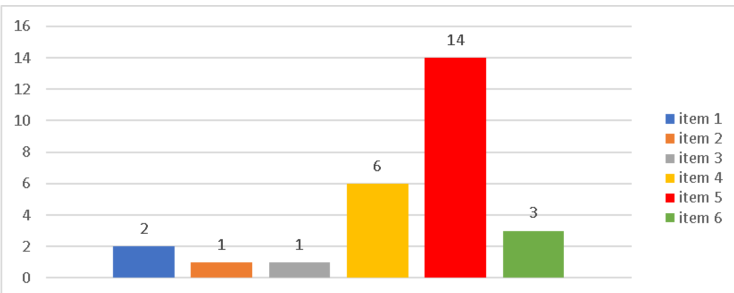
nr.	Name/ surname	sex	Explosive force		total pct
			S	A	
1	A.I.C.E.	M	27	26	53
2	P.L.	W	24	25	49
3	R.V.R.	W	25	24	49
4	B.A.D.	W	26	17	43
5	N.A.G.	W	19	22	41
6	N.D.A.	W	21	19	40
7	A.I.M.	W	22	16	38
8	C.R.M.	M	23	14	37
9	D.C.M.1	M	9	27	36
10	L.D.Ş.	M	15	20	35
11	F.Ş.A.	M	21	12	33
12	O.I.	M	19	14	33
13	P.A.M.G.	W	15	18	33
14	D.C.M.2	M	10	21	31
15	C.D.A.M.	W	4	23	27
16	D.I.A.	W	13	11	24
17	C.M.A.	W	8	15	23
18	H.E.Ş.	W	16	6	22
19	T.A.N.	W	19	2	21
20	D.I.I.	W	7	11	18
21	A.D.A.	M	13	3	16
22	D.M.G	W	11	4	15
23	S.N.I.	M	5	9	14
24	C.P.M.	M	7	6	13
25	M.I.	M	2	8	10
26	P.A.M	M	1	7	8
27	P.D.M.	M	3	1	4

Table no. 3. Hierarchy of Toulon-Pieron values (marking positive answers question 8 from questionnaire)

nr.	Name/surname	sex	pct
1	C.P.M.	M	1
2	L.D.Ș.	M	1
3	C.D.A.M.	W	1
4	D.M.G	W	1
5	D.I.A.	W	1
6	B.A.D.	W	1
7	M.I.	M	1
8	P.A.M	M	1
9	A.I.M.	W	0.962
10	C.M.A.	W	0.96
11	T.A.N.	W	0.944
12	P.D.M.	M	0.939
13	D.C.M.2	M	0.92
14	F.Ș.A.	M	0.92
15	D.I.I.	W	0.909
16	A.I.C.E.	M	0.895
17	C.R.M.	M	0.886
18	P.A.M.G.	W	0.885
19	O.I.	M	0.862
20	D.C.M.1	M	0.857
21	H.E.Ș.	W	0.85
22	N.D.A.	W	0.85
23	A.D.A.	M	0.846
24	N.A.G.	W	0.846
25	R.V.R.	W	0.735
26	P.L.	W	0.727
27	S.N.I.	M	-0.429

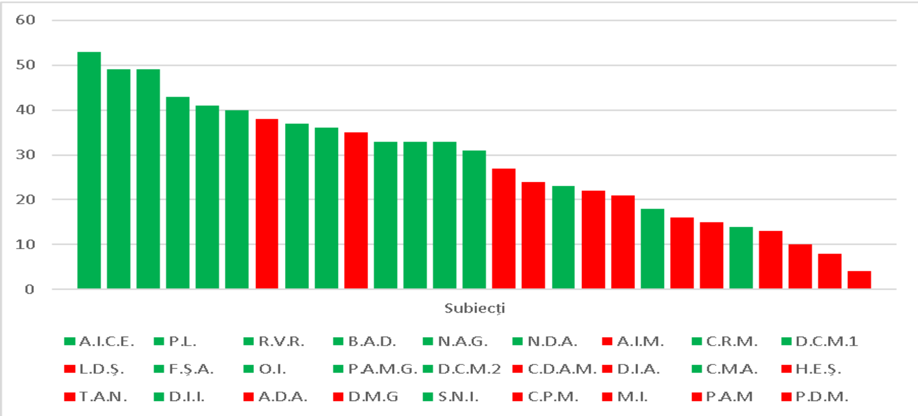
RESULTS

If we analyze the answers received, through the questionnaire, to the main question (no. 8 corroborated with the check no. 2), we can easily see that most of the answers look like the main activity, carried out by children who formed the group of subjects in this research, during extracurricular time is the sports activity (table no.1). The value obtained (14 options) represents more than half of the options of those investigated, this shows the importance of sports activities in the free time budget of rural children.



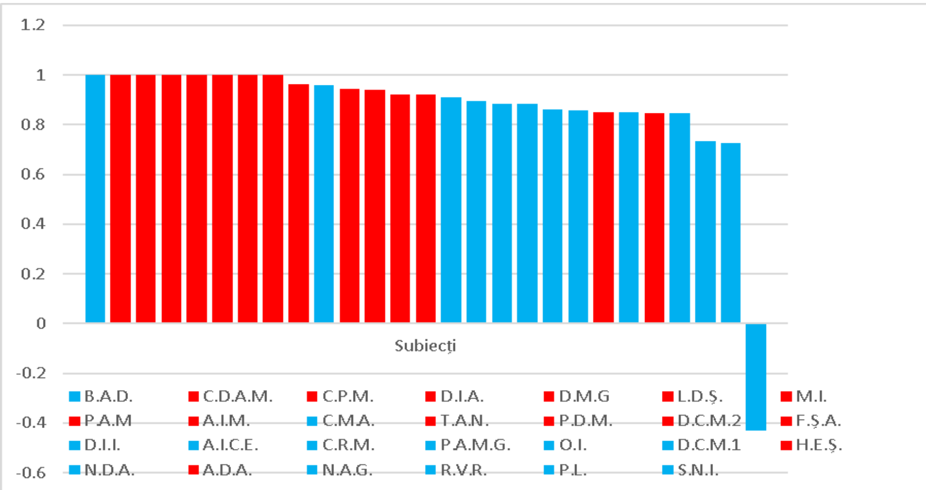
Graph no. 1 Answers received to the main question

In the ranking of the values obtained in the 2 exposure force evaluation tests (table no. 2) we have introduced (in green) the subjects who answered affirmatively to question no. 8 of the questionnaire indicating sports activities as the main option for spending free time. From the 14 subjects located in the first half of the ranking with the best results obtained in the assessment of explosive force, 11 (78.57%) are those who practice extracurricular sports activities in their free time (graph no.2). Following this correlation, we can state, based on the data we obtained for the studied sample, that the explosive force is influenced and can have significantly higher values at students who practice sports activities during extracurricular activities.



Graph no. 2 Explosive force test results

From the 14 subjects located in the first half of the ranking with the best results obtained at the Toulon-Pieron Test, only 2 (14.28%) were among the 14 subjects who answered affirmatively indicating sports activities to question no. 8 of the questionnaire as the main option for spending free time (graph no. 3). Following this correlation, we can state, based on the data obtained by us for the studied sample, that there is no clear influence of the practice of sports activities in free time on the ability to concentrate.



Graph no. 3 Toulon-Pieron test results

DISCUSSION

Following the presented results, we can state that: the explosive force develops, at this age, differently in boys and girls. The values obtained showing a plus for girls; the development of the explosive force is uneven, the values obtained showing differences between the upper train and the lower train.

The correlation of the values obtained in the 2 exposure force evaluation tests with the answers given to question no. 8 in the questionnaire showed that 11 (78.57%) of the 14 subjects located in the first half of the ranking are those who practice extracurricular sports activities in free time. Following this correlation, we can state, based on the data obtained by us, for the studied sample, that the explosive force is influenced and can have significantly higher values in students who practice sports activities during extracurricular activities.

The correlation of the results (quality element) obtained in the Toulon-Pieron Test with the answers given to question no. 8 in the questionnaire showed that only 2 subjects (14.28%) of the 14 subjects located in the first half of the ranking are those who practice activities extracurricular sports in free time. Following this correlation, we can state, based on the data obtained by us, for the studied sample, that there is no clear influence of the practice of sports activities, in free time, on the ability to concentrate.

CONCLUSION

The hypothesis from which we started was partially verified: it is assumed that extracurricular sports activities are essential for the development of explosive strength and the ability to concentrate in 4th grade students from rural areas.

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DURATION OF TENNIS MATCHES IN UNDER 12 AGE GROUP

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ABSTRACT

Tennis is a physically demanding sport. A tennis career consists of numerous matches that start at different age categories, ranging from junior levels to playing in senior tournaments. This article reports the examination and analysis of the duration of tennis matches in age of under 12 between girls and boys. The research follows all matches that took place during weekend on one official tournament. All achieved results were included in the official competition ranking by the Croatian Tennis Federation, considering the age of the players. The analyzed sample consists of 46 matches in both categories. The descriptive statistics were collected from these matches, over the course of two competitive days. The lasting matches are varying in both categories from 24 minutes to 79 minutes, but at the end they are similar in average. The average duration of a single match in the boys' group was 45.53 minutes, whereas in the girls' group, it was 43.31 minutes. Along with analyzing the duration of matches between the genders, the differences in the tournament are minimal and not significant in both tournament phases (DUR=0.44, p≥0,05). Junior tennis player under 12 years of age accumulates a total of 225 minutes of playing time during one official tournament on the weekend. Compare to other sports in this age category, young tennis players spend much more competitive minutes, it emphasizes the importance of age-appropriate training and competition schedules to avoid overexertion and potential injuries among these tennis players Coaches and organizers can use this information to plan tournaments more effectively, ensuring equitable playing time for all participants and creating a supportive environment for young athletes to develop their skills and enjoy the sport.

Keywords: tennis, tournament, match duration, under 12

INTRODUCTION

Tennis is a competitive sport without time restrictions that requires scoring as many points as possible or winning as many points as possible within a designated area by hitting the ball over the net. A tennis career consists of numerous matches that start at different age categories, ranging from junior levels to playing in senior tournaments. During a career, the duration of a tennis game depends on the player's age and the rules of tennis for their specific age group, and a tennis match ends when a certain number of points, games, and sets are won. Novak Djokovic and Rafael Nadal through the Australian Open in 2012 each played over 12 h of tennis across 13 days before competing in a final (Reid & Duffield, 2014). In the younger sporting age, significant changes occur during a child athlete's growth and development, especially in building physical abilities, sports techniques, tactics, and, importantly, the formation of habits and positive personality traits (Milanović, 2013). A complete conditioning program designed to address both the demands of the sport and the individual player's musculoskeletal base is important in tennis, particularly at the competitive junior and professional levels (Chandler, 1995). The duration of tennis matches in younger age groups is an important factor to consider when analyzing playing time and its impact on performance. Previous research has shown physiological changes and player performance changes during two-hour matches (Ojala & Häkkinen, 2013), as well as changes in technical performance during consecutive days of extended, simulated tennis match play (Gescheit et al., 2017). Performance analysis in tennis has primarily advanced through notational analysis, which is complemented by analytical techniques (Takahashi et al., 2023). According to previous research (Carboch, 2017), it has been shown that the performance of the serve significantly influences the duration of a match, which is not prominently evident in the under the 12 tournaments. Understanding the relationship between playing time and performance in younger age groups can help develop training plans and programs that optimize player performance while reducing the risk of injuries. The main goal of this research study was to examine whether there are differences in the duration of tennis matches among competitors under the age of 12 of different genders.

METHODS

Subjects

The study involved 24 youth tennis players under 12 (11.6±0.8 yrs), 15 boys from 10 different clubs and 9 girls from 8 different clubs from all over Croatia competed. All competitors were registered in HTS (Croatian Tennis Association), the boys' top seed was 36th in the ranking list, while the girls' top seed was 21st place.

The sample of variables in this research was the duration of the tennis match, which was played in two shortened sets up to 4. If the result was tied in sets (3:3), a match tie-break was played up to 7. The total sample consisted of 46 matches, 30 matches were played in the boy's category and 16 matches were played in the girl's category.

Procedure

The Valpovo Open for players under 12 years of age took place on April 29th-30th, 2022. It was a Grade 3 tournament held on four clay courts. The tournament followed a Model 2 format, which means that all registered players played round-robin qualifiers on the first day. On the second day of the tournament, the top players from each group played in Tournament A, the second-placed players in Tournament B, the third-placed players in Tournament C, and the fourth-placed players in Tournament D in a knockout format. Doubles were not played in this tournament model. Matches started at 8 a.m. and lasted until 4 p.m. The "No-let" rule applied to all matches, meaning that a let (a ball touching the net during a serve) was not called, and the game continued (HTS, 2020).

The research was conducted by measuring the start of each match, i.e., the time from the first serve to the last completed point. Warm-up and preparation for the match from the moment the players entered the court were not included in the match duration time. However, all breaks and changes of ends between games and sets were included in the time measurement. Also, if the players could not agree on a decision and it was necessary to wait for the referees' decision, the match time continued to run normally and was not stopped or deducted from the game time. Finally, the time of the match's conclusion was subtracted from the match's start time, and the resulting number in minutes was recorded in the table and compared between genders.

Statistical analysis

In order to be able to adequately present results the following statistical data processing was done in the Statistical Package for Social Sciences (SPSS for Windows®, version 26.0). Descriptive statistics [average value (Mean), standard deviation (SD), median (Med), minimum (min) and maximum (Max)] were summarized for all variables. Independent-Samples t-test was used to determine the differences in duration of game between gender. The significance level was $p<.05$.

RESULTS

The results of descriptive statistics reveal that the duration of matches in the boys' category was, on average, approximately two minutes longer than the duration of matches among girls. The average duration of a single match in the boys' group was 45.53 minutes, whereas in the girls' group, it was 43.31 minutes, as shown in Table 1. The median match duration for boys was 44 minutes, which closely aligns with the calculated average. However, for girls, the median match duration was 33 minutes, indicating that a small number of longer matches skewed the calculated average.

Furthermore, examining the distribution of match durations showed greater variability in the girls' matches, with a wider range of durations, while the boys' matches had a more consistent duration pattern (Table 1). This suggests that girls' matches tended to have more variation in terms of length, possibly influenced by differences in playing styles or strategies.

Table 1. Descriptive statistic for boys matches (n=30) and girls matches (n=16)

Variable	G	N	Mean	SD	Med	Min	Max	Std. Error Mean
Match	boys	30	45,53	14,57	44,00	24	74	2,66
	girls	16	43,31	19,23	33,00	25	79	4,80

Legend: G - gender, **N-** number of matches, **Mean -** arithmetic mean, **SD -** standard deviation, **Med -** median, **Min-**minimum, **Max-** maximum, **Std.Err -**standard error difference, **p≤.05.**

Table 2 shows the gender differences in lasting matches of tennis players from two groups, and it can be seen that there is no statistically significant difference (DURATION= .44). The lasting matches are varying in both categories from 24 minutes to 79 minutes, but at the end they are similar in average.

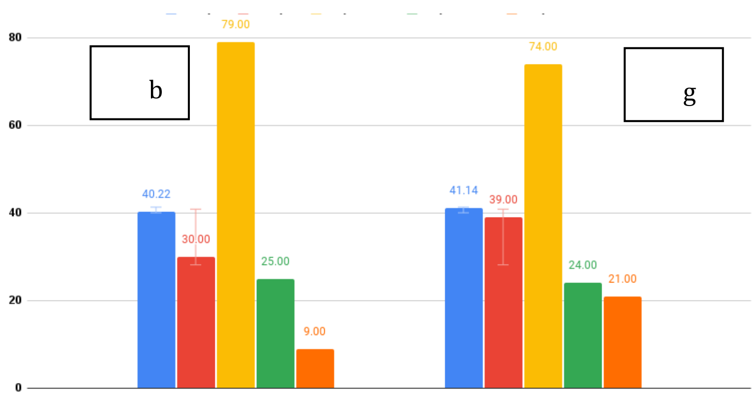
Table 2. Differences in lasting matches between two different groups

Levene's Test for Equality of Variances			T-test for Equality of Means				
F		Sig.	t	Df	Sig. (2-tailed)	Mean	Std. Error
DURATION	3,162	0,082	0,44	44	0,66	2,22	5,04

Legend: F - F test, **Sig.- Mean-** range, **Sig.(2-tailed) -** significance, **Std.Err -**standard error difference, **p≤.05.**

On the first day of the under-12 tournament, the average duration of matches in the boys' category was 41.14 minutes, while in the girls' category, it was 40.22 minutes (see Figure 1). Boys, on average, played 2.29% longer matches than girls. The median match duration for boys stood at 39 minutes, which only slightly deviated from the average match duration. On the other hand, the median match duration for girls was 30 minutes, indicating that only some of them played significantly longer matches than the average. Among the girls, the longest match played lasted 79 minutes, while the shortest was 25 minutes. Among the boys, the longest match played lasted 74 minutes, and the shortest was 24 minutes (Figure 1).

Figure 1. First day results.

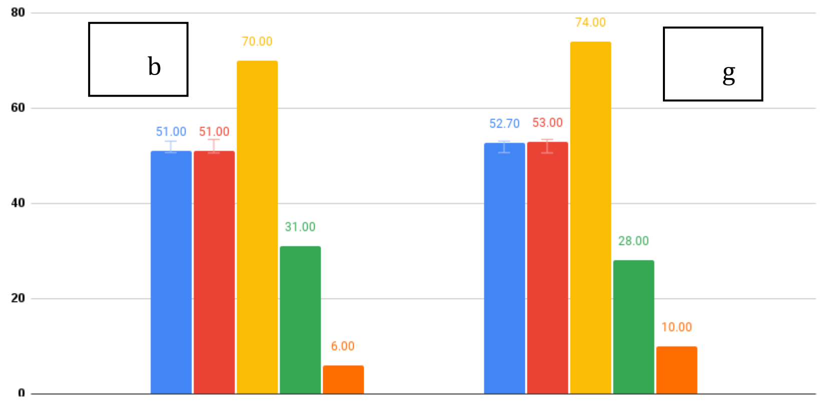


Legend: - mean, - median, maximum - minimum, - matches

On the second day of the under-12 tournament, the average duration of matches in the boys' category was 52.70 minutes, while in the girls' category, it was 51.00 minutes (see Figure 2). Boys, on average, played 3.33% longer matches than girls. The median match duration for boys stood at 53 minutes, which only slightly deviated from the average match duration. On the other hand, the median match duration for girls was 51 minutes. Among the girls, the longest match played lasted 70 minutes, while the shortest was

31 minutes. Among the boys, the longest match played lasted 74 minutes, and the shortest was 24 minutes (Figure 2).

Figure 2. Second day results.



Lege - F - m n, - m an, **i** - ma num - m mum, - matches

Analyzing the data further, we can discern some interesting trends. It appears that there is a wider spread of match durations in both the boys' and girls' categories, suggesting that some matches were considerably shorter or longer than the average (Table 3). This variation could be attributed to various factors, including differences in player skills, game strategies, or the competitiveness of the matches. To gain a deeper insight into the factors contributing to these variations in match duration, it may be beneficial to conduct a more detailed analysis of individual player performance, court conditions, and perhaps even the specific strategies employed during matches. Understanding these nuances can provide valuable information for coaches, players, and tournament organizers, allowing for more tailored training programs and scheduling adjustments in the future.

Table 3. Duration of semifinals and final matches in boys A group

A	TOURNAMENT	-	BOYS		
START	END		START	END	
		SEMIFINAL			FINAL
8:38	9:45	67 min	11:38	12:47	
		3-4(2) 4-0 4-7			69 min
8:37	9:21	44 min			2-4 4-2 7-4
		4-1 4-1			

DISCUSSION

To calculate the total workload of a competitive day, it's essential to consider that in some groups, up to three matches were played, which would amount to 135 minutes of competitive activity. Given that the second day of the competition features elimination rounds, a maximum of two matches can be played, totalling 90 minutes. Therefore, over the course of two competitive days, a junior tennis player under 12 years of age accumulates a total of 225 minutes of playing time.

If we compare the amount of time obtained in this research with competitions in other team and individual sports, it can be concluded that young tennis players spend a lot more time in the competitive mode (Table 4).

Table 4. Playing time of some sport competition under 12

Sport	Playing time
Tennis	225 min
Handball	2x20 min
Football	2x30 min
Basketball	4x7 min
Karate kumite	1,5 - 2 min (2-6 fights)
Judo	2 min

This information clarifies on the physical and mental demands placed on young tennis players during a tournament. It underscores the need for proper conditioning, recovery strategies, and skill development to ensure that young athletes can sustain their performance throughout the competition. Additionally, it emphasizes the importance of age-appropriate training and competition schedules to avoid overexertion and potential injuries among these tennis players. Understanding the workload and its impact on young players is a crucial aspect of their development, ensuring that they can continue to enjoy and excel in the sport while minimizing the risk of injuries or fatigue. Coaches, parents, and tennis organizations should use this data to design effective training programs and tournament structures that support the growth and well-being of young tennis talents.

CONCLUSION

Tennis is a physically demanding sport. Research describing the characteristics of tennis match-play in age group under 12. These investigative efforts have focused on the duration of 46 match-play performed by tennis competitors on one tournament in Croatia ranked from 21st place in girls list and 36th place on boys ranking list.

Based on the obtained results, it can be concluded that there were no statistically significant differences in duration of tennis matches between boys and girls under 12 years. Matches between girls and boys aged 12 are very similar in terms of duration, around 45 minutes. On the second day of tournament matches last a little bit longer, 52-55 minutes on average. This research can contribute to further comparisons of game duration in younger age groups. Based on the available literature, future research wishing to investigate and compare duration in match-play tennis in categories under 14, 16 and 18. If we compare tennis with other sports and disciplines in terms of the duration of the competition, it can be concluded that young tennis players at the age of 12 spend significantly more time in the competition itself, 225 minutes. Furthermore, coaches can utilize this data in their ongoing work with children, aiding in their preparation for upcoming training sessions and tournaments. The findings of this study provide valuable insights into the equality of competition duration between young girls and boys in the under-12 category. Coaches and organizers can use this information to plan tournaments more effectively, ensuring equitable playing time for all participants and creating a supportive environment for young athletes to develop their skills and enjoy the sport. This research may serve as a foundation for future investigations into other aspects of youth tennis, further enhancing the sport's development and nurturing the talents of young players.

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IMPLICATIONS OF AGE AND GENDER DISPARITIES IN STRENGTH TRAINING AMONG CHILDREN AND ADOLESCENTS

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ABSTRACT

When designing a strength training program, a physical fitness expert must take into account gender differences in muscle capabilities, the level of fitness, as well as the effects that these differences have on each individual. The aim of this study was to determine the implications of age and gender differences in strength training for children and adolescents. A review of studies was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). The following databases were used for literature search: Google Scholar, Medline, Science Direct, PubMed, Web of Science, and Research Gate. A total of 68 studies met the defined criteria for inclusion in the systematic review and further analysis. Numerous osteogenic benefits and essential factors of physical activity contribute to the growth and development of the skeletal system in boys and girls during this age period. Children who regularly engage in physical activities involving their body weight and participate in exercise programs that include strength training with external resistance experience an increase in bone density. Participation in such programs during the preadolescent period allows boys and girls to achieve strength gains and other abilities greater than the ordinary gains resulting from growth and maturation. Recent research has clearly shown that if the volume and intensity of exercise are appropriate for their age, boys and girls can increase muscle strength beyond the limits achievable through mere growth and maturation.

Keywords: exercise, strength, training, children, adolescents, individually or in combination.

INTRODUCTION

When designing a strength training program, a physical fitness expert must take into account gender differences in muscle capabilities, the level of fitness, as well as the effects that these differences have on each individual. Children do not grow at a uniform pace, and there are significant differences in physical development at each chronological age due to various factors. In a population of 14-year-old children, there can be a difference in height of up to 23 cm and a difference in body weight of 18 kg. Furthermore, an 11-year-old girl may be taller and physically more capable than a boy of the same age (Lloyd, Oliver, Faigenbaum, Mayer, & De Ste Croix, 2014). This is due to the onset of puberty, which varies between boys and girls (starting significantly earlier in girls), causing some of them to have a biological age that differs from their chronological age by several years. Since the level of maturation is related to the degree of overall physical preparedness, which includes the development of motor skills and muscle strength (Katzmarzyk, Malina, & Beunen, 1997), techniques used to assess the degree of maturation allow children to be assessed for motor abilities not solely based on chronological age. During the period of rapid growth and development, in males, muscle mass increases rapidly (from 25% at birth to 40% after maturation) due to increased testosterone hormone production (Malina, Bouchard, & Bar-Or, 2004), while in females during this period, due to increased estrogen production, the amount of body fat increases (which is stored in the pelvic, thigh, and breast areas), and the increase in muscle mass occurs continuously but at a slower rate (Malina, Bouchard, & Bar-Or, 2004). In this pubertal period, which occurs around the age of 12 for girls and around the age of 14 for boys, changes in muscle imbalances and relative tightening of muscle-tendon units covering rapidly growing bones are often observed, which represents potential risk factors for injury during high physical stress (Micheli, 1991; Mayer, Ford, Divine, Wall, Kahanov, & Hewett, 2009; Van der Sluis, Elferink-Gemser, Coelho-e-Silva, Nijboer, Brink, & Visscher, 2014). Excessive stress and the vulnerability of developmental cartilage to trauma are primary concerns with children (Hewett, Myer, & Ford, 2005), as such injuries can cause permanent growth and development disturbances. To prevent such damage during this period, it is necessary to modify the training program and adapt it to these age characteristics. Therefore, it is essential to exercise correctly under the supervision of a physical fitness expert who will pay attention to proper movement technique and safety measures when performing weighted exercises (Kahrović, Murić, Radenković, 2019). The aim of this study was to determine the implications of age and gender differences in strength training for children and adolescents.

METHODS

A review of studies was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). The following databases were used for literature search: Google Scholar, Medline, Science Direct, PubMed, Web of Science, and Research Gate. The search was performed using the following keywords: exercise, strength, training, children, adolescents, individually or in combination. The search strategy was adapted for each database where possible to increase sensitivity. The selection of studies was performed using inclusion and exclusion criteria. The search and review of studies were conducted by four authors, and data quality assessment was performed by two authors.

To identify relevant studies and exclude irrelevant titles during the electronic search, authors initially screened all titles. In the initial screening, 194 potentially eligible studies were identified. To decide whether to include studies in the systematic review and undergo a review by all authors, studies had to meet specific criteria. For studies to be included in the final analysis, they had to be written in English, test at least two groups of participants (1 experimental + 1 control), be original reports of scientific studies, and involve children and adolescents of both genders as participants. Exclusion criteria for studies from further analysis were studies written in languages other than English, inadequate participant samples, absence of a control group, results presented inadequately, or missing parameters necessary for further analysis. Descriptive methods were used for data analysis. All authors reviewed the selected studies systematically, and a final check was performed by two authors.

RESULTS

Through the electronic database search, a total of 194 relevant studies published in English were identified. After removing duplicates, the number of studies was reduced to 115. Out of these, 16 studies were excluded based on the review of titles and abstracts, 15 studies were excluded due to inadequate sample sizes, 11 studies were excluded due to inadequate outcome data, and 5 studies were excluded due to an inadequate number of participants. A total of 68 studies met the defined criteria for inclusion in the systematic review and further analysis. The overall sample size comprised 1,344 participants, including 624 females and 720 males. Among the 68 studies that met the inclusion criteria for the systematic review and further analysis, 63 studies included both male and female participants, three studies included only boys, and one included only girls. In children subjected to programmed strength training with external resistance for a duration of 8 to 12 weeks, improvements were observed in specific motor skills such as long jump, vertical jump, 30-meter sprint, and agility (Behringer, von Heede, Matthews, & Mester, 2011; Faigenbaum, Farrell, Fabiano, Radler, Naclerio, Ratamess, Kang, & Myer, 2011; Falk, & Mor, 1996; Weltman, Janney, Rians, Strand, Berg, Tippet, Wise, & Katch, 1986). Increasing muscle capabilities is considered the foundation for long-term physical development, as a certain level of force production is required to acquire specific movement skills (Faigenbaum, Lloyd, Myer, 2013; Lloyd, Cronin, Faigenbaum, 2016). To expedite skill development and prevent injuries, children are recommended to participate in specific muscle strengthening programs (Faigenbaum & Westcott, 2009). Participation in strength training programs for youth not only increases muscle strength and endurance but also affects various other health and fitness-related measures (Lloyd, Faigenbaum, Stone, Oliver, Jeffreys, Moody, 2014; Smith, Eather, Morgan, Plotnikoff, Faigenbaum, Lubans, 2014). This type of activity can alter certain anatomical and psychosocial parameters, reducing the risk of injuries for athletes and recreational participants (Valovich-McLeod, Decoster, Loud, Micheli, Parker, Sandrey, & White, 2011), improving motor skills (Behringer, von Heede, Matthews, & Mester, 2011; Faigenbaum, & Schram, 2004;), increasing bone density (McKay, MacLean, Petit, MacKO´Brien, Jansen, Beck, & Khan, 2005; Morris, Naughton, Gibbs, Carlson, & Wark, 1997; Nichols, Sanborn, & Love, 2001), and thus enhancing athletic performance in competitions. Various strength training programs, in addition to improving muscle fitness and bone density, reduce cardiovascular risk factors (Faigenbaum, Lloyd, MacDonald, Myer, 2016; Lloyd, Faigenbaum, Stone, 2014; Smith, Eather, Morgan, Plotnikoff, Faigenbaum, Lubans, 2014). Children who do not engage in physical activities have poorer motor skills (Fransen, Deprez, Pion, 2014). The difference in coordination (one of the most crucial motor skills) is increasing between active, normal-weight children and physically inactive obese children (D'Hondt, Deforche, Gentier, 2013). There is a declining trend in children meeting recommended levels of physical activity (Tremblay, Gray, Akinroye, 2014). Low levels of physical activity result in obesity (Katzmarzyk, Barreira, Broyles, 2015), which hinders the development of high levels of muscle fitness. If motor skills are not improved and muscle strength is not increased in early childhood, children may become less physically active and more susceptible to certain diseases after maturation (Faigenbaum, Lloyd, Myer, 2013). There is no relevant scientific research indicating that programmed physical exercise in adequately nourished boys and girls delays or slows their growth or level of maturation (Malina, 1994; Falk, & Eliakim, 2003). Strength training for children is an effective and safe method of physical preparation (Behm, Faigenbaum, Falk, & Klentrou, 2008; Blimkie, 1993; Faigenbaum, 2000; Faigenbaum, Kramer, Blimkie, Jeffreys, Micheli, Nitka, & Rowland, 2009; Faigenbaum, Milliken, Moulton, & Westcott, 2005; Faigenbaum, & Myer, 2010; Falk, & Tenenbaum, 1996; Lloyd, & Oliver, 2012). Older studies did not show an increase in muscle strength levels among preadolescents who participated in strength training programs (Docherty, Wenger, Collis, & Quinney, 1987; Hetherington, 1976;). However, more recent research has clearly demonstrated that boys and girls can increase muscle strength beyond what can be achieved through growth and maturation alone, provided that the intensity and volume of training are appropriate (Faigenbaum, & Mediate, 2006; Faigenbaum, Milliken, La Rosa-Loud, Burak, Doherty, & Westcott, 2002; Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997; Pfeiffer, & Francis, 1986; Ramsay, Blimikie, Smith, Garner, & MacDougall, 1990; Weltman, Janney, Rians, Strand, Berg, Tippet, Wise, & Katch, 1986).

DISCUSSION

There are numerous osteogenic benefits and essential factors of physical activity in the growth and development of the skeletal system in boys and girls during this age period, especially activities involving their own body weight or external resistance (Vicente-Rodriguez, 2006). During the growth and development of children, there is an increase in muscle mass, leading to an increase in muscle strength. The growth curves of muscle strength during preadolescence and adolescence in boys and girls are similar. During this period of rapid growth and development, muscles or muscle groups first increase in muscle mass and then in the ability to generate a significant force (Buenen, & Malina, 1988). This is supported by the results of a meta-analysis indicating that adolescents, compared to children, achieved a 50% greater increase in muscle strength (Behringer, von Heede, Yue, & Mester, 2010). The greatest increase in strength in girls also occurs at the end of the rapid growth and development phase, although girls exhibit larger individual differences in the relationship between strength and height and strength and body mass compared to boys (Malina, Bouchard, & Bar-Or, 2004). Regardless of the fact that muscle strength levels are nearly identical in boys and girls during preadolescence, hormonal differences that manifest during puberty are responsible for the rapid increase in muscle strength in boys and the plateauing of muscle strength in girls (Lloyd, Faigenbaum, Stone, Oliver, Jeffreys, Moody, 2014; Malina, Bouchard, & Bar-Or, 2004). Another crucial factor in the expression of muscle strength in children is the development of the central nervous system. Skillful and coordinated movements and quick reactions cannot be successfully executed without the presence or complete mineralization of motor neurons (nerve fibers). Children should not be expected to achieve the same level of skill as adults in response to training stimuli or to react in the same way because motor neuron mineralization is incomplete until sexual maturity (Kraemer, Fry, Frykman, Conroy, & Hoffman, 1989). A carefully designed strength training program during early childhood, characterized by rapid changes in the central nervous system, can have long-lasting positive effects (Myer, Faigenbaum, Edwards, Clark, Best, Sallis, 2015). Physiological functions are closely linked to biological age relative to chronological age. Children who mature earlier have greater muscle mass, absolute strength, and a more muscular appearance, whereas children who mature later tend to be leaner and taller (Malina, Bouchard, & Bar-Or, 2004). Although in the past, many experts (doctors, coaches, and sports scientists) as well as parents were concerned that strength training in children could disrupt normal bone development and stunt growth, it is now widely agreed that strength training for children is an effective and safe method of physical preparation (Behm et al., 2008; Blimkie, 1993; Faigenbaum, 2000; Faigenbaum et al., 2009; Faigenbaum, et al., 2005; Faigenbaum, & Myer, 2010; Falk, & Tenenbaum, 1996; Lloyd, & Oliver, 2012). Children should be involved in strength training programs tailored to their individual goals and at a level and intensity that aligns with their age. Additionally, strength training should be adapted to their maturity (biological age) and their level of fitness. Most leading medical and sports organizations worldwide support children's participation in various strength training programs, provided that these programs are adequately designed, age-appropriate, and supervised by experts (British Association of Exercise and Sport Sciences, 2004; American Academy of Pediatrics, 2008). It is essential to emphasize that strength training programs designed for adults should not be applied to youth because the intensity and volume of training are too demanding, and the recovery time between training episodes is too short to allow for proper adaptation. Care must be taken because children are physically immature and not just smaller versions of adults, and overestimating their current capabilities, regardless of how large and strong they may be, will increase the risk of injury and lead to long-term health issues. Strength exercises that are tailored to age and fitness level, in addition to increasing muscle strength, also improve bone density and strength (Society of Health and Physical Educators, 2014). Since muscle strength naturally increases from childhood through the teenage years to full maturity, progress achieved through short-term, low-intensity, and low-volume strength training cannot be distinguished from progress attributed to normal growth and maturation. Older studies did not show an increase in muscle strength levels among preadolescents who participated in strength training programs (Docherty et al., 1987; Hetherington, 1976). While an insufficient amount of evidence can be attributed to methodological shortcomings, such as inadequate training volume or intensity and the short duration of the study, as a form of evidence that strength training is not an effective training method for children, the results of these studies are still often cited. Recent research has clearly demonstrated that boys and girls can increase muscle strength beyond what can be achieved through mere growth and maturation if the intensity and volume of training are adequate (Faigenbaum, & Mediate, 2006; Faigenbaum et al., 2002; Faigenbaum et al., 1993; Lillegard et al., 1997; Pfeiffer, & Francis, 1986; Ramsay et al., 1990; Weltman et al., 1986). In contrast to adults, assessing the degree of strength change in children, due to the simultaneous growth and development process, is very complex. Nevertheless, scientific study data suggest that the strength gains resulting from training interventions during the detraining period are unstable and decline to the level of the control group (Faigenbaum, Westcott, Micheli, Outerbridge, Long, La Rosa-Loud, & Zaichkowsky, 1996; Ingle, Sleap, & Tolfrey, 2006; Tsolakis, Vagenas, & Dessypris, 2004). Changes in muscle hypertrophy significantly contribute to the increase in muscle strength resulting from exercise in adolescents and adults. For preadolescents, it is uncertain whether muscle hypertrophy is primarily responsible for the increase in muscle strength due to training (Ozmun, Mikesky, & Surburg, 1994; Ramsay, Blimikie, Smith, Garner, & MacDougall, 1990). It is not possible to conclude whether muscle hypertrophy occurs in preadolescents as a result of strength training without presenting objective scientific facts. Studies with more precise measurement techniques, longer duration, and a larger scope are necessary to detect potential muscle hypertrophy resulting from youth training. Furthermore, as years pass, the angle of muscle fiber pennation increases (Ormsbee, Pdaro, Ilich, Purcell, Siervo, Folsom, & Panton, 2014), but it is unclear whether strength training can change muscle in this way without a significant increase in overall muscle mass. During the period of intense growth and development, strength gains induced by training are associated with muscle hypertrophy due to hormonal influences. In adolescent girls, other growth factors (growth hormone and insulin-like growth factor) are responsible for muscle development, although lower testosterone levels compared to adolescents limit the size of muscle hypertrophy resulting from training (Kraemer, 1988). Studies have shown that in children who regularly engage in physical activity involving body weight resistance and participate in a strength training program with external resistance, bone density increases (McKay et al., 2005; Morris et al., 1997; Nichols et al., 2001). In addition, authors believe that regular participation in strength training programs in the pre-competitive period increases injury resilience in young athletes (Emery, 2005; Hewett, Myer, & Ford, 2005). Achieving the maximum level of adaptation can be aided by well-planned recovery strategies, such as adequate cooling at the end of training, a carefully prepared meal after a training episode, and quality sleep. Instead of passively raising the legs and placing them in a vertical position in a supine position, young athletes' bodies respond better and recover faster through a combination of active recovery and cold water therapy (Kinugasa, & Kilding, 2009). Adequately prescribed and well-programmed strength training for young athletes is relatively safe compared to activities in other sports disciplines (Hamill, 1994). The belief that strength training is dangerous for children is not in line with the recorded risk and the needs of children, as injuries mostly occurred when instructions, training loads, and supervision levels were inadequate (Faigenbaum, & Myer, 2010), and in situations where safety guidelines for fitness professionals were not followed. In strength training studies for children and adolescents in which participants followed specific guidelines, no serious injuries were reported (Faigenbaum, & Myer, 2010). Furthermore, it has been demonstrated that testing one-repetition maximum (1RM) in young individuals is safe, provided that testing rules and guidelines, such as immediate supervision by fitness professionals, individual load increases, and adequate warm-up time, are followed (Hetzler, DeRenne, Buxton, Ho, Chai, & Seichi, 1997; Kravitz, Akalan, Nowicki, & Kinzey, 2003). To participate in this type of physical activity, such as strength training, since there is no minimum age threshold, children should be emotionally mature enough. In this case, they will meet the demands and solve the tasks set before them (Lloyd, Faigenbaum, Stone, Oliver, Jeffreys, Moody, 2014; Myer, Lloyd, Brent, & Faigenbaum, 2013). The goal of a strength training program for young people should include teaching gym etiquette, promoting a desire for physical activity, educating children about their bodies, and fostering enjoyment and fun. It is very likely that children who engage in sports and enjoy physical activities in their later years will continue to be active (Castro, Crim, Young, Joseph, & Evans, 1995). Fitness professionals should emphasize proper exercise, demonstrate exercise techniques well, and possess the necessary communication skills to relate to children at their level of understanding (Faigenbaum, Lloyd, Sheehan, & Myer, 2013; Lloyd, Faigenbaum, Stone, Oliver, Jeffreys, Moody, 2014). Poor exercise technique can result in excessive strain on musculoskeletal tissues and injury. Therefore, if it is not possible to perform an exercise with proper technique, it is necessary to reduce the level of external resistance and focus on developing the correct technique (Byrd, Pierce, Rielly, & Brady, 2003; Faigenbaum, & Polakowski, 1999)

CONCLUSION

There is no relevant scientific research indicating that programmed physical activity in well-nourished boys and girls delays or hinders their growth or the degree of maturation. Numerous osteogenic benefits and essential factors of physical activity contribute to the growth and development of the skeletal system in boys and girls during this age period. Children who regularly engage in physical activities involving their body weight and participate in exercise programs that include strength training with external resistance experience an increase in bone density. Participation in such programs during the preadolescent period allows boys and girls to achieve strength gains and other abilities greater than the ordinary gains resulting from growth and maturation. Recent research has clearly shown that if the volume and intensity of exercise are appropriate for their age, boys and girls can increase muscle strength beyond the limits achievable through mere growth and maturation. In addition to improving muscle fitness and increasing bone density, strength training programs reduce cardiovascular risk factors. It should be emphasized that programmed strength training designed for adults should not be applied to young individuals because the volume and intensity of such training are too demanding, and the recovery time between workouts is too short to allow for adequate adaptation. Care should be taken because children are physically immature to the extent that slightly reduced adult training cannot be applied to them. Fitness professionals should focus on proper exercise, demonstrate exercise techniques well, and possess the necessary communication skills to relate to children at a level they can understand. Poor exercise technique can lead to excessive strain on musculoskeletal tissues and injury. Therefore, if it is not possible to perform an exercise with proper technique, it is necessary to reduce the level of external resistance and focus on developing the correct technique. The goal of strength training programs for young individuals should also include teaching gym etiquette, promoting a desire for physical activity, educating children about their bodies, and fostering enjoyment and fun.

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DIFFERENCE IN EXPLOSIVE STRENGTH BETWEEN TYPICALLY DEVELOPING CHILDREN AND CHILDREN WITH DEVELOPMENTAL DISABILITIES

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ABSTRACT

The motor skills of children, including strength, speed, flexibility, coordination, precision, balance, and agility, play a crucial role in their physical development and bodily functionality. Children aged 7 to 11 go through a period of rapid development, shaping their motor, cognitive, social, and emotional skills. The aim of this study is to determine if there is a difference in explosive strength between typically developing children and children with developmental disabilities. The sample consisted of 56 participants aged 7 to 12, with an equal number of males and females. The sample included 40 typically developing children and 16 children with developmental disabilities attending the Ivan Štark Center for Education and Training in Osijek. The variables examined included morphological dimensions (height and weight) and three tests of explosive strength (standing long jump, 2kg medicine ball throw, 25-meter sprint). The research results indicate a statistically significant difference in the conducted tests, while there is no difference in morphological characteristics between the two groups.

Keywords: Deficit, motor abilities, differences, students

INTRODUCTION

Motor abilities play a crucial role in the physical development and bodily functionality of children. According to Zaciorski's (1979) definition, motor abilities encompass various aspects of motor activity that can be measured using an identical set of measures. These abilities include strength, speed, flexibility, coordination, precision, balance, and agility. Between the ages of 7 and 11, children go through a period of rapid development, shaping their motor, cognitive, social, and emotional skills.

Explosive strength, defined as rapid and powerful muscle contraction, is essential for performing sudden and vigorous movements such as jumping, sprinting, and striking. Doder and Babiak (2007) emphasize its significance in the development of children's physical abilities, especially in the context of sports activities.

Guth and Roth (2013) investigate the influence of genetics on explosive strength, highlighting the importance of genetic factors and training in shaping these abilities in children.

Children with developmental difficulties may face challenges in developing fundamental motor skills such as walking, running, and throwing. Difficulties in balance, coordination, and other motor skills are often evident. These deficits may begin to be noticed in early childhood but are frequently not recognized until the age of three to five. Providing individualized support and involving children with developmental difficulties in activities tailored to their needs and interests are crucial for their development and progress.

In conclusion, understanding children's motor abilities, particularly explosive strength, is of paramount importance for their physical development. Individualized interventions and support are essential for fostering the development of children with developmental difficulties, enabling them to reach their full potential.

METHODS

Subjects

The sample consisted of 56 children, comprising 40 children without intellectual difficulties and 16 children with intellectual difficulties attending the Ivan Štark Center for Education in Osijek. Out of the total of 56 children, 28 were female, and an equal number of 28 were male.

Table 1 Descriptive Statistics of All Students Who Participated in the Study

	N	**Variable**	**AS±SD (min-max)**
Students	56	Age	9.07 ± 1.35 (7 – 12)
		Height (cm)	137.39 ± 10.69 (120.4- 162.0)
		Weight (kg)	35.92 ± 14.89 (19.4- 81.5)

Procedure

Tests of explosive strength and agility represent an important aspect in assessing the physical fitness of students. The first test, standing long jump, aims to measure the explosive strength of the lower limbs, particularly horizontal jumping. Students stand barefoot on a springboard and perform a forward jump, trying to reach the greatest distance possible. The test is repeated three times to obtain reliable results. The second test, throwing a 2 kg medicine ball, focuses on the explosive strength of the arms. Participants throw the medicine ball by extending their arms forward, emphasizing the importance of maintaining body stability and avoiding sudden backward trunk movements. The test is also performed three times, with marked starting lines and a distance of 8 meters from the throwing point. The third test, the 25-meter sprint, is used to assess agility and explosiveness. Participants sprint at maximum speed for 25 meters between marked lines. This test is also conducted three times to ensure consistent results. It's important to note that all three tests are adaptable in terms of location, allowing for administration in different environments. These tests provide valuable information about the physical fitness of students and help identify their abilities in terms of explosive strength and agility.

Statistical analysis

Dana analysis was performed using the Statistica program for the Windows operating system and in Microsoft Excel 2016, the obtained data were analyzed. Descriptive statistics were calculated for the obtained results in each variable of the participants. To determine the normality of the distribution, the Shapiro- Wilk test was used. The t-test for independent samples was used to determine correlation between variables.

RESULTS

In Table 2 are presented basic descriptive parameters including mean, median, minimum (Min), maximum (Max), variance (Var), standard deviation (Std.Dev.), skewness (Skew), and kurtosis (Kurt). The results of all tests are presented.

Table 2 Descriptive Statistics of Results

Variable	Descriptive Statistics								
	N	Mean	Median	Min	Max	Var	Std.Dev.	Skew	Kurt
AVT (cm)	56	137.39	136.30	120.40	162.00	114.33	10.69	0.36	-0.83
ATT (kg)	56	35.92	30.70	19.40	81.50	221.57	14.89	1.78	2.45
SUDSM (cm)	56	115.87	130.00	0.00	175.00	2397.94	48.97	-1.21	0.76
BM2KG (cm)	56	296.52	325.00	90.00	520.00	11318.11	106.39	-0.11	-0.62
S25M (sec)	56	6.17	5.36	4.33	15.65	5.18	2.28	2.96	9.22

Table 3 shows a statistically significant difference between typically developing children and children with developmental difficulties in the variables SUDSM, BM2KG, S25M ($p < 0.05$). There is no statistically significant difference in morphological characteristics (height and weight).

Table 3 Independent Samples T-Test between Typically Developing Children and Children with Developmental Difficulties

	T-tests; independent samples Group 1: Djeca urednog razvoja Group 2: Djeca s teškoćama u razvoju				
Variable	Mean	Mean	t- value	df	p
AVT (cm)	138.40	134.89	1.11	54.00	0.27
ATT (kg)	34.28	40.01	-1.31	54.00	0.20
SUDSM (cm)	139.15	57.66	8.56	54.00	0.00
BM2KG (cm)	329.63	213.75	4.20	54.00	0.00
S25M (sec)	5.29	8.37	-5.76	54.00	0.00

Tables 4 and 5 confirm a statistically significant difference in all adjusted tests except in morphological characteristics (height and weight) regardless of gender.

	Sex=F T-tests; independent samples Group 1: typicall developing Group 2: developmental difficulties				
Varijable	Mean	Mean	t- value	df	p
AVT (cm)	139.09	134.41	1.00	26.00	0.33
ATT (kg)	34.94	42.24	-1.12	26.00	0.27
SUDSM (cm)	136.24	44.58	6.41	26.00	0.00
BM2KG (cm)	288.33	194.29	2.56	26.00	0.02
S25M (sec)	5.38	9.98	-4.76	26.00	0.00

Table 5. Independent samples T-test between typically developing male children and children with developmental difficulties.

	SEX=M T-tests; independet samples Group 1: typically developing children Group 2: children with developmental difficulties				
Varijable	Mean	Mean	t-value	df	p
AVT (cm)	137.63	135.27	0.53	26.00	0.60
ATT (kg)	33.54	38.28	-0.78	26.00	0.44
SUDSM (cm)	142.37	67.83	5.87	26.00	0.00
BM2KG (cm)	375.26	228.89	4.07	26.00	0.00
S25M (sec)	5.19	7.12	-6.01	26.00	0.00

DISCUSSION

Based on the conducted research, which included 40 typically developing children and 16 children with developmental difficulties attending the Ivan Štark Center for Education in Osijek, attempts were made to determine differences in explosive strength test results between children with developmental difficulties and typically developing children. A statistically significant difference was found in the variables SUDSM, BM2KG, S25M ($p < 0.05$), while no statistically significant difference was observed in morphological characteristics (height and weight). These results are consistent with previous studies that have addressed motor and cognitive functions in children with developmental difficulties.

The relationship between motor performance and executive functions in children with Down syndrome was investigated by Klotzbier, Holfelder, and Schott (2022). It was shown that the associations between cognitive and motor skills vary depending on the specific cognitive and motor skills being studied. This may be relevant to the research as it highlights the complexity of the relationship between motor and cognitive functions in children with developmental difficulties.

The observation of the lack of a statistically significant difference in morphological characteristics may be related to research conducted by Caçola et al. (2016). In their study, it was found that more frequent intervention programs may be more effective in improving motor skills in children with developmental coordination disorder. This suggests that, even though morphological characteristics may not show significant differences, specific interventions could be crucial for improving motor abilities, such as walking on a bench.

The results indicating differences in motor abilities between the two groups of children can be further elaborated upon by the findings of Samara et al. (2022). In their research, a negative impact of motor difficulties on the physical fitness of adolescents was discovered. This may suggest that motor difficulties identified at a younger age could have long-term consequences on physical fitness as children enter adolescence.

CONCLUSION

This research contributes to the understanding of motor abilities in children, focusing on specific differences in explosive strength among different groups. While morphological characteristics, such as height and weight, do not lead to significant differences among groups, the importance of other factors such as socioeconomic status, dietary habits, and individual characteristics of children influencing motor skills is emphasized.

The results highlight the need for targeted interventions to improve the motor abilities of children with developmental difficulties. In addition to enhancing motor skills, such interventions can positively impact self-confidence, social skills, and the overall quality of life for these children.

Despite valuable findings, it is important to consider limitations, including sample size and potential measurement biases. This research sheds light on the challenges faced by children with developmental difficulties and the need for tailored interventions. The importance of inclusive education and individualized programs that consider the specific needs of children with developmental difficulties is emphasized. Extracurricular activities, such as dance and table tennis, can be promoted as therapeutic methods to enhance motor abilities. The significance of educating all stakeholders in a child's life, including teachers and parents, is emphasized to provide adequate support. continuous research and collaboration among experts, including physiotherapists, psychologists, and educators, are crucial for an adaptive approach that accommodates changes in children's development and ensures effective interventions. this research encourages the creation of an inclusive environment that best suits the needs of all children with developmental difficulties and the development of tailored programs that enable them to achieve their full potential.

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EFFICIENCY OF DYNAMIC GAMES AND RELAYS RACE WITH TABLE TENNIS ELEMENTS IN THE DEVELOPMENT OF PSYCHOMOTRICAL SKILLS OF SECONDARY SCHOOL CHILDREN

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ABSTRACT

We considered that table tennis can be used both as a means and as a method. The study carried out by us wanted to show whether the use of specific means of dynamic games and relays with elements from table tennis can contribute to the development of psycho-motor skills by achieving the physical education and sports lesson objectives in a different way. The values of the Student test, the "t" criterion calculated between the results obtained at the initial and final tests indicated statistically significant values for the field of physical education and sports ($p<0.01$) for the components of both groups, but with higher values for experimental group components in all control samples. We consider our hypothesis to be substantiated, in the sense that if on the components of a class in the gymnasium (secondary school) cycle, we will act with a series of means specific to dynamic games and relays with table tennis elements then the level of development of psycho-motor skills will know superior values.

Keywords: dynamic games; relays; table tennis; psychomotor skills

INTRODUCTION

What we know about physical education is well-known and we need only emphasize that those children who practice physical exercise regularly they are not prone to obesity, they have a better quality of sleep, in groups helps young people to improve their teamwork and leadership skills, promotes positive body image in adolescents, teaches children to have improved self-discipline, helps children develop confidence, etc.

Many parents, and not only, emphasize and "push the child" towards the quantity of information and not its quality, towards intellectual activities and less on physical ones. These ideas and concepts should be a thing of the past and yet they are present.

Is it important for children to participate in physical and sports activities at school? Clearly Yes! How do we manage to attract children, constantly looking for new and new methods and means to attract them, coming with pleasure and impatience to "physical education class" Can we do this with table tennis? We considered that table tennis could be used both as a means and as a method. The study carried out by us wanted to show whether the use of specific means of dynamic games and relays with elements from table tennis can contribute to the development of psycho-motor skills by achieving the objectives the lesson of physical education and sports in a different way.

METHODS

The present paperwork starts from the following hypothesis: we believe that if we act on the components of a class in the gymnasium cycle with a series of specific means of dynamic games and relays with table tennis elements, then the level of development of psycho-motor skills will knows superior values.

To validate the hypothesis mentioned above, a battery of tests were performed by the two groups, initially and finally after the introduction of the specific means. The tests were: speed running over a distance of 50 m (AV), raising the trunk vertically, for 30 seconds (RTD), hurdle run (AJ), throwing the OINA ball (AMO), standing long jump (SLL), endurance run - run as hard as you can (AR), shuttle (picking potatoes) (N), coxo-femoral mobility in the anterior plane (MCF) and throwing the ball against the wall (PP).

Throughout the course of the experiment, the members of the control group (CTR), composed of 5th grade B students, carried out their activity within the physical education and sports lessons in accordance with the annual planning. The members of the experiment group (EXP) - 5th grade A had introduces means specific to dynamic games and relays with table tennis elements. The conditions in which the experiment took place were good and relatively similar for the components of both groups, each of the two classes having a gym and specific sports material.

Subjects

The experiment took place during the 2022/2023 school year, between October 2022 and April 2023 at the "Tristan Tzara" Secondary School in the municipality of Moinești, Bacau county, being a comparative pedagogical experiment. 32 students of grades V-A and B., represented the subjects. The students were registered by being given serial numbers, appearing everywhere with these numbers. For the members of the experiment group, a series of means specific to dynamic games and relays with table tennis elements considered highly attractive and efficient for the achievement of the proposed objectives were selected, which were mainly applied in the link of preparing the body for effort and especially, in the realization of the lessons.

Procedure

After carrying out the initial testing (TI), the next stage followed, which had in mind the establishment and introduction within the physical education lessons of the means of action. Examples of means of action used in the experiment:

1. Table tennis preparatory games and relays without specific means. Examples: "Ducks and Hunters", "Life Raft", "The Current", "Number Race", "Seek and Run", "Bouncy Bowling", "Keep the Ball in the Circle", "The Rabbit and the Carrot", "Hokey" , "Rubik's Cube" (fig.1), "Skittle", "Minibasket".
2. Games and relays with tools specific to table tennis (paddle, ball, net, game table). Examples: "Catch the ball", "Follow the circle" (fig. 2), "Ball in the basket", "Ball through the circle", "Carry the bomb"

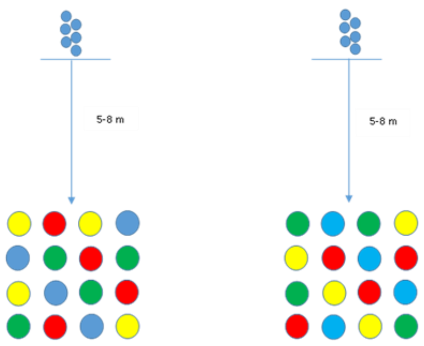


fig.1. "Rubik's Cube"

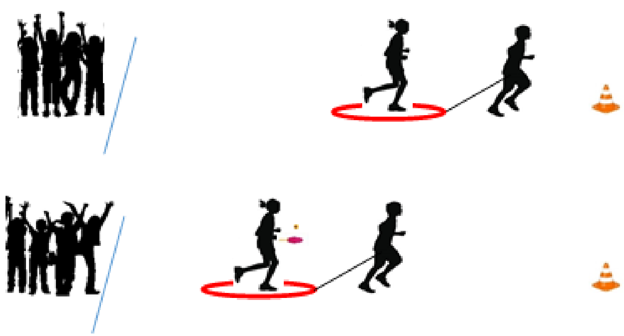


fig.2. "Follow the circle"

After acting with the selected means on the components of the experiment group, the final testing (TF) was performed.

Statistical analysis

Table no. 1. The results obtained by the experimental group members at the initial and final testing

EXP	Arithmetic mean		Standard deviation		Coefficient of variability	
	TI	TF	TI	TF	TI	TF
AV	9,23	8,73	0,34	0,20	3,72	2,33
RTD	28,12	33,84	2,51	2,19	8,91	6,48
AJ	15,49	12,12	1,20	0,89	7,72	7,32
AMO	17,36	21,60	3,26	2,61	18,80	12,10
SLL	151,60	159,08	9,53	8,76	6,29	5,51
AR	5,13	7,29	1,15	0,75	22,41	10,33
N	13,28	10,78	1,96	1,11	14,80	10,27
MCF	24,84	30,68	3,51	3,13	14,12	10,21
PP	16,48	21,76	2,38	2,47	14,46	1136

Table no. 2. The results obtained by the members of the control group at the initial and final testing

CTR	Arithmetic mean		Standard deviation		Coefficient of variability	
	TI	TF	TI	TF	TI	TF
AV	9,24	8,96	0,29	0,22	3,11	2,43
RTD	28,28	31,44	2,21	2,20	7,81	7,00
AJ	15,46	13,67	0,99	0,82	6,42	5,98
AMO	17,24	19,6	2,91	2,29	16,85	11,69
SLL	151,12	155,48	9,48	8,33	6,28	5,36
AR	5,10	6,21	1,09	0,91	21,43	14,59
N	13,30	11,90	1,83	1,37	13,72	11,48
MCF	24,44	28,04	3,18	2,41	13,00	8,58
PP	16,48	20	2,40	1,85	14,56	9,24

RESULTS

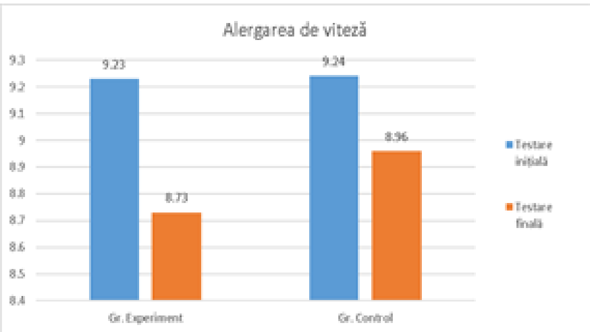


Chart no. 1. Speed running

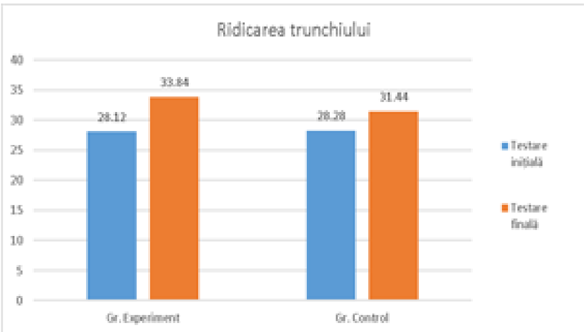


Chart no. 2. Lifting the trunk

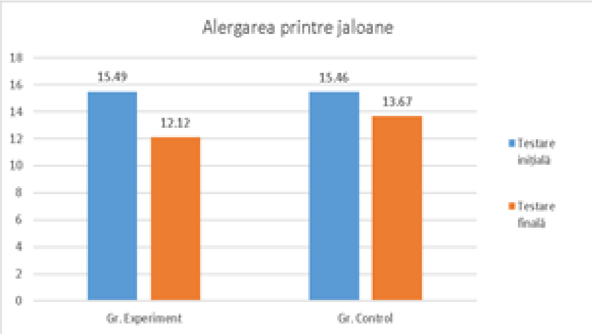


Chart no. 3. Running through the hurdles

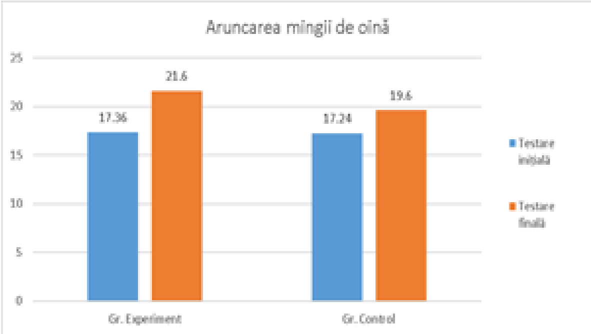


Chart no. 4. Throwing the OINA ball

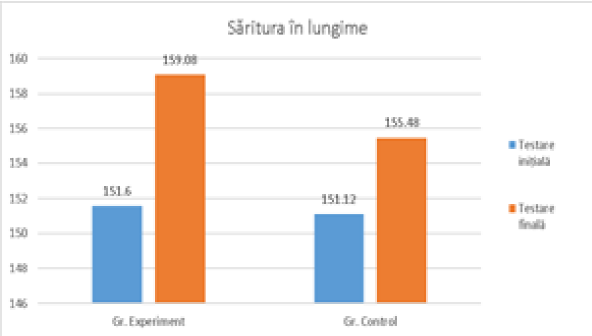


Chart no. 5. Standing long jump

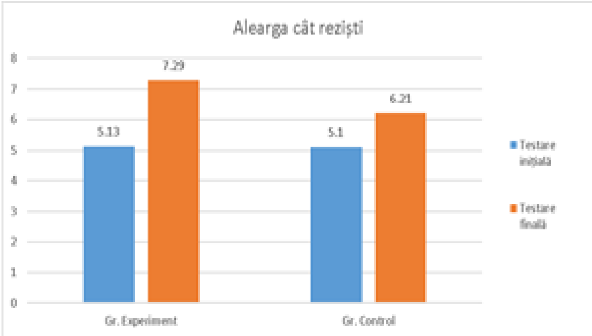


Chart no. 6. Run as long as you can

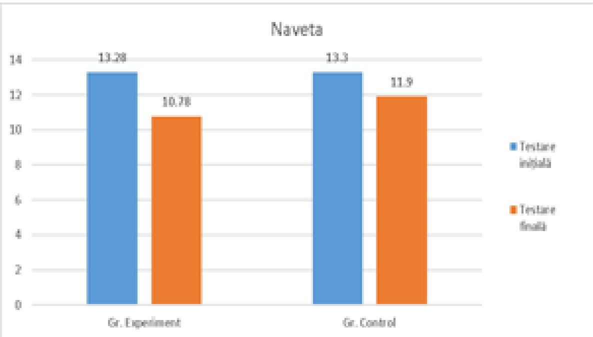
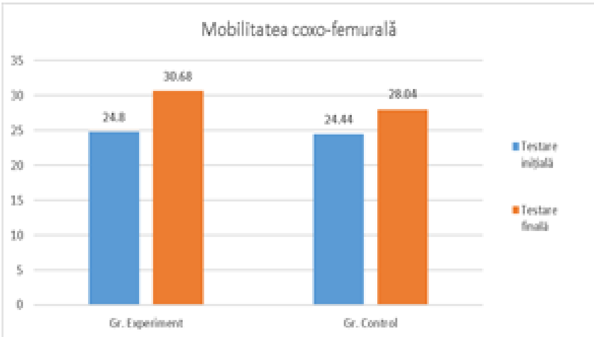


Chart no. 7. Shuttle



Graph no. 8. Coxo-femoral mobility

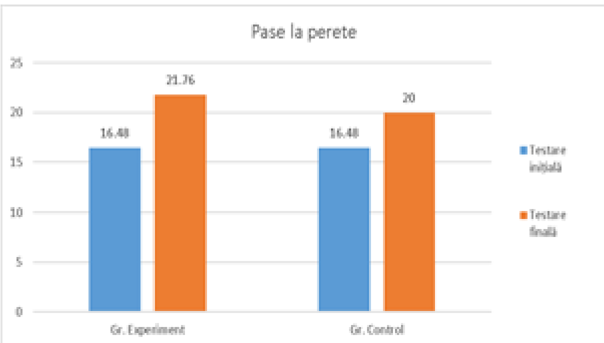


Chart no. 9. Steps to the wall

The performances between the results of the initial testing and the final testing for the components of both groups are at the same threshold of significance, ($p<0.01$), significant for the field of physical education and sports but with higher values for the experimental group

DISCUSSION

During the initial tests, the components of both groups (experiment and control) start from relatively equal values for all control samples, which is highlighted by the arithmetic mean values.

Using elements specific to dynamic games and relays with table tennis elements as means in physical education and sports lessons, we managed to improve basic motor skills. The exercises and means selected and applied by us can constitute a guide, each teacher having sufficient specialized knowledge to find new and as varied means for the development of basic motor skills.

In the final tests within the control tests taken by the members of the two groups subjected to the experiment, the progress recorded by the students in the experimental group is higher than that recorded by the students in the control group.

The superior values of the progress registered by the experimental group members is highlighted by the differences between the initial and final testing, the higher arithmetic mean values for all the control samples for the experimental group members and the superior "t" test results, even if they are at the same threshold of significance .

The values of the coefficient of variability indicate for both groups subjected to the experiment, falling into the three thresholds of homogeneity (high, medium and lack of homogeneity), both within the initial and final tests, which denotes the fact that depending on the control sample , the homogeneity thresholds are different.

The standard deviation values show us a normal distribution of the results around the arithmetic mean in both tests for all control samples (over 68% of cases).

The values of the Student test, the "t" criterion calculated between the results obtained at the initial and final tests show statistically significant values for the field of physical education and sports ($p<0.01$) for the components of both groups, but with higher values for experimental group components in all control samples.

CONCLUSION

We consider our hypothesis from which we started at the time of initiating this study to be justified. If on the components of a class in the gymnasium cycle, we will act with a series of means specific to dynamic games and relays with table tennis elements, then the level of development of psycho-motor skills will know superior values.

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MATERIAL AND SPACE EQUIPMENT OF PRIMARY AND SECONDARY SCHOOLS FOR THE IMPLEMENTATION OF PHYSICAL EDUCATION TEACHING

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ABSTRACT

Physical education classes are in educational and extracurricular process significantly different from other school subjects, first by intensive motor activity of students. Physical education classes are held in very different conditions and hence with different results. The goal of this study was to research material and space conditions of primary and secondary schools, which condition the planning, and the realisation of programme contents of Physical education classes.

For the categorization of school building a six level scale was applied (Petrovic et al., 1995). The sample consisted of 30 primary schools with 15524 students and 25 secondary schools with 20172 students from the region of Sumadija and Pomoravlje.

The greatest number of primary and secondary schools with their material space equipment belong to the third and the fourth category. Only 30.01% of observed primary schools and 40.00 % of secondary schools belong to the first and the second category where teachers can plan and realise all Physical Education programme contents.

The fact that worries is that only 20.00 % of primary and 40.00 % of secondary schools have a big gym for Physical Education, while not all other schools have even outdoor courts. The courts in primary schools have mostly concrete floor, while in secondary schools, asphalt floor. The realisation of programme contents in athletics is partially conditioned by contemporary situation that only 10.00 % of primary and 8.0 % of secondary schools have athletic 200-metre lane, long jump pit, and shot put court. A very small number of schools has free space. The problem also exists with equipment storage room, changing rooms and teachers cabinets. The general conclusion is that the situation in schools has not been changed since 1995. The equipment of school buildings for the Physical Education classes demands attitudes and the participation of students in the realisation of programme contents of Physical Education classes.

Key words: material space conditions, primary school, secondary school, Physical Education class

INTRODUCTION

Teaching is learning according to certain (teaching) plans and programmes and (with direct or indirect) help of a teacher, that is upbringing which is realised under (direct or indirect) management of a teacher by the determined teaching plans and programmes (Bakovljev, 1988: 5-6).

Physical education teaching is based on theoretical basis of Physical Education and theory of upbringing, so that "Physical Education teaching is a unique educational process which demands all strengths and abilities of students, their personality as a whole and their integral development" (Berkovic, 1978: 15).

Note: *This research was funded by the Ministry of Science, Technological Development and Innovation (Contract No. 451-03-47/2023-01/ 200140).*

Physical education teaching is by its characteristics, except for physical exercising (exercise contents) similar to the teaching in general. Three essential characteristics in teaching are that students acquire knowledge, skills and habits that by teaching psychological and physical abilities are developed, that they are developed in versatile way. The structure of teaching process is made up of basic elements: organization, knowledge processes, psychological processes and methodic (Visnjic et al., 2004: 288). In Physical Education teaching by three methodic factors – a student, a teacher and teaching material, one additional factor appears, and that is extensive material basis for Physical Education teaching, which is not the case in the teaching of other subjects in school. The development and the advance of Physical Education teaching imply planned and constant investment in material-space conditions.

Physical Education teaching is set in very different conditions, and hence with different results. The orientation is greater to group team sports, while gymnastics and athletics are neglected. Most of Physical Education lessons are held in the presence of several classes, especially with the students of younger school age (Budja, 1996).

By the analysis of the findings about the school buildings for the Physical Education lessons in 90 primary and secondary schools in Severnobacki and Zapadnobacki regions, Petrovic et al (1995) stated that out of the examined schools only the third of them has the buildings which are close to the norms. The results enabled the categorization of six qualitative levels, so that the first category of the buildings has – sports hall – whose minimal surface was formed according to the dimensions of a basketball court (min. 450 m^2). = small hall (min. 150 m^2) or adapted space of the same dimensions; - outdoor courts for handball, basketball and volleyball; - free space; - space for athletics (round 200 m track for running, jumping pit, shot put place); at least two dressing rooms with sanitation (bathroom and toilet); - equipment room and – teacher office. This category of buildings provides the ability for the realization of all tasks and contents of Physical Education teaching programme.

In the first and the second category of the buildings it is possible to realize all tasks and contents of educational programmes. In the sixth category of the buildings, the building for the Physical Education teaching does not exist, there is eventually adapted space. The realization of teaching programme in such a school building is not possible. Markovic (2016) gets similar results where general image of primary and secondary schools direct to the statement that the third category of the buildings is the most frequent. In this category of the buildings some contents of Physical Education teaching do not have material basis.

Nikolic (2002) stated that on research sample of school buildings for the Physical Education teaching there is no compliance of the conditions for the realization of Physical Education teaching according to the norms. The qualities of the working conditions are first of all for material, technical and spacious conditions and their equipment. They have to be complied to the age, programme demands and predicted activities (Subic, 2016). Out of 280 primary and secondary schools in Belgrade, about fifty of them do not have sport hall, and the average age of the equipment in those schools which have sport halls is about 30 years (Markovic, 2017). Technical accuracy of the buildings, equipment is not in the function of efficient but safe exercising of students (Kragujevic, 2005).

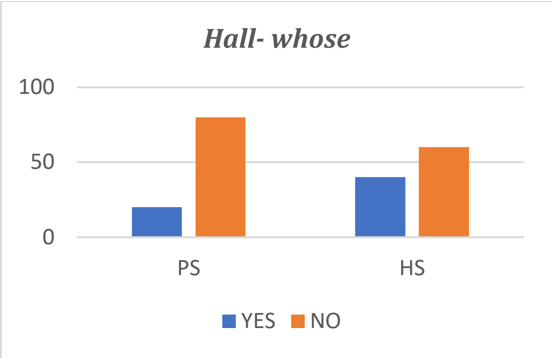
The attitudes of our most eminent methodics experts of Physical Education show that safety measures are obligatory during Physical Education lessons and they are: health –hygienic measures, the control of the technical accuracy of the equipment, exercise tools and the exercise field itself, keeping and helping and order and discipline during the realization of the exercise process (Krsmanovic and Berkovic, 1999; Rodic, 2000; Visnjic et al., 2004; Kragujevic, 2005; Milanovic et al., 2008).

METHODS

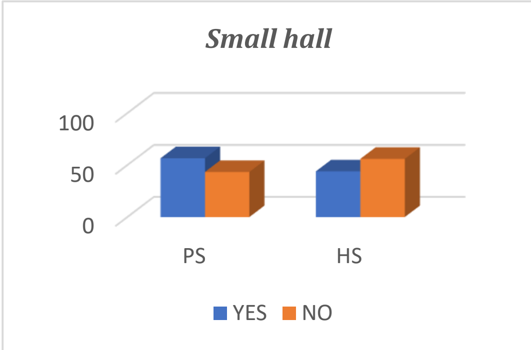
This research was realized in thirty primary and twenty five secondary schools (31 town schools), which are situated on the territory Sumadijski and Pomoravski. The physical education lessons was realised by 30083 students in primary schools and 21904 stdeunts in secondary schools. For the research of material-technical spacious conditions the instrument Petrovic et al., was applied (1995). The instrument was filled by teachers and professors of physical education. In the frame of quantitave analysis of the data percentual research of frequencies was applied.

RESULTS

The results indicate that out of 30 primary schools there is the big sport hall with the dimensions of basketball court in only six of them (20.00%), and out of 25 secondary school ten school have big sport hall (40.00%), which indicates that secondary schools have bigger incidence of big sport halls 20.00% (Graph 1).



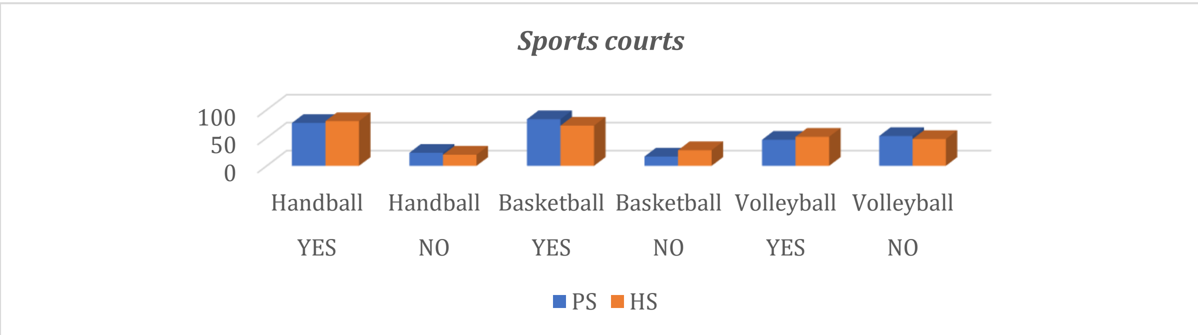
Graph 1. Hall- whose minimal basketball court (min. 450 m ^{2});



Graph 2. Small hall (min. 150 m ^{2}) or adapted spaces with dimensions

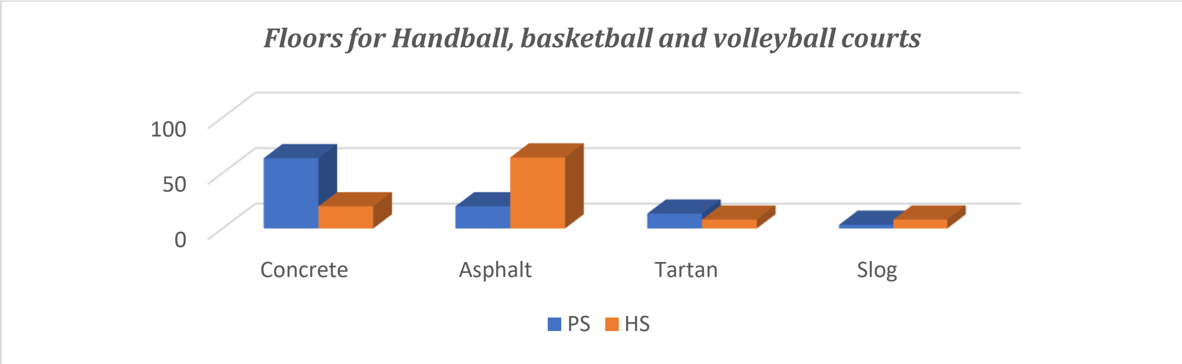
Small sport hall (minimal dimensions of 150m^2) is present in primary and secondary schools in relation to small sport hall. Out of thirty primary schools seventeen schools (56.64%) have a small sport hall. which is for 36.6% more in relation to a big sport hall. Out of twenty-five secondary schools fourteen of them do not have small sport hall (56.00%).

This can be explained by the frequency of village schools, some primary and secondary schools which use town sport hall for the realization of Physical education lessons or several schools which use one sport hall for Physical Education lessons (Graph 2).



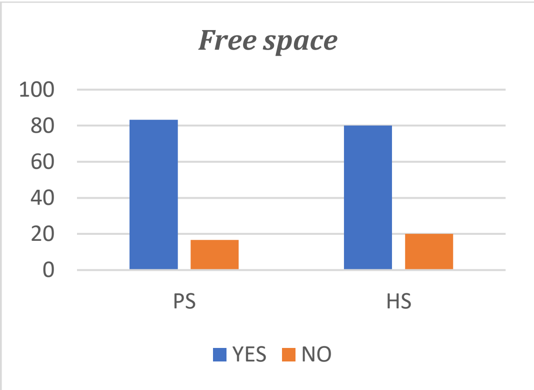
Graph 3. Handball, basketball and volleyball courts

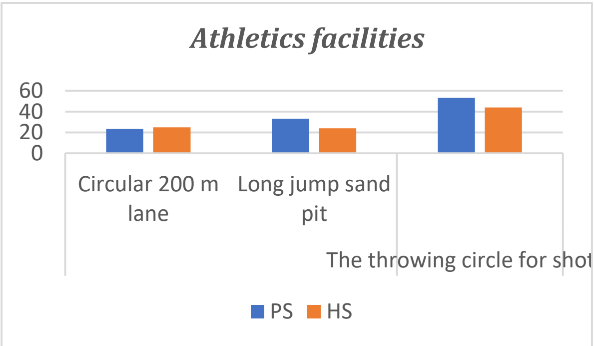
The presence of sport courts differs, so that there are handball courts with dimensions 40 x 20 m^2 in 76.67% of primary and in 80.00% of secondary schools. The presence of the courts can be explained by the action in the eighties of the previous century "*no school without sport court*". Basketball courts are for 11.33% more present in primary schools, so that 83.33% of primary and 72.00% of secondary schools have outdoor basketball courts which are used not only by students but also by citizens in their free time, when there are no Physical Education lessons. The volleyball courts in relation to handball and basketball courts are less present in primary schools (46.66%) and secondary schools (52.00%). Outdoor courts for volleyball are for 5.34% more in secondary schools. The smaller presence of volleyball courts can be explained by insufficient school space, so that handball court is built in the first place which is also used for pitch football, and which can be transformed into two volleyball courts (Graph 3).



Graph 4. Floors for Handball, basketball and volleyball courts

The thing that is encouraging is a high percent of concrete base on handball, basketball and volleyball courts, which are in primary schools 63.33% and in secondary schools 20.00%. Asphalt surfaces are represented in primary schools by 20.00%, and in secondary schools by 64.00%. Fields with a tartan surface are scattered in 13.33% of primary and 8.00% of secondary schools. The surprising thing is one court in primary school and two courts in secondary schools with slag floor. Outdated concrete base floors on the courts are frequent cause of student injuries during Physical Education lessons (Graph 4).



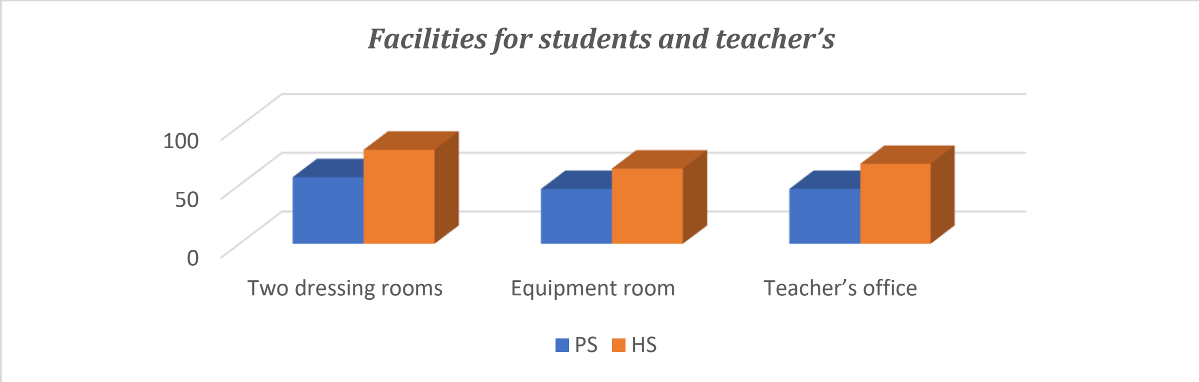


Graph 5. Free space

Graph 6. Athletics facilities

Before and after school and during lessons which are not held, the students spend their time most often in school yard (free space of a school building). Free space or school yard has 83.33% of primary and 80.00% of secondary schools. Free space is for 3.33% more present in primary schools. (Graph 5).

After stated small number of school sport halls, the worrying thing is a small presence of buildings for the realisation of athletics programme contents. Each school should have round 200 m or 400 m running track, or several 80 m tracks for training and exercising of running events, long jump pit, and place for shot put. The smallest presence is for the running space, so that only 23.33% of primary and 25% of secondary schools have these courts. Long jump pit is more present in primary schools for 9.33% more, as well as shot put place for 13.33% in primary schools (53.33% primary and 44.00% secondary schools) (Graph 6).



Graph 7. Facilities for students and teacher's

The presence of dressing rooms is directly conditioned by the presence of a small or a big sport hall, eventually adapted space. In places where dressing rooms do not exist, they usually use classrooms for changing of students before and after the lessons. The presence of dressing rooms is more present in secondary schools (80.00%) in relation to primary schools (56.67%). The same situation is with equipment storage rooms, which are also for 17.37% more frequent in secondary schools. Minimal space for the equipment room for small sport halls is 30m^2, and 50m^2 for a bigger sport hall. Insufficient material technical conditions do not let the realisers of programme contents of Physical Education to have their own office. So that 53.33% primary and 32% of secondary schools for their teachers do not have adapted space for the time before, during and after Physical Education lessons (Graph 7).

Table 1. Categorization of primary and secondary schools according to material-technical conditions

Space	Primary schools		Secondary schools		Total	
	n	*%*	*n*	*%*	*n*	*%*
I Category	4	13.33	5	20.00	7	12.72
II Category	5	16.67	5	20.00	10	18.18
III Category	12	40.00	6	24.00	18	32.72
IV Category	5	16.67	6	24.00	11	20.00
V Category	3	9.99	1	4.00	4	7.27
VI Category	1	3.33	2	8.00	3	5.45

On the basis of these indicators the categorisation of primary and secondary schools shows that the first category is made up of 13.34% of primary schools and 20.00% of secondary schools. The second category is made up of 16.67% of primary and 24% of secondary schools. The third category is the most frequent with 40.00% of primary schools and 24% of secondary schools. The fourth category is present with 16.67% of primary and 24.00% of secondary schools. The smallest presence is for primary schools in the sixth category where only one school. The same situation is for secondary schools where only one school belongs to the fifth category. The first and the second category are made up of 30.00% of primary schools and 40.00% of secondary schools in which it is possible to realise tasks and programme contents.

DISCUSSION

The contents of Physical Education and extracurricular activities are realised in different material-space conditions (Ackovic, 1988, & Brajkovic 1998). On the basis of the results from thirty primary schools and twenty five secondary schools there is a lot to improve so that the planned contents of Physical Education teaching could be realised in larger scale. The Physical Education programme is organised in such a way that more than 60% of the programme is connected with the work in sport buildings, where several classes have lessons at the same time (Milanovic, 2000; Nikolic, 2009). The frequency of small and big sport halls does not allow the realisation of all contents planned by the programme. The solution is a more flexible programme, giving the possibility to schools with consent of certain Ministry of Education services, to change and adapt the programmes to material, teaching and other conditions of certain schools. In schools in the city of Belgrade the situation with sport halls is not better, since in schools on the territory of the city of Belgrade there are only 47.90% of school which have sport hall for Physical education (Nikolic, 2009).

The first two categories of buildings enable planning, programming and realisation of all contents of physical education. The norm is one sport hall for school with sixteen classes, and for school with more sixteen classes two sport halls, in fact a sport hall and a smaller room for gymnastics and corrective-pedagogical work. There are no smaller sport halls in 43.40% of primary schools and in 56.00% secondary schools. The situation with outdoor courts for sport games is encouraging, so that 23.33% of primary schools and 20.00% of secondary schools do not have handball court, football pitch), 16.67% of primary schools and 28.00% of secondary schools do not have basketball courts and 53.34% of primary schools and 48.00% of secondary schools do not have volleyball court. The concrete base is the most frequent in primary schools and asphalt base on the courts in secondary schools. Recent researches indicate that the best results are achieved on asphalt base in running with or without change of direction (Markovic and Visnjic, 2008a,b). Different bases, apart from the quoted conditions, have influence on locomotor apparatus, first on foot arch. The load that is suffered by the foot arch is differently dispersed depending on the base (Tessutti et al., 2007). Free space is present in 83.33% of primary schools and 80.00% of secondary schools. Primary and secondary schools are usually not equipped with the space for athletics. A round 200 m track exists in 23.33% of primary schools and 25.00% of secondary schools. Long jump pit is more present in primary schools, as well as the space for shot put. The teaching of running elements, throwing and jumping is planned for autumn cycle. The equipment of primary and secondary schools does not allow the teaching of these elements. The frequency of dressing rooms is in direct connection with school sport halls, in some cases we find adapted space for dressing rooms or classrooms, without sanitation (washbasins, showers and toilets), which directly influences the attitude in relation to Physical Education (Vukasinovic, 1995). There is an insufficient number of equipment storage rooms and teacher's offices. They are very often improvised rooms for storage of balls and other equipment. By the norm a teacher's office should have 16 m^2 with a special space for clothes, shower and a toilet. All this influences the attitude of the teacher about the equipment of schools about material spacious conditions for work and to the relation to the Physical Education lesson.

CONCLUSION

The results on the researched sample of thirty primary and 25 secondary schools of Sumadija and Pomoravlje region indicate that in primary school the most frequent category is the third category of school buildings, and for secondary schools the third and fourth category, which directly influence that the part of programme contents is not possible to plan and to realise. According to the mentioned criterion, Physical Education teaching programme can be fully realised in schools with the first and the second category of buildings. The current state of material-technical conditions indicates that only 30.00% of primary and 40.00% of secondary schools fulfil this criterion. According to the criterion very limited programme contents can be realised in 13.32% of primary and 12.00% of secondary schools. The equipment of schools for Physical education teaching is always present and the future period represents the great task with the goal of improving of material-technical conditions for planning and realisation of programme contents.

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Session 2

EFFECTS OF STATIC AND DYNAMIC STRETCHING ON INJURY PREVENTION IN FOOTBALL: A SYSTEMATIC REVIEW

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ABSTRACT

In elite and professional football, injuries can have serious consequences for the entire team, as well as for the career of a particular player. Stretching, as one of the main components of the warm-up, may be beneficial in preventing muscle injuries by requiring greater stretch length and force to cause muscle rupture. The aim of this review was to review the published literature that investigates the effects of static and dynamic stretching on the prevention of injuries in football. Index databases were used to collect adequate literature: GoogleScholar, SCOPUS, PubMed. Based on the set subject and research goal, 14 original scientific researches were found and analyzed in detail. Looking at the results of the presented studies, it can be seen that 11 of the 14 presented studies showed positive results in the form of injury prevention by applying stretching before or after football players' training. The two studies that did not show positive effects were of short duration, so the absence of positive effects can be attributed to the shortcomings of the two studies. One study found no positive effects of static stretching on injury prevention in football. Future research should concentrate on developing new methods and combinations with other tools and training methods in order to prevent injuries. In conclusion, stretching is overall good for injury prevention especially when combined (static & dynamic) and practiced for prolonged period of time.

Keywords: soccer, flexibility, additional training, hamstring

INTRODUCTION

In the modern classification of sports activities, football belongs to the group of polystructural sports of a complex character in which cyclic and acyclic movements of dynamic type are dominant and can be categorized as a sport of situational and non-standardized activities (Castagna et al., 2006). There is no strict automation of movements in the game, so it is almost impossible to predict the development of events on the field in advance, which can potentially lead to the possibility of injuries. The intensity of stress in the game ranges from moderate to maximum, and is characterized by the manifestation of all the basic physical properties of a football player and for top achievements, it is necessary to have a high level of technical, tactical and physical preparation (Coulter, Mallett & Gucciardi, 2010).

In order for the players to fully prepare and remain at the optimal level during the season, it is necessary to work on injury prevention. This is most easily achieved by implementing additional flexibility training specifically or during training (specifically during the warm-up -WU) (Amiri-Khorasani, 2013). Anegdotal evidence claimed that warming up with stretching is a tool that can reduce the incidence of injuries and improve football performance itself (Pope, Herbert & Kirwan, 2000). In elite and professional football, injuries can have serious consequences for the entire team as well as the career of a particular player (Dalton, Kerr & Dompier, 2015).

Assessing the effectiveness of stretching methods on injury risk factors is one of the main steps in injury prevention in sports, and research suggests that impaired balance is a major risk factor for injury (Fredericson & Moore, 2005). Hamstring injuries have been shown to be the most common in sports that require running, such as football (Dalton et al., 2015). Usually these injuries were caused by a muscle imbalance between the quadriceps muscle being strong while the hamstring was weak and inflexible. This imbalance puts a lot of pressure on the hamstring leading to injuries and tears (Dalton et al., 2015).

Previous research on the impact of stretching on injury prevention has yielded mixed results. Dadebo, White & George (2004) found that additional flexibility training can significantly reduce incidence of injuries in professional football players ($p < 0.05$). Verrall, Slavotinek, & Barnes (2005) also observed reduced injury rates of hamstring injuries after static stretching program in two teams (9 and 11 injuries pre-intervention vs 2 and 4 post-intervention respectively). In contrast, Arnason, et al. (2008) showed no difference in hamstring strain frequency between experimental and control group ($p > 0.05$). Comparing statis and dynamic stretching, Behm, & Chaouachi (2011) didn't find a significant difference in injury prevention. Azeem, & Sharma (2014) smiliralry noted no statistically significant differences between static and dynamic stretching in football players' injury frequency. Another study found positive effects of static (2.0 ± 1.24 injuries/team) and dynamic (1.42 ± 1.49 injuries/team) warm-ups followed by static stretching on injury prevention in football players, with no differences among protocols ($p > 0.05$) (Zakaria, Kiningham, & Sen, 2015). In contrast, Baumgart et al. (2015) examined a 8-week static stretching program where the experimental group performed 4 different static stretching exercises lasting 2×20 seconds with 10-second breaks. After analyzing the results, the authors concluded that the experimental group didn't significantly reduce injury frequency compared to control group ($p > 0.05$).

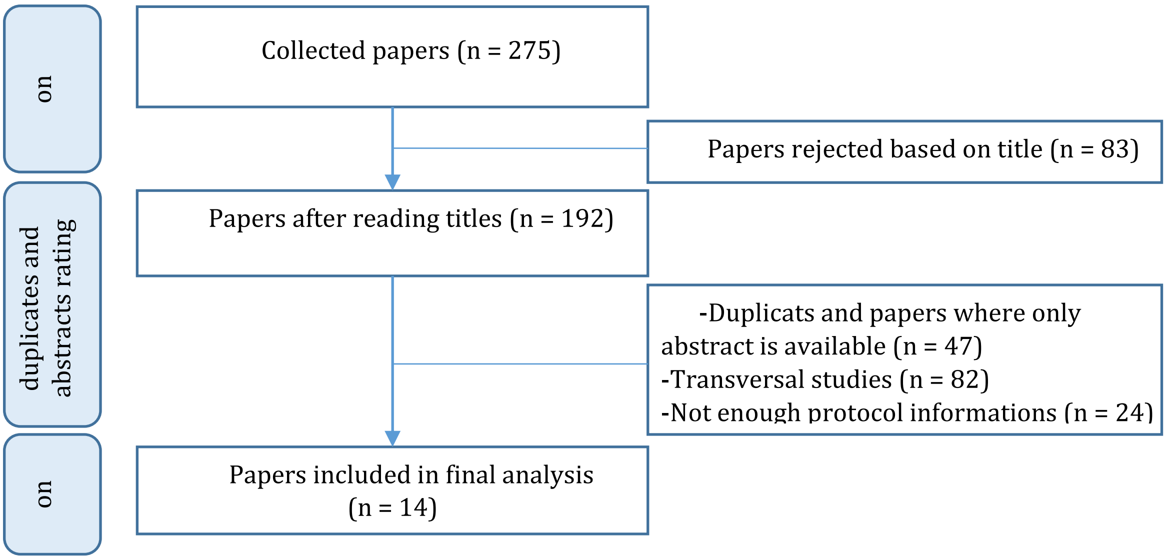
Considering that the previous researches are not fully harmonized, there is a need for a review research that would unify the papers and give a single conclusion. Therefore, the main of this research was to review the published literature that investigates the effects of static and dynamic stretching on injury prevention in football. And the seccond goal was to determinate the most effective protocol.

METHODS

The following databases were used to collect literature: GoogleScholar, SCOPUS, PubMed. The following keywords were used during the search: effects, static stretching, dynamic stretching, injury prevention, football, football. The papers that were analyzed were published English in the last 20 years and only research with football players were included. During the selection of research, those with top, professional and semi-professional football players were analyzed. The studies included in this research were of the original type. The year of publication of the paper was set to be no more than 20 year old. The papers were not analyzed in detail if the research was done on a sample of any other group than football players (recreationists/other sports). Additionally, studies that were published in a language other than English and those studies that didn't have the full text available were not analyzed.

Data extraction

Based on keywords, 275 papers were identified (GoogleScholar, SCOPUS, PubMed). 83 papers were excluded based on reading the title, 47 papers were excluded because they were duplicates or only abstracts were available. Furthure, 82 were transversal studies and 24 didn't have enough informations about protocol.



Flowchart 1. schematic representation of the research collection flow

RESULTS

Table 1. Overview of gathered research and basic characteristics of experimental treatments

First author and year	Participants	Aim of research	Program	Results
Cross et al. (2002)	n = 195 M 18.06±1.5 yo	They investigated the effects of SS on IP during 1 season	A series of SS exercises after training for 15 seconds of individual stretching	Reduced frequency of tendon and muscle injuries by 48%
Dadebo et al. (2004)	n = 30 clubs	They investigated the effects of SS on IP during 1 season	Football players self-reported the SS program after training by means of a questionnaire	SS of the hamstring had positive effects on reducing the frequency of injuries, while other exercises did not have significant effects
Verrall et al. (2005)	n = 70 M 23-26 yo	They investigated the effects of SS on IP	EG applied a set of SS exercises after training for 30-45 seconds. 2-3 times a week throughout the season	They concluded that SS caused positive effects in IP, even though the program was a combination with strength training
Arnason et al. (2008)	n = 93 M & F 17-30 yo	They investigated the effects of SS on IP in football	3x4 SS exercises before training for 45 seconds	SS did not cause positive effects on IP in the LE of football players, especially in hamstring
Soligard et al. (2008)	n = 1892 M & F	They determined the effects of SS+DS on IP	20 min of after training stretching (SS of hamstring and quadriceps and DS – step forward and to the side...)	During one season, injuries were recorded in 264 players: 121 players in EG 143 in KG, indicating that the combination of SS+DS had positive effects
Emery et al. (2010)	n = 744 M & F	They investigated the influence of DS on IP	15 minutes of DS after conventional football training (for LE)	The injury rate in the EG group was 2.08 injuries/1000 hours T/G, and in the control group 3.35 injuries/1000 hours T/G
Amiri-Khorasani et al. (2011)	n = 18 M 19.22 ± 1.83 yo	They investigated the influence of DS+SS on IP	A set of 5 SS exercises lasting 30-45 seconds + DS (15 second exercises) as part of the warm-up	A combined warm-up stretching program helped with IP ($p < 0.05$)

Colak (2012)	n = 15 F 22.13 ± 2.69 yo	The influence of DS on IP was investigated	4 DS exercises (stepping, stepping to the side, kicking, leg to the side) for 10 min.	EG had a lower incidence of injuries 1.91 injuries per 1000 hours T/N, while the CG had 2.46
Daneshjoo et al. (2013)	n = 15 M 18.9 ± 1 yo	They investigated the influence of DS on IP	10-minute DS program after training/match during 8 weeks	The program did not cause positive effects on IP, because it lasted a short period of time
Zakaria et al. (2015)	n = 465 M & F	They investigated the impact of SS+DS on IP	SS (Toes walking, body flexion while walking, walking and touching the ground, stretching the quadriceps, calves, back)	No statistically significant differences between the two types of stretching, but both types reduced the frequency of injuries compared to the previous season
Kristiansen et al. (2017)	n = 8 F	They investigated the impact of a combined program + SS on IP in female football players	Stretching the quadriceps, calves and hamstrings in place. As well as stretching the lower back in a seated position	Combined training had positive effects on IP. The authors suggest that it is necessary to apply the principle of individualization when stretching in order to maximize performance.
Zarei et al. (2018)	n = 56 M 14-18 yo	They examined the influence of SS+DS on the IP of young football players	Stretching with maintaining balance, lunges, forelegs Forefooting - bending through movement	The program showed a reduced frequency of injuries to the hamstrings, quadriceps and calf muscles
Azuma et al. (2020)	n = 124 M	They investigated the influence of SS on IP	SS exercises after training, lasting 15 min for 12 weeks	SS had significant effects on the incidence of injuries, especially overuse or contact injuries
Seçer et al. (2021)	n = 30 M 18.80 yo	They investigated the influence of DS and rollers on IP	EG did a 10-minute set of DS exercises after training for 10 weeks	No statistically significant improvements were observed in the form of a reduction in the frequency of EG injuries

***Legend**: M – male; F – female; n = number of participants; DS – dynamic stretching; SS – static stretching; IP – injury prevention; LE – lower extremities; T/G – training or game; EG – experimental group; KG – control group; PE – positive effects ; yo – year old*

All the studies presented analyzed the effects of static/dynamic stretching (or combination of these two) on injury prevention in football. Looking at the years of publication of these papers, it can be seen that there is an interest of researchers in the given topic in the last 20 years, which indicates the importance of this topic. The number of subjects varied from study to study, with the smallest number in the study by Kristiansen et al. (2017) with a total of 8 participants, up to the largest number of 1892 participants in the paper presented by Soligard et al. (2008). The total number of participants in all papers was 3755 of both sexes. There were a total of 1671 female participants and 2048 male participants.

DISCUSSION

The aim of this review was to determine, based on the previous literature, the effects of static and dynamic stretching on the prevention of injuries in football. The research included 14 original scientific studies that were analyzed in detail. Combination of the previous research came to a mixed conclusion whether these methods are beneficial and should be implemented

Studies have shown that up to one-third of football injuries are classified as muscle injuries, with the majority of injuries occurring in the hamstring, adductor, quadriceps, or calf muscles (Ekstrand, Hagglund

& Walden, 2011). In elite and professional football, injuries can have serious consequences for the entire team as well as the career of a particular football player (Dalton et al., 2015). Football coaches uses stretching as a mean of reducing the incidence of injuries and improving football performance itself (Pope et al., 2000). Assessing the effectiveness of acute stretching methods on injury risk factors is one of the main steps in injury prevention in sports, and research suggests that impaired balance is a major risk factor for injury (Fredericson & Moore, 2005). In general, stretching (such as static or dynamic) is beneficial for a number of reasons. The speed and force of muscle contractions, in addition to muscle temperature, increase after stretching (Woods, Bishop, & Jones, 2007). Moreover, stretching may be beneficial in preventing muscle injuries by requiring greater stretch length and force to cause muscle rupture (Woods et al., 2007). The muscles most commonly rupture during eccentric contraction and contain primarily type 2 fast-twitch fibers (Anderson, Strickland, & Warren, 2001).

Looking at the results, it can be seen that certain studies investigated the effect of static stretching only (Cross et al., 2002; Dadebo et al., 2004; Verrall et al., 2005; Arnason et al., 2008; Azuma & Someya, 2020), while certain studies investigated the effects of dynamic stretching (Seçer & Kaya, 2021; Daneshjoo et al., 2013; Colak, 2012; Emery & Meeuwisse, 2010). Finally, several studies have investigated the effects of combined static and dynamic stretching on injury prevention (IP) in football players (Zarei et al., 2018; Zakaria et al., 2015; Kristiansen et al., 2017; Soligard et al., 2008; Amiri -Khorasani et al., 2011). Study by Cross et al. (2002) observed positive effects of SS. A series of static LE muscle stretching exercises for 15 seconds of single stretching was beneficial in reducing the incidence of tendon and muscle injuries by 48%. Dadebo et al. (2004), reported static stretching exercises lasting 20-30 seconds to be beneficial in prevention of hamstring injuries, while other muscle groups were not affected. Verrall et al. (2005) applied a set of SS exercises after training with a duration of individual stretching of 30-45 sec, 2-3 times a week during the whole season. The research concluded that SS caused positive effects in IP, even though the program was a combination with strength training. Arnason et al. (2008) applied a set of 3x4 pre-training SS exercises lasting 45 seconds and the authors observed no positive effects on IP. Finally, a study by Azuma & Someya (2020) showed that SS exercises after training for 15 min during 12 weeks period have significant effects on the frequency of injuries, especially injuries caused by overexertion or contact. Four of the five studies presented that investigated the effects of static stretching showed that this type of stretching before or after training was an effective strategy in IP (mainly, static stretching of the quadriceps, calf muscles, and hamstrings) (Small, Naughton, & Matthews, 2008; Chaabene, Behm, Negra , & Granacher, 2019).

When reviewing the papers that examined the effects of DS on IP, it was found that 15 minutes of DS after conventional football training can reduce injury rates (Emery & Meeuwisse, 2010). The EG had 2.08 injuries/1000 hours of training/play, and the CG had 3.35 injuries/1000 hours of training/game. Colak (2012) used 4 DS exercises (lunge, lunge to the side, leg kick, leg to the side) for 10 min before training and showed that EG had a 1.91 per 1000 hours of training/game, while the CG had 2.46. Daneshjoo et al. (2013) applied a 10-minute DS program after exercise (training-match) for 8 weeks and showed no positive effects on IP, but the program lasted a short time, football players were not monitored for a long period, which was a limitation those studies. However, Seçer & Kaya (2021) showed that a short-term DS program lasting 10 weeks did not cause improvements in IP in football players. It can be observed that such a program would be more effective if it lasted longer, as already seen in previous literature (Iwata et al., 2019).

Finally, looking at the effects of a combined program of static and dynamic stretching, the following can be seen: Soligard et al. (2008) applied 20 min of stretching after training (SS of the hamstring, quadriceps and calf muscles and DS - lunges forward and to the side, movement and touching the ground, trunk flexion, trunk flexion and lunge) and during one season injuries were recorded in 264 players: 121 players in the EG and 143 players in the CG, indicating that the combined training of static and dynamic stretching had positive effects on the IP of football players. Furthermore, Amiri-Khorasani et al. (2011) applied a set of 5 SS exercises lasting 30-45s + DS (15 seconds of each exercise) as part of the WU. The results of that combined program showed positive effects in reducing the frequency of injuries to the quadriceps, calf and back muscles of football players, and it can be assumed that this is very important in football, considering that the most stressed part of the body are LE. In accordance with this are findings of all research which combined SS and DS. Zakaria et al. (2015) showed that walking on the toes, trunk flexion during walking, walking and touching the ground, stretching of the quadriceps, calves, hamstrings (in a static position) can reduce the incidence of LE injuries in football. Also, the same study showed no difference between static and dynamic stretching, in the sense that both types of stretching contribute to IP. Kristiansen et al. (2017) showed that the combined form of stretching has positive effects on IP and suggesed that it is necessary to apply the principle of individualization when stretching in order to maximize performance. Finally, a study by Zarei et al. (2018) showed that a combined type of stretching (including stretching with balance maintenance, lunges, forelegs, forelegs-bending through movement, etc) reduces the incidence of LE injuries in football. Looking at the results of the presented studies, it can be seen that 11 of the 14 presented studies showed positive results in the form of injury prevention by applying stretching before or after football players' training. The 2 studies that did not show positive effects were short-lived, so the absence of positive effects can be attributed to the shortcomings of the two studies. One study found no positive effects of static stretching on IP in football.

The main limitation of this paper is the lack of specificity in the sense of isolation and analysis of one muscle (or group) or type of program. Future recommendation for IP in football would be to perform longer programs with different kind of exercises. Additionally, scientists could also develop a new method or to examine effects of stretching combined with other training methods.

CONCLUSION

Stretching as a tool that reduces the frequency of injuries and improves football performance itself. It may be beneficial in preventing muscle injuries by requiring greater stretch length and force to cause muscle rupture. Looking at the results of the presented studies, it can be seen that 11 of the 14 presented studies showed positive results in the form of injury prevention by applying stretching before or after football players' training. The 3 studies that did not show positive effects were short-lived, so the absence of positive effects can be attributed to the shortcomings of the two studies.

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PARENTS, COACHES AND YOUNG FOOTBALL PLAYERS: SUPPORTING OR CREATING PRESSURE?

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ABSTRACT

Parents play an important role in a child's socialization and involvement in sports as well as during the period of life in which they engage in sports. The aim of this study was to determine how parental and coach's beahavior affect on the motivation to play sport in the adolescent sample of football players. This study examined 131 subelite football players, age 12-16, from one club playing in Serbian top youth leagues and at the time of testing all of them had a training experience of 4-11 years. The survey was conducted using three psychological instruments that will assess the opinion of children about their motives for playing sports (SIMS), the parental bonding styles (mothers and fathers seperatly) (PBI-BC) and how coaches and the team climate influence them (MCSYS). In the first step predictive power of the parental bonding is tested (parental care for mother and father, parental overprotection for mother and father), which explained 26.6% variance of the dependant variable (p = .000). Mastery climate scores were significantly and positively associated with liking for the coach and desire to play for the coach in the future, whereas MCSYS ego scores were negatively associated with these variables. According to this research's data, the athletes who are high on mastery scores are the ones who have intrinsic motivation and identified regulation, and the ones with ego scores are amotivated.

Keywords: motivation, adolescent athletes, sense of competence

INTRODUCTION

Because of the very nature of youth sport, researches focus on the role that parents play when it comes to their children because their behavior has an impact on young athletes (Cote & Hay, 2002). When it comes to parents, they are often portrayed in a negative light through the eyes of coaches, children and other parents (Gould, Lauer, Rolo, Jannes, & Pennisi, 2008). Parents play an important role in a child's socialization and involvement in sports as well as during the period of life in which they engage in sports (Wuerth, Lee, & Alfermann, 2004). It has been determined that parents fulfill a triple role in the child's sports; first, they are providers, they provide an opportunity, finances, transport, then they are interpreters, which means that they instill emotion and behavior in sports towards the child, and in the and they serve as role models. The extent to which these roles are fulfilled affects a child's beliefs, motivation, behavior, and performance (Fredricks & Eccles 2004). In addition to parents, coaches certainly play the most important role in motivating and developing athletes (Balaguer et al., 2012). Coach's behavior significantly affects the development, cognition and affective response of players by allowing them to learn and progress (Lyle & Cushion, 2010), as well as to improve social, emotional and physical condition (Horn, 2002).

Nevertheless, the great emotional, financial, and logistical support that parents provide to their children can also lead to increased expectations and increased pressure on children (Wolfenden & Holt, 2005) because of the overall support that parents provide to their children, it is logical that they perceive themselves as someone who plays a key role in an athlete's development (Hill, 1993). The coach must also be a role model and leader for young football players, and that depends exclusively on his expertise in working with athletes, on how much he is able to motivate them (Vella, Oades, & Crowe, 2013) as well as on how much he is able to influence parents (Smoll, Cumming, & Smith, 2011).

In this research, we will use the concept of Self-determination theory. SDT has over the last 40 years become a major theory of human motivation (Gagne & Deci, 2014). The fundamental tenets of SDT suggest that motivation and its determinants, mediators and consequences operate at three levels: global, contextual and situational (Vallerand, 2007). Motivation at the global level echoes how an individual generally interacts with his/her environment (Vallerand, 2007). The contextual motivation is a motivational disposition towards a particular context, such as work, sports or education (Vallerand, 1997). The situational motivation refers to doing the activity that you are currently engaded (such as sport that you are practising at the time) (Vallerand, 1997).

All three levels can be further refined and described by various constructs, among them the motivational factors proposed by SDT (Deci, Vallerand, Pelletier, & Ryan, 1991): Intrinsic motivation (Ryan, & Deci, 2000), identified regulation (IR), external regulation (ER) and amotivation (AM), constituting a self-determination continuum from self-determined to non-self-determined motivation. In sum, self-determination theory considers that needs for competence, autonomy, and relatedness should be fostered by the social context in order to produce selfdetermined motivations.

To the best of our knowledge, no study has been conducted with such a large group of young football players. So, the aim of this study was to determine how parental and coach's beahavior affect on the motivation to play sport in the adolescent sample of football players.

METHODS

Subjects

This study examined 131 subelite football players, age 12-16, from one club playing in Serbian top youth leagues and at the time of testing all of them had a training experience of 4-11 years.

Procedure

The survey was conducted using three psychological instruments that will assess the opinion of children about their motives for playing sports (SIMS), the parental bonding styles (mothers and fathers seperatly) **(PBI-BC)** and how coaches and the team climate influence them **(MCSYS)**.

The Situational Motivational Scale (SIMS) – Originally constructed in 2000 (Guay, Vallerand, & Blanchard, 2000), and later validated on a Norwegian sample of adolescents measuring their motivation to attend physical education at school (Østerlie, Løhre, & Haugan, 2019). The original scale consists of 16 items and we used it in this reaserch. It consists of 4 subscales: Intrinsic motivation, Identified regulation, External regulation and Amotivation.

A brief form of the Parental Bonding Instrument (PBI-BC) – The short version consists of 8 items - 8 for the mother, 8 for the father. Adolescents report their degree of agreement with the parental behavior offered. The original version numbered 25 items (Klimidis, Minas, Ata, & Stuart, 1979), but in 1992 a short version of this scale was created that proved equally successful (Klimidis, Minas, & Ata, 1992). It consists of two subscales: care and overprotection.

Motivational Climate Scale for Youth Sports (MCSYS) – It was used to measure the experience of coaching behavior and the motivation of a team of young athletes with coaching incentives (Smith, Cumming, & Smoll, 2008). This scale consists of 12 items and 2 subscales: needs for autonomy, relatedness and a sense of competence (Mastery-initiating items) and competitive, threatening and controlling environment (Ego-initiating items).

The consent of all participants and their parents about their voluntary participation in this research was obtained and the measurements and procedures will be performed in accordance with the Declaration of Helsinki.

Statistical analysis

Basic descriptive statistic will be provided and for the prediction of the players percived motivation, hierarchical regression analysis will be used. All data analysis will be performed with Statistical Package for Social Sciences (SPSS for Windows®, version 26.0).

RESULTS

Table 1. Parental bonding and motivational climate as predictors of the INTRINSIC MOTIVATION

	Subscales	Beta Coefficient (β)	*p*	Concise display of a model
Model (parental bonding)	Mothers's care	.116	.141	R=.531 R^2=.266 p=.000
	Father's care	.368	.000	
	Father's overprotection	.290	.001	
Model's addition (motivational climate)	Mothers's care	.133	.037	R=.554 R^2=.279 p=.000
	Father's care	.332	.000	
	Father's overprotection	.272	.001	
	Mastery-initiating	.174	.038	
	Ego-initiating	.053	.518	

In the first step predictive power of the parental bonding is tested (parental care for mother and father, parental overprotection for mother and father), which explained 26.6% variance of the dependant variable (p = .000). Parental care and overprotection for father have shown statistical significance (β = .368, p = .000) and (β = .290, p = .001). The young athletes who are affected by their fathers (both care and overprotection) tend to have intrinsic motivation towards football.

In the procedure of the regression analysis, parental overprotection for mothers appeared as an excluded variable. Excluded variables are variables that don't bring anything new to the research and no matter of their statistical significance; they are not included in the data analysis because they would only duplicate already gained results.

The final model which includes parental bonding and motivational climate explains 27.9% variance of the criterion.

Table 2. Parental bonding and motivational climate as predictors of the IDENTIFIED REGULATION

	Subscales	Beta Coefficient (β)	*p*	Concise display of a model
Model (parental bonding)	Mothers's care	-.087	.243	R=.594 R^2=.338 p=.000
	Father's care	.535	.000	
	Father's overprotection	.157	.044	
Model's addition (motivational climate)	Mothers's care	-.112	.132	R=.623 R^2=.364 p=.000
	Father's care	.487	.000	
	Father's overprotection	.133	.083	
	Mastery-initiating	.210	.008	
	Ego-initiating	.104	.182	

Based on data shown in the table 2 and the first predictive model, we can conclude that parental bonding model is statistically significant predictor (p =.000). The model explains 33.8% variance of the the dependant variable. Parental care and overprotection for fathers again have shown to be statistically significant predictors, and this time they predict identified regulation (β = .535, p = .000, β = .157, p = .044).

In this table too, parental overprotection - mother is an excluded variable and the final model, which includes parental bonding and motivational climate, explains 36.4% variance of the criterion.

Table 3. Parental bonding and motivational climate as predictors of the EXTERNAL REGULATION

	Subscales	Beta Coefficient (β)	*p*	Concise display of a model
Model (parental bonding)	Mothers's care	.028	.611	R=.804 R^2=.638 p=.000
	Father's care	.773	.000	
	Father's overprotection	.051	.370	
Model's addition (motivational climate)	Mothers's care	.027	.627	R=.804 R^2=.632 p=.000
	Father's care	.773	.000	
	Father's overprotection	.051	.383	
	Mastery-initiating	.000	.999	
	Ego-initiating	.008	.898	

Data in table 3 show that first model, parental bonding (parental care for mother and father, parental overprotection for father), explains 63.8% variance of the dependent variable (p =.000). In this case, father's care turned out to be statistically significant (β = .773, p = .000), which means that subjects who receive father's care use external regulation as type of motivation.

Table 4. Parental bonding and motivational climate as predictors of the AMOTIVATION

	Subscales	Beta Coefficient (β)	*p*	Concise display of a model
Model (parental bonding)	Mothers's care	.292	.000	R=.752 R^2=.555 p=.000
	Father's care	-.041	.538	
	Father's overprotection	.673	.000	
Model's addition (motivational climate)	Mothers's care	.273	.000	R=.768 R^2=.574 p=.000
	Father's care	-.064	.332	
	Father's overprotection	.658	.000	
	Mastery-initiating	.035	.588	
	Ego-initiating	.172	.007	

Based on data shown in the table 4, first predictive model explains 55.5% variance of the dependent variable (p =.000). Mother's care and father's overprotection are statistically significant predictors for the amotivation (β = .292, p = .000; β = .673, p = .000). Amotivated athletes are the ones who receive more care from mothers and more overprotection from fathers.

In these predictive models, as in the previous ones, mother's overprotection is an excluded variable. The final model which includes parental bonding and motivational climate explains 57.4% variance of the criterion.

DISCUSSION

The main goal of this research was to examine whether parental bonding and motivational climate can predict different aspects of situational motivation for the young male football players or, in other words, to predict how parental and coach's beahaviour affects on the motivation to play sport in the adolescent sample of football players.

One of the most important variables to consider in physical education (PE) is motivation, as adaptive types of motivation have been associated with intentions to exercise and with physical activity outside of school (Lonsdale, Sabiston, Taylor, & Ntoumanis, 2011). Situational motivation refers to the motivation individuals experience when they are currently engaging in an activity. It refers to the here-and-now of motivation (Vallerand, 1997). There are four motivational factors proposed by Self-determination theory (Deci & Ryan, 1985): Intrinsic motivation (IM), Identified regulation (IR), External regulation (ER) and Amotivation (AM), constituting a self-determination continuum from self-determined to non-self-determined motivation. Self-determination involves a true sense of choice, a sense of feeling free in doing what one has chosen to do. The objective is to see wheter different types of parental care and control can affect motivational factors, and as well whether coaches and teamates play an improtant role for the motivation towards sport.

The data obtained with hierarchical regression analysis show that, when predicting intrinsic motivation, father's care and overprotection have shown to be statistically significant predictors. By the resultes derived, young football players who are intrinsically motivated tend to have fathers who are both caring and overprotecting. Intrinsic motivation comes from within as internal drives that motivate you to behave in certain ways; including your core values, your interests, and your personal sense of morality. Athletes who are intrinsically motivated have scores high on the positive end of a self-determination continuum and they decide independently, so they enjoy the activity more because it's their voluntary choice. Mother's care is a statistically significant predictor for the instrinsic motivation as well, but because of its negative regression coefficient, football players who have caring mothers are less intrinsically motivated. Also, in the prediction of the intrinsic motivation, mastery-initiating items turned out to be statistically significant predictor. Mastery-involving climates are related to greater sport enjoyment (Papaioannou et al., 2004), so it makes the obvious connection between chosing the activity that you like and doing it with a great sence of joy.

In the prediction of the identified regulation, father's care and overprotection are again statistically significant predictors. They both have positive directions of the regression coefficients, which indicate higher identified regulation among those athletes whose fathers take more care of them and are overprotective in the relationship with their sons. Identified regulation is the somewhat internal motivation based on conscious values being personally important to an individual. In contrast, identified regulation occurs when a behavior is valued and perceived as being chosen by oneself. Yet, the motivation is still extrinsic because the activity is not performed for itself but as a means to an end. The researchers reported IM and IR to be associated with behavioral intentions of future persistence towards the activity (Abramson, Seligman, & Teasdale, 1978), therefore we can conclude that athletes who are higher in this kind of motivation will take longer part in the activity. Mastery-initiating climate is statistically significant predictor for the identified regulation and we can find a corroboration of the results gained in a study that showed positive relationship between IR and eagerness for physical activity (Säfvenbom, Buch, & Aandstad, 2017).

When it comes to predicting the External regulation, subscale father's care is statistically significant for its prediction. That means that young athletes whose fathers are more caring will be externally motivated to perform this activity. ER is exclusively external motivation and is regulated by compliance, conformity and external rewards and punishments (Deci et al., 1991). Researchers also showed that it is the controlling aspect of rewards that undermine intrinsic motivation and bring up the external regulation to light.

Finally, when predicting Amotivation a few predictors have statistical significanse. Mother's care, father's overprotection and, in the second model, ego-initiating climate is a significant predictor too. So, male football players who have caring mothers and overprotective fathers tend to be amotivated in the perfomance of the activity. In AM, you are completely non-autonomous, no drive to speak of, and you are likely struggling to have any of your needs met. Deci and Ryan (1985) have proposed a third motivational concept - amotivation, to fully understand human behavior. When amotivated, individuals experience a lack of contingency between their behaviors and outcomes. Amotivated behaviors are the least self-determined because there is no sense of purpose and no expectations of reward or possibility of changing the course of events. Amotivation can thus be seen as similar to learned helplessness (Abramson et al., 1978) where the individual experiences feelings of incompetence and expectancies of uncontrollabilit. Maybe this particular combination of parenting skills can show a predicting model for having an adolescent child who isn't self-determined, meaning that has a low level of self-confidence and isn't autnomous in its decisions. Ego-initiating climate stood out as a predictor of amotivation which is expected according to previus researches (Gagne, Ryan, & Bargmann, 2003). An ego climate, fosters a competitive, threatening, and controlling environment, undermines intrinsic motivation and enchanses amotivation.

CONCLUSION

Mastery climate scores were significantly and positively associated with liking for the coach and desire to play for the coach in the future, whereas MCSYS ego scores were negatively associated with these variables. Assuming that mastery-involving coaching behaviors would be viewed as more socially desirable than ego-involving ones, we might expect that social desirability would be positively associated with MCSYS mastery scores and negatively correlated with ego scores. According to this research's data, the athletes who are high on mastery scores are the ones who have intrinsic motivation and identified regulation, and the ones with ego scores are amotivated.

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INFLUENCE OF MOTOR SKILLS AND ANTHROPOMETRIC CHARACTERISTICS ON SUCCESS IN RHYTHMIC GYMNASTICS: A SYSTEMATIC REVIEW RESEARCH

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ABSTRACT

Rhythmic gymnastics (RG) is a sport involving both individual and group performances, where participants showcase synchronized body movements while handling various apparatus. The aim of this research was to examine the influence of motor skills and anthropometric characteristics on success in rhythmic gymnastics by systematizing the studies. A total of 1103 respondents participated in the research, i.e. girls who practiced rhythmic gymnastics. Based on two criteria (that they were written in the English and that the respondents are in the training process), 15 studies were included in the final analysis of the studies, which were tabulated and discussed. All previous studies that have been taken into account were presented with the following criteria: citations (authors and publication year), participant sample (quantity of participants and age), observed variables, and findings from the study.Based on all of the above and the analysis of the obtained results, it can be concluded that there is a significant influence of motor skills and anthropometric characteristics on success in rhythmic gymnastics. Taking into account the obtained data and results, it can be observed that by improving various motor skills and monitoring anthropometric characteristics, the final result and sucess of rhythmic gymnasts in competitions can be influenced.

Keywords: competition, evaluation, performance.

INTRODUCTION

Rhythmic gymnastics (RG) is an individual and group sport that is characterized by the unity of movement of the whole body with simultaneous work with apparatus (rope, hoop, ball, clubs and ribbon) in accordance with music, which is an integral part of all movements of a competitive choreography (Wolf-Cvitak, 2004). Well-developed motor skills enable the acquisition of the basic elements of rhythmic gymnastics, creating a broad basis for achieving optimal results and for learning more complex competition choreographies and technical skills: elements with apparatus and without them (Jastriembskaia & Titov, 1999). Some of the most important motor skills include coordination (Purenović-Ivanović, Popović, Bubanj & Stanković, 2016); specific coordination (Miletić, Katić, & Maleš, 2004), balance (Kioumourtzoglou, Derii, Tzetzis & Thomas, 1998) as well as flexibility and explosive strenght (Miletić et al., 2004).

In addition to motor skills, the success of rhythmic gymnasts is also influenced by anthropometric characteristics, which are very important for performing elements of competitive choreography, but also for artistic impression (Vandorpe et al., 2011). Success is strongly influenced by the body aesthetics of rhythmic gymnasts, which is the main reason to believe that body size, body type and body composition affect performance in rhythmic gymnastics (Purenović-Ivanović et al., 2016). The required aesthetic appearance of gymnasts (long limbs and low body fat percentage) is indirectly encouraged by the rules of the International Gymnastics Federation, where factors such as range of motion, elegance and fluidity are related to the ability to perform technical requirements (Amigo et al, 2009).

Previous research aimed to identify the necessary motor skills and anthropometric characteristics, as prerequisites for achieving optimal results and successful performance in rhythmic gymnastics. In the research conducted by Miletić et al. (2004) it is concluded that 41% of success in rhythmic gymnastics can be predicted by flexibility and explosive strength, while in the research by Purenović-Ivanović et al. (2016) is determined that specific coordination has a share of 50% in the prediction of desirable results. Research by by Di Cagno et al. (2014) concluded that 50% of the prediction of competition results in younger age categories can be explained on the basis of precision while in older age categories the share of prediction is only 20%. Considering coordination, Kolarec, Horvatin-Fučkar & Radaš (2013) conducted research and obtained as the main result that coordination had a share in the prediction of results, but only 21%. In addition to research that included the influence of motor skills on success in rhythmic gymnastics, some authors investigated what other parameters are necessary for a successful performance in a competition in rhythmic gymnastics. Purenović- Ivanović et al. (2016) determined that somatotype has a 51% share of prediction on achieving success in rhythmic gymnastics, while Claessens, Lefevre, Beunen & Malina (2000) proved that on the basis of somatotype and anthropometric characteristics it is possible to predict 32% to 45% of the obtained grade and results in the competition. Douda et al. (2008) indicated that 45% of the achieved result in rhythmic gymnastics can be predicted based on anthropometric characteristics. In the work of the authors Purenović et al. (2019) regression analysis proved that body composition has a share of 46% and 51% in predicting success in rhythmic gymnastics.

However, since the previous researches are insufficiently harmonized and there are many doubts about the success factor in rhythmic gymnastics, there is a need for a systematic overview research that will unite the relevant researches so far and give a general conclusion. Also, the intention is to find out what are the motor skills and anthropometric characteristics that are of crucial importance for success in rhythmic gymnastics in order to put a special emphasis on them during training and achieve the desired results in the competition. Based on all of the above, the goal of this research was to examine the influence of motor skills and anthropometric characteristics on success in rhythmic gymnastics by systematizing the articles.

METHODS

The relevant literature was searched in the following databases: Google scholar, PubMed, ResearchGate. Studies published in the period from 1998 to 2023 were searched. In order for the study to be included in the analysis, it had to meet the following criteria: that they were written in English and that the respondents were in the training process. Studies written in other languages and articles where non-standardized measuring instruments were applied were not included in this study. The keywords used in the database search are: competition, evaluation, performance References from all studies were reviewed in order to find more studies that dealt with a topic that is interesting and related to our review study. The parameters on the basis of which the research is presented and analyzed are: references (authors and year), sample of respondents (number of respondents and number of years), monitored variables, research results.

RESULTS

A search of studies using keywords found 347 articles. Studies were selected based on the title and abstract, where after the first step, the title, 278 studies were excluded, while after the second step, reading the abstract, an additional 54 studies were excluded. The final number of studies that entered the analysis and were included in the review research is 15 studies that met the criteria, based on which the scheme of research collection is shown in Figure 1.

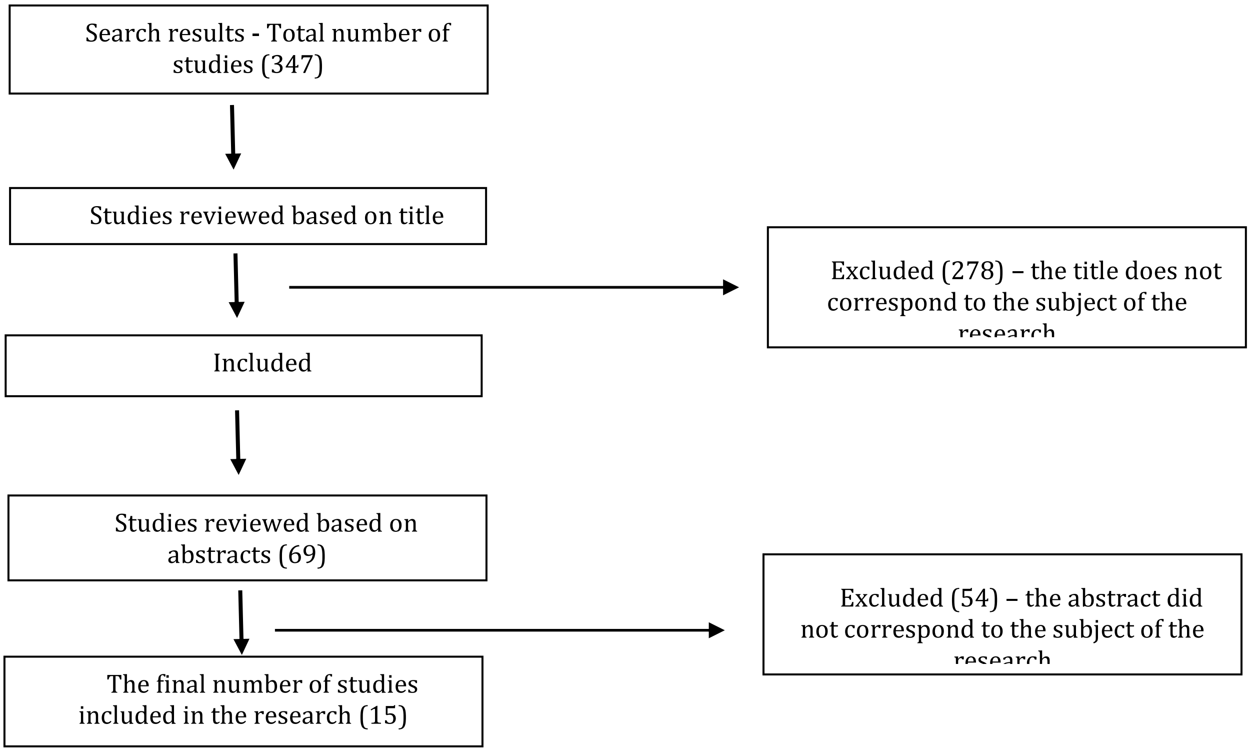

Figure 1. Flow diagram of data retrieval procedure

Studies that met following criteria are shown in Table 1. Each study is presented using the following parameters: references (authors and year), sample of respondents (number of respondents and number of years), monitored variables and research results.

Table 1. Analysis of included studies

First author and year	**Sample of respondants**	**Variables**	**Results**
Kioumourtzoglou et al. (1998)	n=40 11-15 years	CRT, P, DB, EHC, C SC	DB,K,P,C ⇩ 55% SUCC*
Miletic et al. (1998)	n=100 11 years	BT(C,SB, DB, HRM, HT, FT, SLJ, SLO, SLC, SAC) SC	BT ⇩ 38% SCW(SUCC)* 41% SCJ (SUCC)* 58% SCB (SUCC)*
Claessens et al. (2000)	n=168 21.9 ± 2.4 years	BH, BM, SH, LL, AL,ST,SMT SC	ST,SMT ⇩ 32-45% SUCC*

Miletic et al. (2004)	n=55 7.1 ± 0.3 years	C, A, FT, HT, VJ, SR, S, SU SL	C,VJ ⇩ 65% SUCC*
Miletic et al. (2004)	n=50 7.1 ± 0.3 years	BH, BM, ST, HT, FT, SLJ, VJ, SU, SR, S SL	SR, S, SLJ, VJ ⇩ 41% SUCC*
Douda et al. (2008)	n=34 13.41 ± 1.62 years	BH, BM, BMI, ST, 30m, SLG,VJ, SR, SFE,S, LLT SC	BH, BM, ST ⇩ 45% SUCC* SR,LLT ⇩ 12.1% SUCC* VJ, SLG ⇩ 9.2% SUCC*
Vandorpe et al. (2012)	n=23 7-8 years	BH, BM, BFP, SH, LL, SMT, SR, CMJ, SLJ, PU, SU, 20m, MC(KTK) SC	MC (KTK) ⇩ 44% SUCC*
Kolarec et al. (2013)	n=52 20-22 years	C, SR, SFE, BRT, SLJ, VJ, SU SL	C ⇩ 21% SUCC
Di Cagno et al. (2014)	n=100 11-15 years	DJ, OSRT, BBTT 4 SRGE (P,J,R1,R2) SC	OSRT ⇩ 50% SUCC* BBTT ⇩ 30% SUCC**

Purenovic-Ivanovic et al. (2016)	n=127 11.93 ± 3.09 years	BH, BM, BMI, MC (B-ROL, R-TCJ, H-SKP, C-JUG) SC	MC ⇩ 50% SUCC**
Purenovic-Ivanovic et al. (2016)	n=126 11.95 ± 3.09 years	BH, BM, BMI, ST,SMT SC	SMT ⇩ 51% SUCC**
Donti et al. (2016)	n=46 9.9 ±1.3 years	BM, BH, SB, SFE, SR, HRM, BRT, PU, SU, CMJ, DJ, SAT TES	SR,SFE,PU,SU ⇩ 62.9% SUCC* HRM, BRT ⇩ 37.3% SUCC*
Kritikou et al. (2017)	n=46 9.9 ± 1.3 years	BM, BH, ST, SMT, SB, SR,SFE,OSRT, BRT,PU, SU, CMJ, DJ AS (U, MM, E)	SR,OSRT ⇩ 43.7% SUCC* ST,PU ⇩ 29.2% E (SUCC)*
Purenovic-Ivanovic et al. (2019)	n=84 7-16 years	BM, BH, BMI, BFP, MMP SC	BM, BH, BFP, MMP ⇩ 46-51% SUCC*
Aji-Putra et al. (2021)	n=52 10.63 ± 2.9 years	BM,BH,LL, LLT, VJ SL	LL,VJ ⇩ 32% SUCC**

Legend: **n**-number of respondents; **BM**-body mass; **BH**-body height; **BMI**-body mass index; **ST**-skin folds; **BFP**-percentage of body fat; **MMP**-percentage of body muscles; **SH**-sitting height; **LL**-leg length; **AL**-arm length; **SMT**-somatotype; **CRT**-reaction time; **P**-perception; **DB**-dynamic balance; **EHC**-eye-hand coordination; **C**-coordination; **A**-agility; **BT**-battery of motor skills tests; **HT**-hand tapping **FT**-foot tapping; **SLJ**-standing long jump; **VJ**-high jump; **S** (Split)-flexibility test**;** **LLT**-promotion from standing; **OSRT**-test for assessing the reaction speed of the lower extremities; **BBTT**-accuracy test; **SRGE**-specific elements of rhythmic gymnastics; **J**-jump; **R1**-"risk" 1; **R2**- "risk" 2; **MC**-motor coordination; **KTK** ("The KorpercoordinationsTest fur Kinder")-test of coordination; **B-ROL**-ball rolling; **R-TCJ**-throwing, catching and skipping the rope; **H-SKP**-jumping throught hoop; **C-JUG**-clubs juggling; **SB**-static balance; **SFE**-flexion and extension in the shoulder joint; **SR** (Sit and Reach) **-** flexibility test; **HRM** (Hip range of motion)

- flexibility test; **BRT** (Bridge test) - test of flexibility; **PU**-push-ups; **SU**-sit-ups; **20m**-sprint at 20 meters; **30m**-sprint at 30 meters; **CMJ** - squat jump; **DJ**-jump from a height; **SAT** (Specific Agility test) - agility test; (**SLO**)-standing on one leg longitudinally on the balance beam with the eyes opened; (**SLC**)-standing on one leg longitudinally on the balance beam with the eyes closed; (**SAC**)-standing on both legs across the balance beam with the eyes closed; **SC**-grade; **TES**-evaluation of technical performance; **AS**-grade in artistry; **U**-unity; **MM**-harmony of music and movement; **E**-expression; **SL**-scale, **SCJ**-grade in choreography with a rope; **SCB**-grade in choreography with a ball; **SCW**-grade in choreography without apparatus; **%**- share of prediction on success; statistical significance * **p** < 0.05. ** **p** <0.01; **SUC**-success.

DISCUSSION

Within this paper, Table 1 presents and analyzes 15 articles that are discussed below. The articles were published in the period from 1998 to 2021, and are presented in tabular chronological order. As the topic of this review paper was the influence of motor skills and anthropometric characteristics on success in rhythmic gymnastics, the first published research that was analyzed on this occasion was the work of Kioumourtzoglou et al. (1998), while the last published work by Aji-Putra et al. (2021).

A total of 1,103 respondents, who engaged in rhythmic gymnastics, participated in the research, which leads to the conclusion that all respondents were female. The smallest number of respondents (n=23) was recorded in the study by Vandorpe et al. (2012) while the largest number of respondents (n=168) was in the research by authors Claessens, Lefevre, Beunen & Malina (2000). Taking into account the age of the respondents who were tested within 15 studies, it was concluded that the youngest sample of respondents was in the work of authors Miletić, Sekulić & Wolf-Cvitak (2004) as well as Miletić, Katić & Maleš (2004). The respondents in these articles were rhythmic gymnasts aged 7.01 ± 0.3 years, while the oldest respondents were tested in the work of authors Claessens, Lefevre, Beunen & Malina (2000) where the respondents were rhythmic gymnasts aged 21.9 ± 2.4 years.

By analyzing the 15 articles included in the systematic overview research, it was concluded that all respondents were gymnasts of either recreational or international level, that is, that not a single rhythmic gymnast was involved in gymnastics at the highest level, i.e. professional level. The motor skills that were included in the testing are balance, flexibility, strength, coordination, speed, endurance, agility and specific coordination.

In fourteen studies, a statistically significant influence of motor skills and anthropometric characteristics on results in rhythmic gymnastics was confirmed, while only in one study there was no statistically significant influence (Kolarec et al., 2013). Within these 15 studies, three studies examined the influence of only anthropometric characteristics on success in rhythmic gymnastics, in four studies the influence of only motor skills and in 8 studies the influence of both components on success in rhythmic gymnastics was examined. Based on a detailed analysis of the articles and the obtained results, we conclude that success in rhythmic gymnastics can be influenced by various factors. Considering motor skills as some of the most important for predicting good results and success in the competition, flexibility, explosive strength and balance stand out (Kioumourtzoglou et al., 1998; Miletić et al., 1998; Miletić et al., 2004; Miletić et al. ., 2004; Douda et al., 2008; Donti et al., 2016; Kritikou et al., 2017; Aji-Putra et al., 2021) and from the anthropometric characteristics somatotype, skin folds, leg length and body mass (Claessens et al., 2000; Douda et al., 2008; Purenović-Ivanović et al., 2016; Purenović-Ivanović et al., 2019; Aji-Putra et al., 2021).

CONCLUSION

The aim of this review was to determine, through a systematic literature review and data analysis, whether and to what extent motor skills and anthropometric characteristics can influence the achievement of desirable grades and success in the competition. Data analysis and detailed discussion led to the conclusion that one can clearly see what are the motor skills and anthropometric characteristics on the basis of which the achievement of top results in the competition can be predicted. Based on the results of all 15 articles included in this research review, it can be concluded that balance, flexibility and explosive power are the biggest predictors of success in rhythmic gymnastics having a share of as much as 65%. Within the monitoring of anthropometric characteristics, it can be concluded that the best predictors of success are sculpted somatotype, the amount of skin folds, body mass and leg length, showing a prediction share of over 50%.

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EFFECTS OF PLYOMETRIC TRAINING ON PHYSICAL PERFORMANCE IN ADOLESCENT MALE BASKETBALL PLAYERS

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ABSTRACT

For researchers, coaches, and athletes, improving performance in vertical jumping is very important because the ability to jump more than an opponent can be an advantage in team competitions and many individual sports. The purpose of this study was to determine the effects of a 6-week plyometric training program during the season on the development of explosive strength and sprint in young basketball players. A total of fifteen male participants were included in this study (mean ± SD; age: 14.60 ± 0.50 years). Explosive power and speed were estimated using field tests: jump against movement (CMJ) and jump from squat (SJ) force and sprint speed at 10m, 20m, 30m. There is a statistically significant difference between the initial and final measurements in CMJ (p=0.001, d= 0.30) and SJ (p=0.001, d=0.48). Based on the obtained results, the height of the CMJ increased after the experimental program (= 39.4) compared to the initial measurement (= 37.6), while the height of the SJ at the final measurement was 28.1 and the initial 26.5. This suggests that plyometric training is an effective way to improve strength and speed for young basketball players and that it can be included in physical fitness programs. the application of plyometric training does not lead to an improvement in running speed. These results can help in further research as well as coaches to find an adequate plyometric program and the duration of the program, as well as when applied to regular basketball training, which is related to improving the speed of basketball players.

Keywords: speed, basketball, explosive power, strength, plyometric program

INTRODUCTION

Plyometric training is used to improve human neuromuscular function, as well as performance in sports in which explosive power and endurance are dominant (Fischetti et al.,2018; Marković & Mikulić, 2010). However, many individual and environmental factors affect the performance of athletes in plyometric training (Davies et al., 2015). Various exercises have been used in the plyometric program (de Villarreal et al., 2009), including vertical, horizontal, and deep jumps (CMJ, DJ, SJ). For researchers, coaches, and athletes, improving performance in vertical jumping is very important because the ability to jump more than an opponent can be an advantage in team competitions and many individual sports. The ability to jump is one of the main motor skills of basketball players. In basketball, the ability to generate the maximum level of strength in the shortest period (muscle strength) is necessary to achieve a high level of sports performance (Abdelkrim et al.,2007). Plyometric training has been shown to improve athletes performance including change of direction speed, vertical jump, and sprint abilities (Hammami et al., 2019). Biomechanical changes resulting from other types of training, such as plyometrics and combined training, have attracted much less attention in the literature (Arabatzi et al., 2010) despite improved performance jumps that appear to produce (Lloyd et al., 2015; Rodriguez - Rosel et al., 2015). Sprinting and jumping reflect energy production, and are used to indicate the neuromuscular condition and identify talent (Asadi et al., 2018). Several studies have shown that regular participation in strength training and/or plyometric training programs can improve performance in jumping and sprinting, as well as increase strength, regardless of the age and level of play of the basketball player (Asadi et al.,2017; Santos & Janeira, 2008; Brown et al.,1986). McLeod et al. (2009) found that a 6-week neuromuscular training program (2 days per week; 90 minutes per day) increases the balance and proprioceptive capacity of high school basketball players. In a study conducted by Houghton et al. (2013), plyometric training on a small sample (n = 15) did not prove useful in improving sprint performance. In a systematic review of De Hoyo et al. (2016), they found unsurpassed evidence that plyometric training is useful in improving sprint performance. In some studies, the results showed a correlation between maximum absolute isometric power and maximum speed and showed that this was significantly related to power qualities (Brady et al.,2019; Maulder et al.,2006). Correia et al. (2020) investigate the effect of six weeks of a PT program only on vertical jump in young basketball athletes. De Villarreal et al. (2021) investigated the effects of a plyometric program on explosive power and sprinting on high school students. It is important to examine the effect of the plyometric program on basketball players, ages 13-15, when explosive and speed power develop. Motor power gradually increases during the growth process depending on the increase in body weight. With increasing strength, there are changes in motor skills, muscle contraction strength, but many factors remain unknown. Running is a form of plyometrics, but low intensity. In sprint disciplines, plyometrics is an indispensable part of training. In studies examining the effects of a plyometric program on speed and power (Tsimahidis et al., 2010; Arazi & Assadi, 2011; Assadi, 2013), the respondents were basketball players aged 18-20. It is very important to apply for plyometric training programs before the age of sixteen and see if there are any effects because there is a development of explosive power in the sixteenth year of 53% and a speed improvement. This study aims to evaluate the effects of an 6-week plyometric training program during the season on the development of explosive power and sprint in young basketball players (ages 14 to 15).

METHODS

Subjects

A total of fifteen male participants were included in this study (Mean±SD; Age: 14.60±0.50 yrs; Body height: 172.53±3.06 cm; Body mass: 65.73±2.93 kg and basketball training experience 3.27±1.98 years). All of them were basketball players who played basketball for more than a year. Basketball players were from the junior team from Serbia (KK Novi Pazar). All participants were informed about the study procedures. Informed consent was obtained from all subjects and parents before the study began. All participants were free from any health conditions and violation at this point in testing based on data collected through self-reports structured interviews.

Table 1. Body composition parameters

Body composition	Initial n=15	Final n=15
Age (yrs)	14.60±0.50	14.60±0.50
Body height (cm)	172.53±3.06	172.53±3.06
Body mass (kg)	65.73±2.93	65.72±3.17

Procedure

This research was conducted in the form of a longitudinal design. It was conducted during the preparations for the season over 8 weeks, designed to assess the effects of a plyometric training program on the explosive strength development of young male basketball players. At the beginning of the first week, the initial measurement (pretest) was performed, and at the end of the 8th week, the final measurement (post-test). Tests followed a general warm-up that consisted of running and stretching. The training sessions altogether lasted 6 weeks, starting in the second week and ending in the seventh week. Before testing the athlete passes an introduction to plyometric training and vertical jump tests, using two types of jumps: squat jump (SJ) and countermovement jump (CMJ). All measurements were conducted on a hardwood indoor floor. They have not changed their regular basketball training routine, which consisted of technical-tactical training. All athletes were instructed not to perform any training other than that suggested. Anthropometric characteristics (height and weight) were collected by researchers according to standardized procedures. Height was measured to the nearest 0.1 cm using anthropometry. Body weight was measured to the nearest 0.1 kg (light indoor clothing, without shoes) using a calibrated electronic scale.

Performance tests

Countermovement Jump & Squat Jump

Lower limb explosive power was assessed using a vertical countermovement jump (CMJ) (centimeters) and the squat jump (SJ) with the flight time. The heights of the countermovement jump (CMJ) and the squat jump (SJ) of force were calculated from the flight time measured by the Optojump photoelectric system (Microgate SRL, Bolzano, Italy). Subjects began the SJ at a knee angle of 90 degrees., avoiding any downward movement, and performed a vertical jump by pushing upwards, keeping their legs straight throughout. For the CMJ, they started from an upright and static position; subsequently, they performed an acceleration against their own center of gravity and knee flexion at approximately 90°. Both jumps must be executed with the hands on the hips. The athletes performed 3 SJs, then 3 CMJs, two minutes of rest was allowed between trials, with the highest jump on each test being used in subsequent analyses. The Optojump photoelectric cells, which consist of two parallel bars (one receiver and one transmitter unit, each measuring 100 × 4 × 3 cm), were placed approximately 1 m apart and parallel to each other. The transmitter contains 32 light-emitting diodes, which are positioned 0.3 cm from ground level at 3.125-cm intervals (Glatthorn et al.,2011). The Optojump system measured the flight time of vertical jumps with an accuracy of 1/1000 seconds (1 kHz).

Running Speed

Performance over a 20-m sprint was assessed at 10, 20, and 30-m using an electronic timing system with 4 single beam photoelectric gates (Witty Microgate). Athletes received verbal motivation during testing and were verbally and visually informed to assume the starting position

0.5 m behind the starting line 6 s before each sprint (Chaouachi, et al., 2010), which was placed 0.75-m above the ground to ensure it captured trunk movement and avoided false signals from limb motion. Three trials were separated by 3-4 minutes recovery intervals. The participants decided on the sprint start timings themselves (standing start).

Training interventions

Plyometric training was applied on two non-consecutive weekdays for 6 weeks (Tuesday and Thursday). Respondents had their regular 60-minute workouts four times a week and one game day during the week, except for the day when they did the plyometric training program (included in regular training). A standardized warm-up, which included running at increasing speed and guided by verbal stimuli, as well as dynamic stretches lasting approximately 10 minutes (Negra et al.,2016). Training volume was defined based on the number of jumps, which was gradually raised each week (Table 2). In all training sessions, the jump exercises progressed in intensity and complexity. The intensity was assessed from a technique-based jump progression (exercise complexity). Plyometric training details are described in Table 2 (Correia et al.2020). Rests between jumps and sets comprehended 30 and 120 seconds, respectively; there was no rest between jumps. The athletes were instructed on the mechanics of the jumps and encouraged to jump with as much effort as possible; all jumps were executed under the same environment and floor conditions.

Table 2. Plyometric training program

Jump exercises	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Vertical (CMJ)	2x10	1x10	1x15	1x10		2x10
Lateral	2x10	1x10	1x15		1x10	
Horizontal	1x10	2x10	2x10	2x10	2x10	2x10
With knee raise		4x5		2x10	2x10	
With alternating lunges			4x5			2x10
Forward and consecutive				4x5		
Vertical unilateral					4x5	4x5
Lateral unilateral					4x5	4x5
Total # of jumps	50	60	70	80	90	100

2x10 indicates 2 sets and 10 repetitions, CMJ – countermovement jump

Statistical analysis

Statistical analyses were performed using IBM®SPSS® software, version 20.0 (SPSS, Inc., Chicago, IL, USA). Normality of all variables was tested using the Kolmogorov–Smirnov procedure. Means and standard deviation (SD) were calculated, using standard statistical methods. A paired t-test was used to determine differences in CMJ, SJ, and for the parameters, 10m, 20, 30m, the difference between the initial and final measurement was determined by the Mann - Whitney test. The statistical significance was set at $p<0.05$. Effect sizes (ESs) were determined by Cohen's d. According to Cohen (Cohen, 1988), ESs can be classified as small (= 0.2–0.49), medium (= 0.50–0.79), and large (≥ 0.80).

RESULTS

The results between the pre and post-test for explosive strength and sprint scores are shown in Table 3. There is a statistically significant difference between the initial and final measurements in CMJ ($p=0.001$, $d= 0.30$) and SJ ($p=0.001$, $d=0.48$). Based on the obtained results, the height of the CMJ increased after the experimental program (= 39.4) compared to the initial measurement (= 37.6), while the height of the SJ at the final measurement was 28.1 and the initial 26.5. The results showed that there was no statistically significant change ($p > 0.05$) in the variables 10m, 20m, 30m ($p = 0.307$, $p= 0.118$, $p=0.100$).

Table 3. Output variables on the initial and final measurement mean ±SD

variable	***pre***	***post***	***p value***	***ES***
CMJ(cm)	37.6±5.7	39.4±6.1	<0.001	d=0.30
SJ (cm)	26.5±2.9	28.1±3.6	<0.001	d= 0.48
10m (s)	2.21±0.07	2.19±0.11	0.307	d= 0.21
20m (s)	3.05±0.23	3.00±0.20	0.118	d= 0.23
30m (s)	5.26±0.29	5.18±0.29	0.100	d=0.27

SJ—squat jump; CMJ—countermovement jump; p value– significant difference, p = 0.05; ES—effect size, d- Cohen's d

DISCUSSION

This study aimed to examine the effects on the explosive power and speed of basketball players by combining six weeks of plyometric training and standard basketball training. The effects of plyometric training can be different and depend on many factors such as the level of the athlete, gender, sports activity, duration, type of plyometric training, whether plyometric training was done in combination with regular training or not. The main findings were major improvements in CMJ and SJ in terms of explosive power. However, the combined program did not achieve significant results in running speed. In study Bouterra et al. (2020) that aimed to examine the effects of substitution part of the standard basketball training regime up to 8 weeks plyometric program on female basketball players (age= 16.04± 0.5) there were no significant main effects of time for SJ (p =0.36) or CMJ (p = 0.58) or for any sprint interval. Many studies in the literature have reported that sprinting improves when applying plyometric training (Chelly et.al., 2010; Kotzamanidis, 2006) as one of the essential parts of basketball movement. (Ziv & Lidor, 2009). The results of this study differ from other studies in the effects literature plyometric training on velocity values. In a study conducted by Poomsalood, & Pakulanon (2015), the aim of the study was the effects of a 4-week plyometric program designed for basketball movements that include speed, agility and leg muscle strength in men's college basketball player. the results showed that there was an improvement when comparing the results after testing in between training group and control group, that was it found speed and agility in the training group were significantly higher than those in control the group. In a study by Correia et al. (2020) results showed that all in small groups improved their CMJ (p = 0.007) and SJ (p = 0.001). Ramirez-Campillo et al. showed significantly improving CMJ results: [D 4.4%, ES = 0.23]; SJ: [D 5.1%, ES = 0.27]) after 6 weeks of plyometric training with football players. Thomas et al. have not seen significant improvements in running speed in postadolescent semi-professional footballers (ages = 17.3 ± 0.4 years) after 6 weeks of the deep jump or CMJ training. A study by Assadi & Arazi (2012) found a significant 23% improvement in vertical jump after a 6-week PT among semi-professionals basketball players.In the study, Aksović et al. (2020b) the results obtained showed an improvement in the 5m and 20m sprints in young basketball players, while the effect of the plyometric program on the 10m sprint was absent. Based on some research it has been shown that the combination of strength training and plyometric training gives results in improving the sprint time at 5 and 10 m and muscle strength performance than plyometric training alone in male adolescents (Fathi et al.,2019; Eraslan et al.,2021). A limitation of this study is the lack of a control group. With the existence of a control group, it is possible to compare the effect of the diagram between the experimental and control groups. Also, basketball players could be sampled so that they could be compared to male. In further research, the effects of combining a plyometric program with various strength, speed, agility, and other fitness training, depending on the sport, could be examined, because some studies have shown a positive effect.

CONCLUSION

This study showed that applying for a six-week plyometric program, caused positive effects on CMJ and SJ in young basketball players. Qualitative results have shown that plyometric programs are useful for SJ and CMJ. Based on the results obtained in the research, it is possible to confirm the importance of applying plyometric training to all types of training aimed at improving vertical jump and explosive forces in athletes, as well as different age groups.

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MOTOR SKILLS INFLUENCE ON MORPHOLOGY PARAMETERS IN MALE PRESCHOOL CHILDREN INCLUDED IN THE ARTISTIC GYMNASTICS RECREATIONAL PROGRAM

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ABSTRACT

The performance in artistic gymnastics can be determined by the optimal trade-off between physical fitness and extensive technical abilities. Also, a greater fitness level is required, in order to meet the sports standards. Based on the necessity to monitor children's motor development and morphology, we have aimed to examine the influence of motor skills on morphology parameters in male preschool children that are included in the artistic gymnastics recreational program. A total of 19 preschool boys (5.32±0.89 years) were taken into consideration. They were already included in the artistic gymnastics preschool recreational program (3x a week/60 min. per training). Morphology parameters were assessed based on a total of 8 anthropometric characteristics measures: body height, body weight, Body Mass Index (BMI), and adipose tissues: triceps (ATC), biceps (ABC), subscapular (ASB), suprailiac (ASP), and triceps surae (ATS). Likewise, motor skills were assesed using the Eurofit Batery test: flamingo balance test (FBT), plate taping (PTT), sit and reach (SAR), standing board jump (SBJ), handgrip strength (HGS), sit-ups (SUP), bent arm hang (BAH), backward polygon (BWP) and shuttle run 10x5 (SHR). By implementing the regression analysis, we have identified that only adipose tissue triceps (ATC) have showed to be significant for whole set of variables (p=.050), as well as for the separate variables, handgrip strength (HGS), sit-ups (SUP) and shuttle run 10x5 (SHR) (p=.009; p=.026; p=.018, respectively). In order to obtain more precise results, there is a necessity for more periodic checks and follow-ups, cross-sectional and longitudinal studies. Likewise, as an inexhaustible space of new knowledge for talent identification, spotting young gymnasts who exhibit qualities for potential success in the future are worthwile.

Keywords: Eurofit Battery test, impact, skinfold, preschoolers, recreational gymnastics

INTRODUCTION

Fitness, sports engagement and motor skill development are important components to consider as possible indicators of child health (Lloyd, Colley, & Tremblay, 2010). In that regard, physical activity in childhood has also been related to better adult health outcomes (Kvaavik, Klepp, Tell, Meyer, & Batty, 2009). The development stages, with the help of monitoring the physical development and growth of an individual, are mutually dependent, because they complement each other (Halaši, 2016). As a result, it is necessary to monitor children's physical growth, motor development, skill development and morphology, because their bodies are vulnerable to variety of internal and external factors/impacts, of which are felt later in life and are difficult to „change". (Popović, 2008). Hence, bio-psycho-social status (constitution, body composition, structure), as an organized and relatively constant totality and morphological characteristics are connected (Božić-Krstić et al., 2003).

Artistic gymnastics promotes jumping, explosive power, pushing and pulling abilities, stability, and aesthetics development (Bradshaw et al., 2010; Bressel et al., 2007; Gautier et al., 2008; Sleeper et al., 2014). The performance itself is determined by the optimal trade-off between physical fitness and extensive technical abilities, that are required (Minganti et al., 2010). Thus, a greater fitness level is required, in order to meet the sports standards (Mellos et al., 2014). More precisely, some authors (Bassa et al., 2002; French et al., 2004) are emphasizing that increased stamina, elasticity and synergy levels are in the interest of effective and accurate performance in this sport. In that regard, it is crucial to primarily influence the fundamental skills, i.e motor behaviour, by learning the basic artistic gymnastics positions/elements, since a delay in it's development will have a direct impact on the child's performance in executing simple motor activities, let alone more complex ones (Hands, 2008; Popović, 2010).

On a sample of 220 preschool children, Zarić et al. (2018) have two groups, developmental gymnastics program as organized physical activity and unorganized physical activity group. Beside anthropometric characteristics, motor skills were also taken into consideration. Applied t-test have revealed differences in almost all variables, whereas the organized physical activity group have showed better results in all health-related fitness variables. Jaksic et al. (2020) have had similar program, with aim to investigate it's effects on physiological characteristics and motor skills. The study results have revealed that body weight significantly increased in both experimental and control group over time. Likewise, experimental group have significantly progressed in chest cicumference, running speed, standing board jump and bent arm hang test, whereas waist cicumference and flexibility remained unchanged. In cross-sectonal study conducted by Pavlović & Marinković (2013), it was identified significant correlation between skinfold circumference with bent arm hang test and backward polygon in preschool boys. Similarly, Đorđević et al. (2020) have revealed significant correlation in most of morphological characteristics and motor skills in preschool gymnasts.

According to the previously stated, there is a great need to focus on motor skills and morphology characteristics examination and it's impacts on one another, for two reasons: in order to prevent the health risk development throughout early childhood and later in life, as well as for talent identification. In that regard, in this cross-sectional study, we have aimed to examine the influence of motor skills on morphology parameters in male preschool children that are included in the artistic gymnastics recreational program.

METHODS

Subjects

A total participant sample were consisted of 19 preschool boys (5.32±0.89 years) and as active members of the Gymnastics Club „Niš", they were already included in the artistic gymnastics preschool recreational program (3x a week/60 min. per training). Participants descriptives were presented in Table 1.

Table 1. Participants descriptive statistics values

Variables	Mean±SD	Min	Max	Range	Skew	Kurt
Age (years)	5.32±.89	4	7	3	.36	-.25
Body height (m)	1.19±.06	1.05	1.30	0.25	-.45	.20
Body weight (kg)	22.58±4.03	15	29	14	-.33	-.56
BMI (kg/m^2)	15.80±1.80	13.08	19.24	6.16	.13	-.98

Legend: SD-standard deviation, Min-lowes value, Max-highest value, Skew-skewness, Kurt-kurtosis, BMI-Body Mass Index

Procedure

Participants morphology parameters were assessed based on a total of 8 anthropometric characteristics measures: body height, body weight, Body Mass Index (BMI), and adipose tissues: triceps (ATC), biceps (ABC), subscapular (ASB), suprailiac (ASP), and triceps surae (ATS). The technique and conditions for measuring anthropometric characteristics were carried out in accordance with the International Biological Program (IBP) (Lohman, Roche, & Martorell, 1988), using the following measuring instruments: Martin anthropmeter, calibrated weight and caliper. BMI was additionally calculated, using the formula: BMI=kg/m^2.

Furthermore, motor skills were assesed using the Eurofit Batery test, consisted of 9 tests: flamingo balance test (FBT), plate taping (PTT), sit and reach (SAR), standing board jump (SBJ), handgrip strength (HGS), sit-ups (SUP), bent arm hang (BAH), backward polygon (BWP) and shuttle run 10x5 (SHR).

Informed consent was obtained before any measurement assessment, whereas all the measurements were obtained according to the Helsinki Declaration.

Statistical analysis

In order to determine necessary statistical processing data based on the study aim, descriptive statistics, Kolmogorov-Smirnov Z test and regression analysis were conducted, using the SPSS v20.

RESULTS

As presented in the Table 2, the normality distribution values are showing that the most of the parameters are normally distributed, except the variables adipose tissues triceps (ATC), biceps (ABC), subscapular (ASB), suprailiac (ASP) and flamingo balance test (FBT).

Table 2. Descriptive statistics with normality distribution values

Variables	Mean±SD	Skew	Kurt	1KS	p
ATC	5.61±6.10	.54	-1.58	1.564	**.015**
ABC	2.99±4.58	1.66	1.09	2.028	**.001**
ASB	1.68±3.12	2.80	6.60	2.151	**.000**
ASP	4.05±5.12	.91	-1.22	1.809	**.003**
ATS	11.48±5.19	-1.40	1.07	1.000	.270
FBT	18.30±27.62	3.20	11.45	1.383	**.044**
PTT	18.84±4.17	.81	-.21	.510	.957
SAR	19.89±6.10	-.47	1.31	.604	.860
SBJ	101.53±23.95	-.39	-.19	.393	.998
HGS	5.37±4.08	1.39	1.62	.814	.521
SUP	12.00±5.02	-0.19	-.82	.560	.913
BAH	3.41±2.89	1.03	.54	.718	.681
BWP	26.63±5.99	.02	-.81	.421	.994
SHR	46.80±5.55	.87	.84	.587	.880

Legend: SD-standard deviation, Skew-skewness, Kurt-kurtosis, 1KS-Kolmogorov-Smirnov Z test, p-statistical signifiance ($p<0.05$), ATC-adipose tissue triceps, ABC-adipose tissue biceps, ASB-adipose tissue subscapular, ASP-adipose tissue suprailiac, ATS-adipose tissue triceps surae, FBT- flamingo balance test, PTT-plate taping, SAR-sit and reach, SBJ-standing board jump, HGS-handgrip strength, SUP-sit-ups, BAH-bent arm hang, BWP-backward polygon, SHR-shuttle run 10x5

Tables 3 and 4 are showing the results of the conducted regression analysis. As presented in the Table 3, the results of the regression analysis are showing that only adipose tissue triceps (ATC) have showed to be significant for whole set of variables (p=.050), whereas for the rest of the variables (on both whole set of variables and separately), there is no significance. Obtained significance can be expained by the Beta values, as well as from the only 3 significant p values for separate variables, handgrip strength (HGS), sit-ups (SUP) and shuttle run 10x5 (SHR) (p=.009; p=.026; p=.018, respectively).

Table 3. Regression analysis of dependent variables BMI, ATC and ABC

Variables	BMI				ATC				ABC			
	Beta	p	F	p	Beta	p	F	p	Beta	p	F	p
FBT	.052	.920	.649	.735	-.328	.336	3.050	**.050**	-.076	.851	1.766	.205
PTT	.149	.722			.250	.357			-.193	.552		
SAR	-.031	.935			.028	.906			.499	.112		
SBJ	.080	.881			-.207	.547			-.899	.051		
HGS	.682	.332			1.396	**.009**			.088	.868		
SUP	.270	.561			.761	**.026**			-.321	.377		
BAH	-.090	.888			-.418	.320			1.051	.056		
BWP	.201	.565			.107	.630			.150	.579		
SHR	.178	.753			1.002	**.018**			-.068	.875		

Legend: BMI-Body Mass Index, ATC-adipose tissue triceps, ABC-adipose tissue biceps, FBT- flamingo balance test, PTT-plate taping, SAR-sit and reach, SBJ-standing board jump, HGS-handgrip strength, SUP-sit-ups, BAH-bent arm hang, BWP-backward polygon, SHR-shuttle run 10x5, Beta-standardized values of regression coefficient, F-multiple regression analysis significance test, p-regression significance level

Table 4. Regression analysis of dependent variables ASB, ASP and ATS

Variables	ASB				ASP				ATS			
	Beta	p	F	p	Beta	p	F	p	Beta	p	F	p
FBT	-.515	.268	1.219	.387	.176	.743	.545	.810	.000	1.000	.368	.924
PTT	.130	.717			-.128	.766			-.024	.957		
SAR	.517	.137			.025	.949			.589	.178		
SBJ	-.005	.991			-.446	.424			-.311	.597		
HGS	.510	.397			.607	.400			-.103	.891		
SUP	-.228	.569			.357	.460			.204	.688		
BAH	.490	.384			-.481	.473			.632	.379		
BWP	-.295	.337			.023	.949			.024	.950		
SHR	.074	.878			.196	.736			.165	.790		

Legend: ASB-adipose tissue subscapular, ASP-adipose tissue suprailiac, ATS-adipose tissue triceps surae, FBT- flamingo balance test, PTT-plate taping, SAR-sit and reach, SBJ-standing board jump, HGS-handgrip strength, SUP-sit-ups, BAH-bent arm hang, BWP-backward polygon, SHR-shuttle run 10x5, Beta-standardized values of regression coefficient, F-multiple regression analysis significance test, p-regression significance level

DISCUSSION

Our study aim was to examine the influence of motor skills on morphology parameters in male preschool children that are included in the artistic gymnastics recreational program. In that regard, the study results have revealed that presented motor skills, measured by the Eurofit Battery test, are influential only on adipose tissue triceps (ATC) for whole set of variables (p=.050), whereas for separate variables, only handgrip strength (HGS), sit-ups (SUP) and shuttle run 10x5 (SHR) have revealed to be significant (p=.009; p=.026; p=.018, respectively).

Engaging in the gymnastics recreational programs may serve as one of the most benefitial method to learn numerous forms of movements (Coelho, 2010, Madić & Popović, 2012). Since we have identified that motor skills are influential only on adipose tissue triceps in preschool boys, our results can be connected to the results conducted by Zarić (2018). Mentioned study have discovered that preschool children included in the organized physical activity (i.e. developmental gymnastics, 6 months; 3x a week; 60-90min) have better results in abdominal and triceps skinfold, compared to the unorganized group. Furthermore, Jaksic et al. (2020) have also conducting multiple-sport physical activity (9 month; 2x a week; 60min.), and it is a noteworthy to mention that artistic gymnastics was conduted in mentioned period in fully. Hence, they have also revealed significant differences in the intervention group in adipose tissue triceps, compared to the control group who have participated only in standard preschool program and did not engaged in any organized physical activity program. Although children included in this sport most often have lower values of body mass circumferences and amount of subcutaneous adipose tissue (Zarić, 2018), there are some facts that should be taken into consideration. Both mentioned studies were longitudinal, our was cross-sectional, and have had included mixed sample of participants, we had males only, as well as the fact that both of them had control groups, we have not. Most importantly and from a practical point of view, the majority of elements in artistic gymnastics are conducted on straight arms and more less on bent (cartwheel or handstand on floor, basic swings or scissors on pommel horse, basic swings or L-sit on parallel bars etc.). Hence, as the m. triceps brachii is the elbow extensor, the result rationale is evident.

Furthermore, we have presented that handgrip strength, sit-ups and shuttle-run are influential on adipose tissue triceps (p=.009; p=.026; p=.018, respectively). Contrary, Đorđević et al. (2020) have revealed their non-significant small correlation between the adipose tissue triceps and mentioned parameters (r=.28; r=.11; r=.18 respectively). Also, it is a noteworthy to mention that in our case, standing board jump and bent arm hang are closest to be influential on adipose tissue biceps (p=.051; p=.056, respectively), which could be related to Đorđević et al. (2020), who have revealed small non-significant correlation between the mentioned parameters (r=-.16; r=.29, respectively). According to the above mentioned, the results can be explained by the previously acquired motor experience, which can be contribute to achieve a better result. Likewise, personality traits may represent a disturbing factor in assessng the actual ability level (Bala, 2004; Madić, 2006), as well as the maturation factor (Malina & Katzmarzyk, 2006), since there is a wide year range in both ours and compared study.

As far as the study limitations are concerned, we did not have included any control group to compare our results with. Likewise, we did not take into consideration the training experience, as well as the training frequency, since there were children who were rarely coming in the gymnastics hall, and we have still taken those children into consideration. Accordingly, future studies should include abovementioned.

CONCLUSION

Artistic gymnastics training allows for the most throught ideal morphological and motor skill parameters, which is why it is frequently recommended sport at preschool age. Also, there is a necessity for more periodic checks and follow-ups, cross-sectional and longitudinal studies, in order to obtain more precise results. In that regard, as an inexhaustible space of new knowledge for talent identification, spotting young gymnasts who exhibit qualities for potential success in the future are worthwile.

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DIFFERENCES IN AGILITY PERFORMANCE IN FUTSAL PLAYERS

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ABSTRACT

In this paper, the testing of various manifestations of agility in futsal, a sport characterized by intense activity, rapid changes in tempo and complex technical-tactical elements, was carried out. The aim of the paper is to determine whether there is a connection between morphological characteristics and agility tests and whether there is a difference between minor and adult players in the performance of agility tests. The sample of respondents consisted of junior futsal club Osijek, which included a total of 18 players of average age (17.06 ± 1.16 years), height (177.73 ± 9.03 cm) and mass (69.18 ± 8.66 kg). The sample of variables consists of six tests. Two tests are related to morphological characteristics (body height and body weight), while four tests are related to agility. The research results showed statistically significant moderate to high correlations between different variables ($p < 0.05$). Analysis of group statistics reveals that minor players on average achieve better results in most tests, except for the T-test of agility and reactive agility test knowing that they go left first, where adult players record better results. There are statistically significant differences in agility between minor and adult players in the 10-meter sprint test, which measures a certain aspect of agility, minor players proved to be superior to their adult counterparts, with an average time of 1.72 seconds, which is statistically significant ($p < 0.05$) faster, the same applies to the reactivity tests (first on the right) and the reactivity test. These results suggest that minor players have an advantage in some manifestations of agility and reactivity compared to adult players, which may be crucial for planning training and developing strategies to improve player performance in the future.

Keywords: Futsal, reactive agility, sprint speed

INTRODUCTION

Futsal requires constant changes in speed, direction and technical-tactical elements of the game (Rodrigues et al., 2011). Due to the importance of agility in the game, diagnostic protocols for this motor ability are essential in a scientific and coaching context (Zeljko, 2020). Agility is a key ability in futsal that indicates the player's ability to quickly change direction or speed of movement (Milanović et al., 2011; Spasić et al., 2015). There is a difference between pure change of direction and agility, where agility is reactive and related to response to external stimuli. In everyday practice, agility is tested to assess player abilities and guide training practice (Dawes, 2019). Knoop et al. (2013) developed a test to assess the reactive agility of soccer goalkeepers using light-emitting diodes. Benvenuti et al. (2010) created a test to measure differences in reactive agility between soccer and futsal players using light signals. Uchida et al. (2013) developed a test for "open-skill" sports, using a computer to instruct subjects. The aim of this paper is to determine whether there is a connection between morphological characteristics and agility tests and whether there is a difference between minor and adult players in the performance of agility tests.

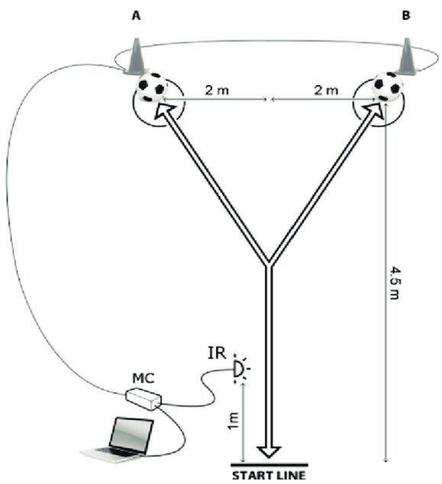
METHODS

Subjects

The study sample is made of the U19 category of the futsal club Osijek, a total of 18 players (10 minors, 8 adults) of average chronological age (17.06 ± 1.16 years), body height (177.73 ± 9.03 cm) and body weight (69.18 ± 8.66 kg). The sample of respondents was divided into minor and adult players. There were ten minor players, with average chronological age (16.20 ± 0.79), body height (178.85 ± 11.49) and body weight (67.78 ± 5.91 kg). There were eight adult players, with average chronological age (18.13 ± 0.35), body height (176.33 ± 4.93) and body mass (70.93 ± 11.45 kg).

Procedure

The sample of variables consists of six tests. Two tests are related to morphological characteristics (body height and body weight), while four tests are related to agility. The tests that determined speed and speed of change of direction are as follows: 10-meter sprint, T agility test, reactive agility test and random reactive agility test. Body height was measured using an anthropometer and the result was expressed in centimeters. Body weight was measured using a digital scale. The test was performed once and the result is expressed in kilograms. Sprint speed at 10m was measured using the Microgate Witty system from a high start, and the test was performed three times. The agility T test was also measured using the Microgate Witty system from a high start and the test was performed three times. The random reactive agility test starts with the player running at maximum intensity through the door where the IR signal is placed (Figure 1). At that moment, the timing started, one of the cones (either "A" or "B") was lit, and the player had to run at maximum speed in the direction of that cone, leading the ball, leaving it in the marked area and returning through the starting gate as quickly as possible. When passing the starting gate on the way back, the timing was stopped, and the running speed was recorded, the test was carried out three times. The reactive agility test was conducted in the same way, only in this test the players knew which cone would be lit after passing the starting gate.



Picture 1. Testing polygon for reactive agility (RRAG i NRAG)

Statistical analysis

Data analysis was performed using the IBM SPSS software package. For the results of the subject's research variables, the following descriptive statistical indicators were calculated: arithmetic mean (Mean), median (Median), lowest value (Min), highest value (Max), standard deviation (SD), indicators of asymmetry of distribution (Skewness) and indicators distribution elongation (Kurtosis). To determine the normality of the distribution, the Shapiro-Wilk test was used. The t-test for independent samples was used to determine the correlation between study variables.

RESULTS

In Table 1. Are presented the basic descriptive parameters of the research variables for the variables ALVT, AVTT, S10, TTEST.

Table 1. Basic descriptive parameters of the study variables divided by subsamples

		N	Mean	Std. Dev.
S10 (s)	Minor (under 18)	10	1.72	0.09
	Adult (age 18, 19)	8	1.82	0.07
TTEST (s)	Minor (under 18)	10	10.79	0.61
	Adult (age 18, 19)	8	10.75	0.41
RAGL (s)	Minor (under 18)	10	3.59	0.34
	Adult (age 18, 19)	10	3.57	0.08
L (s)	Minor (under 18)	8	3.91	0.51
	Adult (age 18, 19)	10	3.61	0.10
D (s)	Minor (under 18)	8	3.76	0.66
	Adult (age 18, 19)	10	3.68	0.24
NRAGD (s)	Minor (under 18)	8	3.38	0.25
	Adult (age 18, 19)	10	1.73	1.85
LL	Minor (under 18)	8	3.19	0.28
	Adult (age 18, 19)	10	3.24	0.11
DD	Minor (under 18)	8	3.40	0.26
	Adult (age 18, 19)	10	1.62	1.73

Table 2. T – test for independent samples

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
S10 (s)	Equal variances assumed	1.43	0.25	-2.54	16	0.02	-0.10
	Equal variances not assumed			-2.62	15.96	0.02	-0.10
TTEST (s)	Equal variances assumed	1.56	0.23	0.16	16	0.88	0.04
	Equal variances not assumed			0.16	15.59	0.87	0.04
RAGL (s)	Equal variances assumed	5.74	0.03	0.13	12	0.90	0.02
	Equal variances not assumed			0.20	10.96	0.842	0.02
L (s)	Equal variances assumed	6.39	0.03	1.15	11	0.28	0.30
	Equal variances not assumed			1.70	9.28	0.12	0.30
D (s)	Equal variances assumed	0.58	0.46	0.24	12	0.81	0.08
	Equal variances not assumed			0.34	12	0.74	0.08
NRAGD (s)	Equal variances assumed	883.50	0.00	2.80	16	0.01	1.65
	Equal variances not assumed			2.50	7.21	0.04	1.65
LL (s)	Equal variances assumed	10.26	0.01	-0.37	12	0.72	-0.06

	Equal variances not assumed			-0.53	12	0.61	-0.06
DD	Equal variances assumed	823.38	0.00	3.24	16	0.01	1.80
	Equal variances not assumed			2.90	7.24	0.02	1.80

Levene's test does not show a statistically significant difference between the variances of variables S10, TTEST, D and DD ($p > 0.05$). There is a statistically significant difference in the S10 test ($p < 0.05$), where minor players achieved better results on average than adult players. There is no statistically significant difference in the TTEST variable ($p > 0.05$). There is no statistically significant difference in D (random reactive agility test to the right, $p > 0.05$) but there is a statistically significant difference in DD (reactive agility test to the right, $p < 0.05$) in which minor players achieved a better average result than adult players. Levene's test shows a statistically significant difference between the variances of the variables RAGL, L, NRAGL and LL ($p < 0.05$). There is no statistically significant difference in the RAGL, L test (random reactive agility test to the left), but there is a statistically significant difference in the NRAGL ($p < 0.05$), where minor players on average achieved a better result than adult players.

DISCUSSION

The results of this research indicate that younger players tend to achieve better results in the 10-meter sprint. This may be the result of physiological predispositions, such as greater explosiveness and speed ability in younger individuals (Armstrong and van Mechelen, 2008). The lower body mass of younger players may play a role, as it is known that there is a relationship between body mass and sports performance (Nevill, Stewart, Olds, & Holder, 2006). Although adult players performed better in the T test for agility but the difference was not statistically significant. According to Sheppard and Young (2006), agility is a complex ability that can vary among athletes depending on various factors, including experience and training.

A statistically significant moderate to high correlation was found between various parameters including reactive agility tests and body weight and agility tests. In the research Sekulić et al. (2020), various player abilities were investigated, while the research by Krolo et al. (2020) focused more on reactive agility and speed of direction change, which is similar to the current results.

Comparing the research results with Sekulić et al. (2020), it is observed that in both studies younger players show better performance in certain tests compared to older players. For example, in the results of this research, younger players achieved better results in the DD and NRAGL variables, which can be compared with the findings of Sekulić et al. where younger players, although they did not show a significant difference in anthropometry, were better in certain tests, implying better reactive agility. However, Sekulić et al. point out that the difference could be caused by technical skills or tactical knowledge, which could be significant for the interpretation of the results of this research.

On the other hand, the research by Krolo et al. (2020) deals in detail with the reliability and validity of newly developed tests of reactive agility and speed of change of direction, thereby confirming the importance of these factors in determining success in futsal. In this study, older players (U15) were found to perform better in most tests compared to younger players (U13), which is in contrast to the current results where younger players showed better performance in certain tests.

Research by Sekulić et al. and Krolo et al., emphasize the importance of reactive agility and speed of change of direction in determining performance in futsal, with special emphasis on possible differences between age groups. Additionally, future research could investigate how other factors, such as technical skills and tactical knowledge, may influence these variables.

CONCLUSION

This research provides insights into the potential association between morphological characteristics and performance among junior futsal club Osijek. Further research is needed to better understand the impact of on-field performance. The results indicate that body height and mass do not play a key role in specific performances such as short sprints and agility. It is important to note that the sample of 18 players is relatively small and specific to one club, which may limit the generalization of the results. This suggests that more research could provide better insight into how body characteristics affect performance in the futsal field.

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IMPACT OF MORPHOLOGICAL CHARACTERISTICS AND MOTOR-FUNCTIONAL ABILITIES ON THE EFFICIENCY OF PERFORMING MOVEMENT STRUCTURES IN DANCE AMONG YOUNG DANCERS

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ABSTRACT

The goal of the research was to determine the significance and relative size of the influence of morphological characteristics, motor and functional abilities marked as an input or predictor set on the effectiveness of the implementation of a composite test in dance that serves to assess the success in the realization of dance structures of movement in dance, marked as an output or criterion set. The sample of respondents consisted of 84 young dancers of both sexes aged 11-16 from The respondents were recruited from 4 different dance academies. The research used a set of 15 variables for the assessment of morphological characteristics, a set of 8 variables for the assessment of motor abilities and a set of 7 variables for the assessment of functional abilities marked as a predictor set and a composite test that assessed the level of success in the performance of dance movement structures marked as a criterion. To determine the significance and relative size of the influence of morphological characteristics, motor and functional abilities marked as a set of predictors on the efficiency of the implementation of the composite test in dance, which serves to assess the success in the realization of dance structures of movement in dance, marked as a criterion, a regression analysis was applied. The obtained results of the regression analysis show a statistically significant influence of the selected predictor variables on the success in the realization of dance movement structures (R = 0.76). The results of the research provided useful information about the most informative morphological characteristics and motor-functional abilities for success in the performance of specific dance structures, and thus their role for success in dance. The obtained research results can serve as a significant orientation in better programming of training work in dance with young dancers, which must be taken into account in the selection of training activities when programming training work.

Keywords: dance, subjects, morphological characteristics, motor and functional abilities, regression analysis.

INTRODUCTION

Dance is a sport, however, we all perceive it as an art. The World Dance Federation estimates that more than 4 million people are actively engaged in dance, and its popularity is growing every day. Although many high social classes owned it, it has always belonged to everyone. Dance has its own educative, educational, socializing and aesthetic character. By joining the family of sports, where the slogan "Citius, altius, fortius" is often heard, a scientific approach to the management of training processes in dance is introduced. The synergy of endogenous and exogenous factors, i.e. certain morphological characteristics, motor and functional abilities, psychological traits and everything that is defined as the psychosomatic status of an athlete, affects the improvement of results, which is the main goal of competitive sports. The aesthetic, emotional and visual experience and the very communication that dance artists achieve with the audience undoubtedly lead us all through the most beautiful dance fairy tales and untold stories in the dance atmosphere.

Success in dance is assessed through harmony, general beauty, elegance, rhythm and precision, harmony and elaborate artistic performance (Anthony, 1968: according to Zaletel, Tušak and Zagorc, 2006).

Training is a specific process, and for each individual, the order of activities and the number of factors, on which success depends, are continuously programmed. When it comes to programming dance training, research by Bonacin, D. and Bonacin, Da., is helpful (2007) who points out that "there are sports in which models based on cybernetics cannot meet the increased requirements for achieving results. "These sports include those with a high "dose" of creativity, and the programming must be adapted to each subject for the purpose of his optimal development.''

In order for sports training to be successfully planned, programmed and operationalized, it is necessary to find out which anthropological characteristics of athletes influence success in a certain sports branch or discipline, because only those traits and abilities that influence success in that sport should be systematically processed in the course training process.

Knowing the characteristics and abilities that have the greatest influence on achieving the desired results in every sport, even in dance, as well as the possibilities of their improvement, is the key basis for quality programming, monitoring and management of the training process.

In doing so, the laws of the training process must not be ignored, and the programming of training activities should be based on clearly defined goals and tasks of the training units, not neglecting endogenous and exogenous factors of sports development. Unfortunately, often in practice, the management of training processes is based on the trainer's "feeling" and previously acquired experience. Therefore, errors in the diagnosis of the athlete's state of training are inevitable, and accordingly, the need for a more organized approach to the management of transformational processes in dance arises.

METHODS

Subjects

The sample of respondents consisted of 84 young dancers of both sexes, aged 11-16 years, from Dance Club "Gemma" Banja Luka, Dance Club "City Jazz" Banja Luka, Dance Club "Bolero" Banja Luka and Dance Club "Orion" Pale. When selecting respondents for this research, it was taken into account that all respondents were between the ages of 11 and 16, that all respondents were medically examined, that they regularly attended training sessions, that they were registered in the current year as competitors in the home dance association at the level of Bosnia and Herzegovina. The dance class of the competitors is I (international) and A (highest national).

The research included subjects in accordance with all relevant national regulations and institutional policies, and followed the principles, ethical guidelines and rules for research with human subjects in accordance with the Declaration of Helsinki.

Predictor set of variables

A sample of variables for the assessment of morphological characteristics:

1. body height... AVISTJ

2. arm length...ADUZRU

3. leg length.. ADUZNO

4. foot length.. ADUZST

5. abdominal circumference...AOBTRB

6. circumference of the upper arm..AOBNAD

7.circumference of the forearm...AOBPOD

8. circumference of upper leg..AOBNAT

9. lower leg circumference..AOBPOT

10. body weight...ATEZTJ

11. body mass index..ABMIDX

12. skin fold of the upper arm.. ....AKNNAD

13. skin fold on the back...AKNLED

14. skin fold on the stomach..AKNTRB

15. skin fold of lower leg..AKNPOT

A sample of variables for the assessment of motor skills:

16. Flamingo balance test ....MFLAMI

17. taping by hand.. ....MTAPRU

18. foot taping..MTAPNO

19. standing long jump...MFESDM

20. Sergeant jump test...MFEVIS

21. drumming with hands and feet..MBUBRN

22. lateral speed change moving to the left side...MLATBL

23. lateral speed change movement to the right..MLATBD

A sample of variables for assessing functional abilities:

24. forced expiratory volume.. ....FFEV75

25. maximum expiratory volume in the first second...FMFEV1

26. forced vital capacity..FFVCAP

27. maximum speed of exhalation...FMAPEF

28. maximum voluntary ventilation...FMVVNT

29. time needed to exhale lung capacity...FFETME

30. heart rate at rest...FSRFRM

Criterion variable

The composite test (SMKOMT) was used as a criterion for evaluating the influence of the predictor set of variables on the performance of movement structures in dance.

Statistical analysis

The data obtained in this research were processed using the STATISTICA 6.0 and SPSS 14.0 software packages. A regression analysis was used to determine the significance and relative size of the influence of morphological characteristics, motor and functional abilities marked as a set of predictors on the effectiveness of the performance of the composite test in dance, which serves to assess the success in the performance of specific dance movement structures, marked as a criterion.

RESULTS

In this research, the three spaces of anthropological status were observed as one system of variables - a predictor system in determining the influence on the assessment of the performance of the composite test, as a criterion, which assesses the success of the realization of specific movement structures in dance.

Based on the size of the multiple regression (RO), the shared variance (DLT) is explained only if it is statistically significant. If the multiple correlation is statistically significant, the analysis of the influence of individual variables on the performance of the composite test in the examined population was started.

Regression analysis of the criterion variable for assessing the level of performance of movement structures in dance (SMKOMT) in manifest space

The results of the regression analysis of the criterion variable SMKOMT, which assesses the level of success in the realization of specific movement structures in dance, are shown in table 1. By looking at the given table, it can be seen that the entire system of predictor variables is significant in the prediction of the criterion variable at the level of significance p=0.032, which means that it is possible to approach the analysis of the relative influence of each individual predictor on the criterion. The coefficient of multiple correlation is very high and amounts to R = 0.76 (table 1), which explains the connection of all 30 variables from three areas as predictors and the composite test in dance as a criterion.

The entire system of predictors explains 57% of the common variance of the criterion system (DLT 0.57) (table 1).

Analyzing the influence of individual variables of the predictor system on the performance of the composite test shows a statistically significant influence of almost the entire system of predictor variables. In the explanation of the criteria, the following variables are singled out:

- from the morphological space, body weight (ATEZTJ 9.3%) – variable for estimating body mass, upper leg circumference (AOBNAT 13.0%) – variable for estimating body circumference;
- from the motor area, drumming with arms and legs (MBUBRN 19.2%), – a variable for assessing coordination, long jump from a standing position (MFESDM 11.6%) and Sergeant jump test (MFEVIS 7.8) - a variable for assessing explosiveness leg strength, lateral speed change moving to the left side (MLATBL -13%) and lateral speed change moving to the right side (MLATBD 26%);
- from the functional space, forced expiratory volume (FFEV75 28%) and maximum voluntary ventilation with a negative sign (FMVVNT -31.3).

The following variables stand out as distinct predictors in the explanation of the criterion variable:

- upper leg circumference variable (AOBNAT) from the morphological space,
- variables drumming with arms and legs (MBUBRN) and lateral change of speed moving to the right side (MLATBD) from the motor area.

Table 1. *Regression analysis of the criterion variable for assessing the level of performance of specific movement structures in dance (SMKOMT) in manifest space*

	R	Q(R)	P-R	B	P	S-B	Q(B)	F(B)
AVISTJ	0.1790	0.1016	-0.0200	-0.0670	-1.1983	0.4599	0.8796	0.2364
ATEZTJ	0.1265	0.2519	0.1049	0.7355	9.3073	0.9576	0.5479	0.1672
ABMIDX	0.0802	0.5240	-0.0560	-0.2509	-2.0138	0.6145	0.6875	0.1060
ADUZRU	0.1839	0.0923	-0.0212	-0.0341	-0.6268	0.2209	0.8725	0.2430
ADUZNO	0.1262	0.2533	-0.0960	-0.2040	-2.5739	0.2905	0.5073	0.1667
ADUZST	0.1528	0.1639	-0.0586	-0.0767	-1.1716	0.1796	0.6747	0.2018
AOBTRB	0.1106	0.3193	0.0468	0.1178	1.3034	0.3455	0.7340	0.1461
AOBNAD	0.1534	0.1622	0.1846	0.2866	4.3965	0.2096	0.1741	0.2026
AOBPOD	0.1845	0.0912	-0.1190	-0.2410	-4.4467	0.2761	0.6092	0.2437
AOBNAT	0.2102	0.0538	0.2765	0.5973	12.5567	0.2851	0.0386	0.2777
AOBPOT	0.0586	0.6038	-0.2234	-0.5009	-2.9339	0.3002	0.0973	0.0774
AKNNAD	-0.0545	0.6289	0.0065	0.0114	-0.0620	0.2419	0.9616	-0.0720
AKNLED	-0.0559	0.6200	-0.1066	-0.1935	1.0825	0.2479	0.5556	-0.0739
AKNTRB	-0.0626	0.5790	-0.0462	-0.0766	0.4799	0.2274	0.7369	-0.0827
AKNPOT	-0.1535	0.1620	0.0064	0.0081	-0.1246	0.1746	0.9620	-0.2027
FFEV75	0.1467	0.1820	0.2172	18.887	27.6984	11.661	0.1074	0.1937
FMFEV1	0.1490	0.1750	0.0012	0.1018	1.5170	120.062	0.9894	0.1968
FFVCAP	0.1224	0.2682	0.0105	0.0264	0.3238	0.3458	0.9374	0.1617
FMAPEF	0.1755	0.1086	-0.1027	-0.1718	-3.0144	0.2286	0.5378	0.2318
FMVVNT	0.1487	0.1758	-0.0243	-21.096	-31.3736	119.345	0.8546	0.1964
FFETME	-0.1135	0.3063	0.0166	0.0190	-0.2154	0.1575	0.9003	-0.1499
FSRFRM	0.0836	0.5429	-0.0187	-0.0160	-0.1336	0.1172	0.8872	0.1104
MFLAMI	-0.2169	0.0466	-0.0454	-0.0372	0.8063	0.1123	0.7410	-0.2864
MTAPRU	0.3754	0.0009	-0.1802	-0.1992	-7.4792	0.1494	0.1850	0.4959
MTAPNO	0.2959	0.0070	0.0857	0.0819	2.4225	0.1307	0.5408	0.3909
MBUBRN	0.4099	0.0003	0.4697	0.4697	19.2536	0.1212	0.0005	0.5415
MFESDM	0.5070	0.0000	0.1730	0.2279	11.5559	0.1782	0.2039	0.6697
MFEVIS	0.4630	0.0001	0.1666	0.1697	7.8577	0.1379	0.2218	0.6116
MLATBL	-0.3778	0.0008	0.1989	0.3272	-12.3596	0.2214	0.1417	-0.4990
MLATBD	-0.4539	0.0001	-0.2966	-0.5834	26.4773	0.2580	0.0262	-0.5995
	DLT	S-DLT	RO	F	DF1	DF2	p	
	0.5731	0.6534	0.7570	2.3718	30	53	0.0032	

Table 2. *Analysis of variance*

	Sum of Squares	Df	Mean squares	f	p
Regresion	56.502	30	1.8834	2.3718	**0.0032**
Residual	42.085	53	0.7941		
Total	98.5885				

Legend: R-correlations of predictor variables and criteria, Q(R)-level of significance, P-R-partial correlations of predictors with criterion, B-beta coefficient, P-percentage of explanation of criteria, S-B-errors of beta coefficient, Q(B)-significance of beta coefficient, RO-coefficient of multiple correlation, DLT-coefficient of determination of criterion variable (explained part of the common variance), p-significance of regression (entire table)

DISCUSSION

Analyzing the results of the regression analysis, it can be concluded that there is a statistically significant influence of the entire predictor system on the criterion (success in the realization of dance technique elements) and that all applied predictor variables participate in the specification equation.

The negative sign of the variable lateral speed change moving to the left side (MLATBL -13%), may point to the conclusion that the subject has a violation of the existing symmetry between the right and left sides. The reasons for such a phenomenon should be sought in the choice of training operators (exercises) that are applied in the training of dancers.

The variable, forced expiratory volume (FFEV75), contributes to the explanation of the criteria with 28%, which indicates that the training takes into account the proper breathing of the dancer as an important factor in the performance of dance movement structures.

The negative sign of the variable, maximal voluntary ventilation (FMVVNT), may indicate a disturbance, because it is not possible to breathe voluntarily, but as required by the performed activity.

Based on the results of the regression analysis, it can be concluded that the applied predictor variables have a significant impact on the performance of dance structures, which must be taken into account in the selection of training activities when programming the training work.

Based on the results of the regression analysis, it can be concluded that there is a statistically significant influence of the selected morphological characteristics, motor and functional abilities as a set of predictor variables on the performance of technical elements in sports dance as a criterion.

Such results are consistent with previous similar research (Kostić, Miletić, Jocić and Uzunović, 2002; Kostic, Zagorc and Uzunovic, 2004; Sifrar and Zaletel 2014; Cosma, Dragomir, Dumitru, Lică, and Gheţu, 2016). and it also supports previous research about the connection of the observed spaces in this research (Srdic, Bajrić, Oreb, Lolic, & Zagorc, 2013).

The results of this research are directly applicable in the training process of young dancers as a basis for understanding important factors in the optimization of planning and programming, realization and monitoring of transformational processes in dance.

CONCLUSION

Regression analysis was applied with the aim of determining the significance and relative size of the influence of morphological characteristics, motor and functional abilities marked as an input or explanatory or predictor set on the efficiency in the performance of the composite test in dance, which serves to assess the success in the performance of dance movement structures in dance, marked as output or criterion set, regression analysis was applied.

Regression analysis determined the significance and size of the influence of the entire predictor system of variables on the criterion, as well as the prediction of the results in the criterion variable based on the individual influence of each of the variables of the predictor system.

In this research, the three spaces of the anthropological status of the interviewee-dancer were observed as one system of variables - a predictor system in determining the influence on the evaluation of the performance of the composite test, as a criterion.

The results of the regression analysis of the criterion variable SMKOMT show that the entire system of predictor variables is significant in the prediction of the criterion variable at the level of p = 0.032. The multiple correlation coefficient is very high and, as in the initial measurement, amounts to R = 0.76, which explains 57% of the common variance of the criterion system (DLT 0.57).

The variables, body weight (ATEZTJ 9.3%) – a variable for estimating body mass, upper leg circumference (AOBNAT 13.0%) – a variable for estimating body circumference from morphological space, had the largest partial contribution of individual motor variables in explaining the significance of the regression model. drumming with arms and legs (MBUBRN 19.2%), – variable for evaluating coordination, standing long jump (MFESDM 11.6%) and Sergeant jump test (MFEVIS 7.8) – variable for evaluating explosive leg strength, lateral change velocity movement to the left side (MLATBL -13%) and lateral change of velocity movement to the right side (MLATBD 26%) from the motor space, forced expiratory volume (FFEV75 28%) and maximum voluntary ventilation with a negative sign (FMVVNT -31.3) from the functional space.

Analyzing the results of the regression analysis, it can be concluded that there is a statistically significant influence of the entire predictor system on the criterion (success in the realization of the elements of dance technique) and that all applied predictor variables participate in the success specification equation.

The results of the research provided useful information about the most informative morphological characteristics and motor-functional abilities for success in performing specific dance structures, and thus their role for success in dance, which must be taken into account when programming, monitoring and managing the training process when working with young dancers.

The results of this research are directly applicable in practice as a significant factor in programming, monitoring and managing the training process in dance with young dancers.

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ANALYSIS OF DIFFERENCES IN MORPHOLOGICAL CHARACTERISTICS AND MOTOR-FUNCTIONAL ABILITIES IN JUNIOR DANCERS

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ABSTRACT

The research was conducted on a sample of 84 subjects - young dancers of both sexes, aged 11-16 years old, randomly divided into two groups, the experimental group (N = 44) with whom a three-month experimental program was implemented and the control group (N = 40) who trained according to the standard dance program. The respondents were recruited from 4 different dance academies. The research used 15 morphological variables, 8 motor variables, 7 functional variables and 1 variable used to assess the level of success in performing specific movement structures in dance so that together they form a battery of 31 measuring instruments. The main goal of the research was to determine the differences in morphological characteristics, motor and functional abilities between the experimental and control group of subjects - juniors in dance in the initial and final measurements. To determine the differences between the experimental and control groups of subjects in the initial and final measurements at the multivariate level, a multivariate analysis of variance was applied (MANOVA). For each applied variable, at the univariate level, differences were tested for dependent and independent samples (ANOVA), which can occur through two time points (initial and final measurement), as well as differences between the control and experimental groups in the initial and final measurement. The obtained results point to the conclusion that there were statistically significant differences between the subjects of the experimental and control groups in the final measurement and globally they are somewhat greater in favor of the experimental group.

Keywords: experimental program, dance, morphological characteristics, motor abilities, functional abilities

INTRODUCTION

Research on transformational processes in all sports, including dance, is very relevant today. The main goal of such research is to answer the question of whether and to what extent the mentioned programs can improve success in dance. Often in research, athletes of senior age are subjected to experimental treatment, however, younger ages, in this experiment juniors, were a challenge, given the inconsistent characteristics of the population aged 11 to 15, but also the fact that they are the base of future top competitors. The physical development of the mentioned age is intense, uneven and heterochronic in nature. Sudden changes occur upon entering puberty and it often happens that the biological age does not coincide with the chronological one. Consequently, motor development is intermittent and disproportionate, and is individual regardless of gender and previously acquired abilities. At an older age, transformations are slower and more difficult, so the established effects of targeted transformation processes at a younger age have practical value in designing future training programs.

The effects of training work (Srdic, Bajric, O., Bajric, S., & Ilic, 2023) mainly depend on the quality of the application of the appropriate forms and method of work, volume and intensity of load in accordance with the individual characteristics of athletes.

To determine the most optimal process of transformation of the relevant and dominant dimensions of the athlete's personality under the influence of training and recovery, along with monitoring their effects, is one of the biggest challenges of science, but also provides the basis for planning and programming the training process and the basis for the selection of athletes. Each transformation takes place through several stages in a certain period of time intervals, its integral part is the competition. Several researchers (Drabik 1996; Corbin and Noble, 1980; Malacko and Radjo, 2004) claims that the effects of the exercise process are different in certain time periods of the maturation process, and the advantage of this form of training work should be reflected in the application of an individualized form of work and determination of the optimal pace of development of abilities and characteristics in accordance with the age, gender and capabilities of each athlete.

Coordination, explosive strength and segmental speed influence performance in sports dance, a modern sports dance training can improve their results (Uzunović, 2008; Uzunović, Kostić and Miletić, 2009). There are studies that confirm the influence of anthropological dimensions on dance in general and to sports dance (Oreb, 1989; Kostić, Zagorc and Uzunović, 2004; Lukić and Bijelić, 2006; Vlašić, Oreb, Prlenda and Zagorc, 2011). Dancers spend more than half of their time in the high-intensity zone, from the point of view of functional load (Zagorc et al., 1999), and standard dances are more demanding (Šika, Banini, and Despot, 2003). It is also interesting to investigate the morphological space (Kostić et al., 2004), according to which dancers who have an ideal body weight without excess fat and a naturally narrow pelvis should be more successful in sports dancing, while Dolgener, Spasof and Džon (1980) determined that female dancers have lower body weight and less fat tissue, as well as that their body measurements are smaller. There is no doubt that the body of the dancer as an aesthetic criterion has an impact on the visual experience during evaluation at dance competitions, but it can also be the cause of various nutritional disorders at an early age and the consequences thereof are insufficiently known (Pigeon, Oliver, Charlet and Rochiccioli, 1997). .

Today, various types of additional training are applied in dance, which include aerobics, yoga, fitness,pilates, tai chi, acro balance and classical ballet classes. Special attention is also paid to the elements conditioning preparations, which certainly include proprioception training and drill training. The experimental program in this dissertation refers to determining the effects of proprioception training and training with a screw.

Proprioceptive training used to be used in rehabilitation, and today it is an indispensable part of preventive fitness training, which is also called proprioceptive vestibular visual training (PVV) and sensory-motor training. Proprioceptive training stimulates the activation of proprioceptors, which enables the body's optimal reaction in emergency situations that could lead to injury (Jukić, Milanović, Šimek, Nakić and Komes, 2003). Proprioception refers to static (conscious orientation between body parts) and dynamic (provides neuromuscular to the system information about speed and direction of movement) sense of position. The significance of proprioception training is greater, if it is known that proprioceptive deficit, weak musculature and lack of coordination are often cited as causes of ankle and knee injuries (Eils and Rosenbaum, 2001).

The screwdriver is used at the beginning of training as a means of warming up, but also for developing a series of motor skills abilities such as speed, coordination, speed of reaction, explosive power, agility, balance, rhythm, but also kinesthetic and proprioceptive sensitivity. Lee (2003) also indicates that it improves with a screw dynamoical balance.

METHODS

Subjects

Research was conducted on a sample of 84 respondents - young dancers of both sexes aged 11-16 years from Dance Club "Gemma" Banja Luka, Dance Club "City Jazz" Banja Luka, Dance Club "Bolero" Banja Luka and Dance Club "Orion" Pale. Respondents were randomly divided into two groups,, the experimental group (N = 44), with which the three-month experimental program was implemented and the control group (N = 40) who trained according to the standard dance program.

When selecting respondents for this research, it was taken into account that all respondents were between the ages of 11 and 16, that all respondents were medically examined, that they regularly attended the experimental program, that they were registered in the current year as competitors in the home dance association at the level of Bosnia Herzegovina. The dance class of the competitors is I (international) and A (highest national).

Procedure

The research included subjects in accordance with all relevant national regulations and institutional policies, and followed the principles, ethical guidelines and rules for research with human subjects in accordance with the Declaration of Helsinki.

Structure of the experimental program

Modern training technology in working with younger categories of dancers implies the creation of such experimental work programs that will be fully adapted to their age abilities. The experimental program implemented in this research through 40 training units consisted of a proprioceptive program (exercises on a balance board and exercises on a trampoline) and a program with a screw. The experiment was performed during regular dance training. Regular trainings began with a mandatory warm-up lasting 10-15 minutes, and then an experimental program lasting 15-20 minutes. The duration of individual tasks ranged from 30 seconds to 2 minutes.

The structure of the training content represented in the experimental program was as follows:

• 13 training sessions were carried out on the balance board,

• 13 training sessions were carried out with a screwball,

• 12 training sessions were carried out on the trampoline and

• 2 training sessions were carried out on a balance board and a combined trampoline.

A sample of variables for the assessment of morphological characteristics:

1. body height.. AVISTJ

2. arm length..ADUZRU

3. leg length.. ADUZNO

4. foot length.. ADUZST

5. abdominal circumference..AOBTRB

6. circumference of the upper arm..AOBNAD

7.circumference of the forearm..AOBPOD

8. circumference of upper leg..AOBNAT

9. lower leg circumference..AOBPOT

10. body weight..ATEZTJ

11. body mass index...ABMIDX

12. skin fold of the upper arm.. ....AKNNAD

13. skin fold on the back...AKNLED

14. skin fold on the stomach..AKNTRB

15. skin fold of lower leg..AKNPOT

A sample of variables for the assessment of motor skills:

16. Flamingo balance test ....MFLAMI

17. taping by hand... ....MTAPRU

18. foot taping...MTAPNO

19. standing long jump...MFESDM

20. Sergeant jump test..MFEVIS

21. drumming with hands and feet..MBUBRN

22. lateral speed change moving to the left side..MLATBL

23. lateral speed change movement to the right...MLATBD

A sample of variables for assessing functional abilities:

24. forced expiratory volume... ....FFEV75

25. maximum expiratory volume in the first second..FMFEV1

26. forced vital capacity...FFVCAP

27. maximum speed of exhalation...FMAPEF

28. maximum voluntary ventilation..FMVVNT

29. time needed to exhale lung capacity..FFETME

30. heart rate at rest...FSRFRM

Variable for assessing the level of success in performing elements of dance technique

31. composite test………………….............…………………………………..….SMKOMT

Statistical analysis

To determine the differences between the experimental and control groups of subjects in the initial and final measurements at the multivariate level, a multivariate analysis of variance was applied (MANOVA). For each applied variable, at the univariate level, differences were tested for dependent and independent samples (ANOVA), which can occur through two time points (initial and final measurement), as well as differences between the control and experimental groups in the initial and final measurement. The data obtained in this research were processed using the STATISTICA 6.0 and SPSS 14.0 software packages.

RESULTS

Analyzes of any differences between a large number of entities in a multivariate space are always very sensitive, given the possible complex character of the characteristics and abilities of the subjects involved in the transformation processes. This is especially true in cases where legality is being determined

define the experimental and control transformation procedure, and thus the experimental and control group, on which such procedures are carried out.

According to classical (although not the only possible) settings, for quality analysis of the effects of transformation procedures, it is necessary to ensure virtual equality in the initial status of groups that will later be subjected to different transformation procedures. This request is a natural thing, because if such conditions are not ensured at the beginning, it is usually not possible to evaluate different treatments later, because it is very difficult to distinguish which part of the effects can be attributed to certain properties of the treatment, and which to the initial position of some of the groups of respondents.

Multivariate analysis of variance of the experimental and control group of respondents in the initial measurement

Table 1 presents the results of the multivariate analysis of variance of the subjects of the experimental and control groups (E= 44; K=40) in the initial measurement. By analyzing the presented table, it can be seen that the multivariate differences between the experimental and control groups in the initial measurement are significant at the significance level of p = 0.015. Given that multivariate analysis accumulates all these individual differences, then it is clear that statistical significance is expressed.

Table 1 *Multivariate analysis of variance of experimental and control groups - initial measurement*

Trace	1.167525
Root	1.167525
%Trace	100
Wilks	0.4614
DF1	31
DF2	52
F	1.9584
P	0.0157

Multivariate differences are significant because one part of the variables individually shows univariate differences. The following variables stand out in particular: FMAPEF, FSRFRM, MBUBRN, MFESDM, MFESGT, MLATBD and SMOKMT. Other variables do not show statistically significant differences between groups.

Univariate analysis of the variance of subjects in the experimental and control groups in the initial measurement

Table 2 shows the results of the univariate analysis of variance between the experimental and control groups of subjects in the initial measurement. Arithmetic means of variables (Mean) and analysis of variance (ANOVA) with F-test (F) and probability (P) for the experimental (E) and control (K) groups in the initial measurement are shown.

As can be seen from the presented table, the differences between the groups in the initial measurement are statistically insignificant. By analyzing the results presented in table 2, it can be seen that in the initial measurement there are no statistically significant differences between the subjects of the experimental and control groups in morphological characteristics. In the area of functional abilities in the initial measurement, there are also no serious differences. Exceptions are FMAPEF and FSRFRM.

Statistically significant differences remained only in several variables of motor abilities, namely: MBUBRN, MFESDM, MFESGT, MLATBD and FMAPEF and FSRFRM.

Table 2 *Analysis of variance between the experimental and control groups in the initial measurement*; *Arithmetic means of variables (Mean) and Analysis of variance (ANOVA) with F-test (F) and probability (P) for the experimental (E) and control (K) groups in the initial measurement*

variables	Mean	Mean	ANOVA	
	Experimental group	Control group	F	P
AVISTJ	161.5	158.975	2.0437	0.1530
ATEZTJ	52.8182	51.3	0.3091	0.5866
ABMIDX	20.1818	20.0075	0.0459	0.8253
ADUZRU	67.3045	66.65	0.4803	0.5027
ADUZNO	91.0205	90.155	0.6605	0.5758
ADUZST	24.2136	23.6875	3.5044	0.0614
AOBTRB	67.2932	64.8825	1.9964	0.1578
AOBNAD	23.9955	22.9025	2.4666	0.1162
AOBPOD	21.7932	21.1825	2.1627	0.1414
AOBNAT	47.3182	45.065	3.0733	0.0796
AOBPOT	34.3227	32.9975	2.6093	0.1061
AKNNAD	14.4864	13.6175	0.5527	0.5340
AKNLED	11.3227	12.19	0.3938	0.5392

AKNTRB	15.8864	16.0675	0.0098	0.9182
AKNPOT	17.6545	18.015	0.0551	0.8101
FFEV75	2.4707	2.2323	3.4909	0.0619
FMFEV1	2.7552	2.5428	2.4548	0.1171
FFVCAP	3.2723	3.076	1.7584	0.1854
FMAPEF	305.5227	266.975	4.7843	0.0297
FMVVNT	104.2523	95.4325	3.0025	0.0831
FFETME	2.7659	2.86	0.2833	0.6025
FSRFRM	88.0909	81.4	7.5414	0.0074
MFLAMI	7.0227	7.85	0.5999	0.5530
MTAPRU	37.7123	38.9415	1.3093	0.2546
MTAPNO	49.9018	50.1335	0.0394	0.8375
MBUBRN	10.2955	9.25	4.4013	0.0367
MFESDM	152.6961	140.233	5.3986	0.0213
MFEVIS	34.6855	28.9675	12.3852	0.0010
MLATBL	4.7498	4.96	2.9334	0.0867
MLATBD	4.7475	5.067	6.2981	0.0134
SMKOMT	3.1209	2.4995	8.6785	0.0044

Multivariate analysis of the variance of subjects of the experimental and control groups in the final measurement

Table 3 presents the results of the multivariate analysis of variance of the subjects of the experimental and control groups (E= 44; K=40) in the final measurement. By analyzing the presented table, it can be seen that the multivariate differences between the subjects of the experimental and control groups in the final measurement are more pronounced and statistically significant at the level of significance p = 0.000.

Table 3 *Multivariate analysis of variance of experimental and control groups - final measurement*

Trace	2.303872
Root	2.303872
%Trace	100
Wilks	0.3027
DF1	31
DF2	52
F	3.8646
P	0.0000

Univariate analysis of variance of experimental and control group subjects in the final measurement

Table 4 shows the results of the univariate analysis of variance, which show a more detailed analysis of the quantitative differences between the experimental and control groups of subjects in the final measurement. Table 4 shows that the differences in the final measurement are significantly larger and are expressed by a significant number of variables that show a statistically significant difference after the implemented experimental program, and thus have a statistically significant effect on the discrimination of groups. The following variables showed a statistically significant difference: foot length (ADUZST 0.023) from the morphological space, resting heart rate (FSRFRM 0.000) from the functional space, variables for evaluating coordination (MBUBRN 0.0007), variables for evaluating the explosive power of the legs (MFESDM 0 .0391, MFESVM 0.0012), variables for assessing agility in the right and left side (MLATBL 0.0014, MLATBD 0.0014) and variables for assessing the level of success in performing dance technique elements (SMKOMT 0.000) from the motor area.

Table 4 *Analysis of variance between the experimental and control groups in the final measurement; Arithmetic means of variables (Mean) and Analysis of Variance (ANOVA) with F-test (F) and probability (P) for the experimental (E) and control (K) groups in the final measurement*

Varijable	Mean	Mean	ANOVA	
	EG	KG	F	P
AVISTJ	162.4091	159.475	2.9309	0.0869
ATEZTJ	54.7727	52.25	0.9236	0.6589
ABMIDX	20.75	20.26	0.3993	0.5363
ADUZRU	69.1273	67.77	2.0331	0.1549
ADUZNO	92.2568	91.0225	1.3598	0.2454
ADUZST	24.5591	23.97	5.2305	0.0233
AOBTRB	67.3182	65.3275	1.6191	0.2041
AOBNAD	23.9114	23.175	0.9155	0.6567
AOBPOD	21.4068	21.0225	0.8991	0.6521
AOBNAT	48.6932	47.195	1.3888	0.2403
AOBPOT	34.1227	33.48	0.6538	0.5734
AKNNAD	13.9477	13.725	0.0366	0.8429
AKNLED	11.3159	11.97	0.3477	0.5641
AKNTRB	15..75	16.31	0.1289	0.7211
AKNPOT	16.9159	17.5125	0.1696	0.6846
FFEV75	2.4743	2.2943	2.0089	0.1565
FMFEV1	2.7986	2.6075	1.9158	0.1666
FFVCAP	3.2782	3.198	0.3073	0.5876
FMAPEF	298.1591	278.275	1.3168	0.2532
FMVVNT	104.9636	97.8375	1.8929	0.1692
FFETME	2.8955	3.075	0.9075	0.6544
FSRFRM	87.7727	77.85	25.3665	0.000
MFLAMI	5.0455	5.95	1.2644	0.2631
MTAPRU	41.6066	39.8583	2.2047	0.1376
MTAPNO	51.9991	51.5925	0.1474	0.7038
MBUBRN	12.5682	10.5	13.5891	0.0007
MFESDM	153.6809	142.8338	4.2868	0.0391
MFEVIS	34.7434	29.2498	11.8889	0.0012
MLATBL	4.6361	5.055	11.5123	0.0014
MLATBD	4.5648	5.0473	11.5679	0.0014
SMKOMT	3.6977	2.5415	32.5435	0.0000

DISCUSSION

There is a visible difference between the experimental and control groups in the test for assessing the level of success in performing elements of the SMOKMT dance technique. The other variables do not show statistically significant differences between the groups, so it can be argued that such initial positions are more realistic and enable the application of subsequent statistical and mathematical procedures, which otherwise could not be applied.

The existing differences between the groups probably contribute to the selection system, organization and way of working as well as the professional training of the coaching staff, because certainly the working conditions, knowledge and previous experience are not the same in all clubs (Srdić, 2009).

However, the fact that the sample treated in this research is in a period of violent biological changes must be taken into account, which certainly contributes to these slight changes between the groups in the initial measurement.

However, it can be stated that such a modest and insignificant number of those variables that show statistically significant differences from a total of 30 applied measuring instruments, convinces us of the fact that these differences are accidental and that they arose as a result of a quasi-random selection of entities. Unambiguously, therefore, it is a unique sample that should not show major differences at the beginning of the treatment, because this would mean that the entities do not have the same initial positions, which could possibly lead to wrong conclusions.

The number of variables that do not show a statistically significant difference in the final measurement has been significantly reduced. Therefore, it can be concluded that there were statistically significant differences between the subjects of the experimental and control groups in the final measurement, and they are slightly larger overall. This means that the experimental treatment produced a quantitative separation of the control group from the experimental one in such a way that the subjects of the experimental group became superior, which, of course, is not a bad statement, because it is to be expected that the special program will produce slightly better effects considering the increased intensity of work , to more content-rich and focused stimuli.

On the basis of what has been said, it can be claimed that clear global effects of proprioceptive training and training with a screw are visible, i.e. differences in the two time states.

The obtained results point to the conclusion that there were statistically significant differences between the subjects of the experimental and control groups in the final measurement and they are slightly larger overall. The number of variables that do not show a statistically significant difference in the final measurement has been significantly reduced.

This means that the experimental treatment is structured from a proprioceptive program (exercises on the balance board and exercises on the trampoline) and the screw program. produced a quantitative separation of the control group from the experimental one in such a way that the test subjects of the experimental group become superior, which, of course, is not a surprising finding, because it is to be expected that the special program will produce significantly better effects given the increased intensity of work, the content being richer and more focused stimuli.

The obtained results support earlier research on positive changes under the influence of proprioceptive training (Simek, 2006; Simek Salaj, Milanovic, & Jukic, 2007; Srdić, Bajrić, Oreb, Lolić, & Zagorc, 2013; Ljubojevic, Bijelic, Gerdijan, & Sebic, 2017).

On the basis of what has been said, it can be claimed that clear global effects of proprioceptive training and training with a screw are visible, i.e. differences in the two time states.

CONCLUSION

The research sample consisted of 84 young dancers of both sexes, aged 11-16 years, who were randomly divided into two groups, experimental (N = 44) and control group (N = 40). A three-month specially defined experimental program was implemented with the experimental group, while the control group was trained according to a standard dance program. The subjects treated were from Dance Club "Gemma" Banja Luka, Dance Club "City Jazz" Banja Luka, Dance Club "Bolero" Banja Luka and Dance Club "Orion" Pale. The research used a set of 31 variables from the space of morphological characteristics (15), motor (8) and functional (7) abilities, and one variable that assessed the level of success in performing elements of dance technique.

The main goal of the research was to determine the differences in morphological characteristics, motor and functional abilities as well as the level of success in performing elements of dance technique between the experimental and control group of subjects - juniors in dance in the initial and final measurements.

Multivariate analysis of variance (MANOVA) was used to determine the differences in the treated variables between the experimental and control groups of subjects in the initial and final measurements at the multivariate level. For each applied variable, at the univariate level, differences were tested for dependent and independent samples (ANOVA), which can occur through two time points (initial and final measurement), as well as differences between the control and experimental groups in the initial and final measurement.

The obtained research results indicate that the applied three-month experimental program implemented through 40 training units structured on the basis of a proprioceptive program (exercises on a balance board and exercises on a trampoline) and a program with a screw produced statistically significant effects in the subjects of the experimental group in all the researched areas and thereby contributed statistically to a significant difference between the subjects of the experimental and control groups in the final measurement in favor of the experimental group in the sense that the subjects of the experimental group become superior.

The following variables showed a statistically significant difference: foot length (ADUZST 0.023) from the morphological space, resting heart rate (FSRFRM 0.000) from the functional space, variables for evaluating coordination (MBUBRN 0.0007), variables for evaluating the explosive power of the legs (MFESDM 0 .0391, MFESVM 0.0012), variables for assessing agility in the right and left side (MLATBL 0.0014, MLATBD 0.0014) and variables for assessing the level of success in performing dance technique elements (SMKOMT 0.000) from the motor area.

Such results are not surprising, because it is to be expected that a specially defined program will produce significantly better effects, considering the increased intensity of work, and more content-rich and focused stimuli.

Based on the obtained results, it can be concluded that the applied experimental program structured on the basis of proprioceptive training and training with a screw significantly contributed to the differentiation of the groups.

Also, the obtained results open up the possibility of modifying the training process in the training technology of young dancers by introducing suitable experimental programs that would probably give better results than the standard (classical) training of dancers, because both the quality and quantity of the impact on the dimensions of anthropological characteristics and abilities would be greater. and better.

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CORRELATION BETWEEN VERTICAL JUMP, SPEED, COD AND REACTIVE AGILITY IN ADOLESCENT SOCCER PLAYERS

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ABSTRACT

Introduction Testing the physical ability of football players has many benefits in young age categories. Here are some important reasons: recognition and selection of young football players, determination of "strong" and "weak" sides of football players' physical preparation, monitoring, and evaluation of training effects, giving feedback to players about their progress and state of training, motivating players to train more and more intensively. Therefore, the aim of the research is to determine the relation and influence of vertical jump, speed and speed of change of direction of movement in football players in the cadet age.

Methods The work method is experimental with one group of football players (n = 53) of the cadet category (15.96±.854 years old), whereby testing the mentioned motor abilities, the connection and their influence on the ability of reaction agility is determined.

The data obtained from this research are processed with the statistical program SPSS 20.0 ("Statistical Package for the Social Sciences"). To obtain the connection and influence in the tests of vertical jump, speed, speed of change of direction of movement and reaction agility of football players, the statistical method of multiple regression analysis was applied, which shows the connection of the variables of vertical jump, speed and speed of change of direction of movement affect the reaction agility of football players. Through Pearson's correlation method, it is shown how the mentioned abilities are interconnected, and by the statistical method of multiple regression analysis (stepwise method), which has the task of showing a unique predictor that has the most influence on reaction agility in this research work on this group of respondents. The results that are presented show the connection of the three mentioned variables to the variable of reaction agility and each one shows how much it affects only reaction agility.

Results Correlation between vertical jump, speed, speed of change of direction of movement and reaction agility was tested using the Pearson correlation method of all key variables for this work. Every variable is closely related to almost everyone, especially where we see that the correlation coefficient in all agility tests is related to 20 meter speed with correlation coefficients of .000* and .001*. The only place where the number of the correlation coefficient is higher, that is, which shows a lower correlation, is the vertical jump with the speed of changing the direction of movement to the left with a correlation coefficient of .224 and vertical jump and reaction agility with a correlation coefficient of .129.

Regarding the relationship between vertical jump, speed and speed of change of direction of movement and reaction agility, the results from the vertical jump test with a value of .705 have the least impact on the reaction agility of soccer players, then the speed at 20 meters has a greater impact on the reaction agility with a value of .701. The speed of changing the direction of movement, which is agility, in this case pre-planned, where the players knew in advance where they should go (right and left), as well as the well-known Illinois test, have an impact on the reaction agility of soccer players with a correlation coefficient of .235 to the left. and the highest association of the correlation coefficient with the speed of change of direction of movement to the right with a value of .082. correlation coefficient.

The results showed that the speed of changing the direction of movement is related to the reaction agility of football players with a correlation coefficient (p = 0.03), but with repetitive sprints the connection is not so significant (p = 0.46) and it was concluded that for the speed of changing the direction of movement, i.e. agility, you should work in the training process of specific exercises for the development of this ability.

Discussion The purpose of this study is to examine the relationship and influence of vertical jump, speed, and speed of change of direction of movement in cadet football players. In the vertical jump test, the results showed that reaction agility had the least impact, while in the speed tests there was a greater correlation. The greatest influence, unique in relation to the influence of other variables, on reaction agility is the agility itself, which is predetermined and the unique predictor for reaction agility is the speed of changing the direction of movement to the side where the dominant leg (CoD right) is present, in this work and in the case of the right leg, which was also shown in the research by Henry, Dawson, Lay, & Young, (2016) on a sample of 31 football players of Australian citizenship. For more accurate and better results, a larger number of samples will be required.

Conclusion Based on the obtained results and the hypothesis of the research, it can be concluded that the vertical jump, speed and speed of change of direction of movement have a positive effect on the reaction agility of cadet age footballers and that the hypothesis was partially confirmed.

Keywords: agility, football, team sport, young

INTRODUCTION

It is known that man prefers to approach what is already close to him, what he likes and what is popular. There is no doubt that the most visited and most popular sport in the world is football. Football is a collective sport played between two teams, made up of eleven players each. Soccer is currently the most popular sport in the world. It is played in over 200 countries. It can be played by people of all ages and both sexes. Football is often referred to as "the most important sideline in the world". It is played with a soccer ball on a rectangular playing field with a grass or artificial surface. The goals are placed opposite each other at the end of the narrow side of the playing field. The aim of the game is to throw the ball into the opponent's goal with any part of the body except the hand. Only the goalkeeper can play with his hand in a limited area, the so-called penalty area . The winner of the match is the team that scores more goals at the end of the match. Soccer is a game played by millions of children, youth and adults on all continents. As a creative expression of a wide social and cultural spectrum, football moves in the space of five human phenomena. This is evidenced by the very diverse sports infrastructure (from improvised fields where the game dominates to football castles where the results of work are demonstrated through tried-and-tested communication), rich personnel potential (players of both sexes, managers, scientists, journalists, etc.), dominance of the media space, financial mega dimensions, as well as other numerous indicators. In all of this, a special place is occupied by multi-million social groups stratified by special criteria (from emotional and rational to local and national) designated as audience and fans who communicate with football and with each other in their own unique way. That communication has special, spectacular features in the final club and representative competitions such as: the European Club Champions Cup, the European Championship and the World Championship in which national selections participate.

At the beginning, I will state the fundamental reasons for testing the physical abilities of football players. Here are some important reasons: recognition and selection of young football players, determination of "strong" and "weak" sides of football players' physical preparation, monitoring and evaluation of training effects, giving feedback to players about their progress and state of training, motivating players to train more and more intensively.

Contemporary sport, like any other creative field, requires constant collection of information, monitoring and control of the situation, which is necessary considering the specific direction and goals required by contemporary sport. In a situation where in sports there are increasing needs for better physical preparation, the athlete develops and maintains functional and motor abilities by applying appropriate training plans and programs.

THEORETICAL FRAMEWORK OF THE WORK

The football game from its beginnings to the present has experienced a large number of changes in technical and tactical terms, the rules of the game have also undergone certain modifications, and what is significant for this work, the requirements in the functional and motor characteristics of football players have evolved. The modern game requires movements and activities that are characterized by extremely fast, powerful and explosive abilities. By raising those abilities, the game itself has progressed, and by testing the ability of explosive leg strength, i.e. vertical jump on the tenzo platform, speed and speed of changing the direction of movement, we will get an insight into whether these abilities, how and to what extent affect the player's reaction agility itself.

From the previous research on this topic, four papers were presented that studied whether the abilities of explosive power of the legs, i.e. vertical jump, the speed itself and the speed of changing the direction of movement affect reaction agility, as well as the correlations, or connections between these abilities. Can leg strength significantly influence reaction speed and do cadet-age players with better scores on measures of those abilities perform better on a test of reaction agility. Greg J Henry et al. **(2016**) conducted a study examining the relationship between reactive agility and vertical, horizontal and lateral jump. This study compared the reaction agility time to listed jumps between the dominant and non-dominant leg of Australian rules football players (n = 31) to compare whether leg strength has an effect on reaction agility. Agility and speed of change of direction of movement are monitored by video analysis. Correlations between types of jumps were high ($r = -0.62$ to -0.77), but between agility and jumps were weaker ($r = -0.25$ to -0.33). The dominant leg during jumps was associated with reaction agility in changing the direction of movement (4.5%; $p = 0.04$) compared to the non-dominant leg. When the respondents were divided into faster and slower performers (by agility scores), a difference was seen. Although the ability of jumps to predict agility performance is limited, factors involved in the vertical jump from the dominant leg may be associated with advantages in agility performance on that leg and reactive agility on that leg. Paul Comfort et al (2014) performed studies looking at jump performance, relative and absolute power and their correlation with sprinting. The goal was to examine the relationship between strength, sprinting and jumping in well-trained soccer players. 34 male players (17.2 ± 0.6 years, body mass 72.62 ± 7.42 kg, height 179.27 ± 6.58 cm) performed a maximum squat test, speed at 20m, squat jump and vertical jump. Absolute power had the highest correlation with 5m sprint time ($r = -0.596$, $p < 0.001$, power = 0.99), squat jump ($r = 0.762$, $p < 0.001$, power = 1.00) and reverse jump ($r = 0.760$, $p < 0.001$, power = 1.00), and relative power has the highest correlations with the 20-meter sprint ($r = -0.672$, $p < 0.001$, power = 0.99). The results of this research show the importance of developing high levels of lower body strength, explosive leg strength to improve speed performance and that players with better leg strength scores perform superiorly in sprinting and jumping. David Rodriguez-Rossel et al. (2017) performed a study measuring traditional tests and sport-specific vertical jump tests in soccer players aged 14-18 years and validating the correlation between leg strength and speed. They tested 127 soccer players aged 14 to 18, two tests were standard (CMJ - vertical jump and AJ - Abalak's test) and sport - a specific test with running and one-legged jump in three age categories (U-15, U-17, U-18) There were three jumps from each test and a 20m sprint. The results showed a correlation between the two-legged vertical jump from a full squat with the 20m sprint (0.969-0.995), and the one-legged jump test showed the least correlation with speed and power. All other jumps showed a high correlation with speed ($r = 0.580$-0.983). This work determined that the tests and jumps CMJ - countermovement jump and AJ - Albakov's jump are the most reliable tests for evaluating the explosive power of the legs, which also affect the speed of soccer players. Haris Pojskić et al. (2018) carried out a study to define the reliability, validity and connection of agility tests CoD - Change of Direction and specific reaction agility test RAT - Reactive Agility Test and whether there are differences in the results of different age categories, in this case U17 and U19. The study consisted of 20 players who competed in the highest national level of football competition (17.0±0.9) years) divided into three groups by playing positions (defender, midfielder and forward) who fell into the age group U17 and U19 . Among the variables were body mass, body height, BMI, 20-meter sprint, squat jump, 1-RM squat, reactive power index, and tests for speed of change of direction of movement - CoD and reactive agility test RAT. A high association between CoD and RAT was demonstrated in addition to other tests with a score of (ICC: 0.70 to 0.92) and shared the same variance with 25-40%. The players were different in their body mass index results (defenders higher index, midfielders and forwards lower) where in the 1-RM squat midfielders had lower results than defenders. Also, players belonging to the age category U19 had better results in the CoD test (t-test: 3.61 $p < 0.05$) and in the RAT reaction agility test (t-test: 2.14 and 2.41 $p < 0$,05). Newly developed football-specific agility tests are applicable to differentiate between U17 and U19 players. The results were in favor of the U19 players who achieved better times in the reaction agility test. The connection between the speed of changing the direction of movement and reaction agility has also been proven. Coaches who work with younger football players must do sport-specific exercises in football depending on the age category they lead, they must not neglect the development of this motor skill.

The aim of the research is to determine the connection and influence of the vertical jump, speed and speed of change of direction of movement and which ability is a unique predictor of the reaction speed of cadet-aged football players. In accordance with the aim of the research, a hypothesis was put forward, that a correlation is expected between tests of vertical jump, speed, speed of change of direction of movement and reactive agility of soccer players.

METHOD OF WORK

The work method is experimental with one group of football players (n = 53) of the cadet category (15.96±.854 years old), where by testing the mentioned motor abilities, the connection and their influence on the ability of reaction agility is determined.

The review of previous literature related to the research problem includes books and relevant scientific works available on the Internet in the form of summaries and on platforms that are scientifically and research oriented: Google Scholar, Human Kinetics, PubMed, SCIindeks, Academia.

A sample of respondents

The sample of respondents consists of a total of 53 male players of cadet age (15.96±.854) with sports experience (9.58±1.46), average height: (178.21±8.18)cm; and average body weight: (66.88±10.30) kg. The respondents are well-trained, selected players from the football club "Spartak" from Subotica who compete in the Serbian Quality League.

A sample of measuring instruments

The research includes the analysis of two components:

1) anthropometric dimensions (body height, body weight, body composition)

2) motor abilities (speed **- Microgate - Witty-GATE** , agility **- COD - Change of Direction** and **Illinois Agility Test,** reactive agility **- RAT test - Reactive Agility Test** , explosive power of the lower extremities **- Kistler Quatro Jump**).

Sample motor tests

1. Explosive leg strength (vertical jumping on the **Kistler Quatro Jump tensiometric platform**)
2. Speed 5m, 10m, 20m (**Microgate – Witty-GATE**)
3. Agility (**COD – Change of Direction** and **Illinois Agility Test**)
4. Reactive agility (**RAT test - Reactive Agility Test**)
5. Flexibility (**Sit & Reach)**

For the purposes of research, football players will be measured: anthropometric measurements, body height, body mass, and calculated BMI (Body mass index).

Body mass index (BMI) is derived by the formula:

$$BMI = body\ mass\ (kg)\ /\ body\ height\ (m)^2$$

1. Morphological characteristics

Body height and leg length were measured according to the IBP (International Biological Program) protocol. The instrument used for measurement is the Martin Anthropometer.

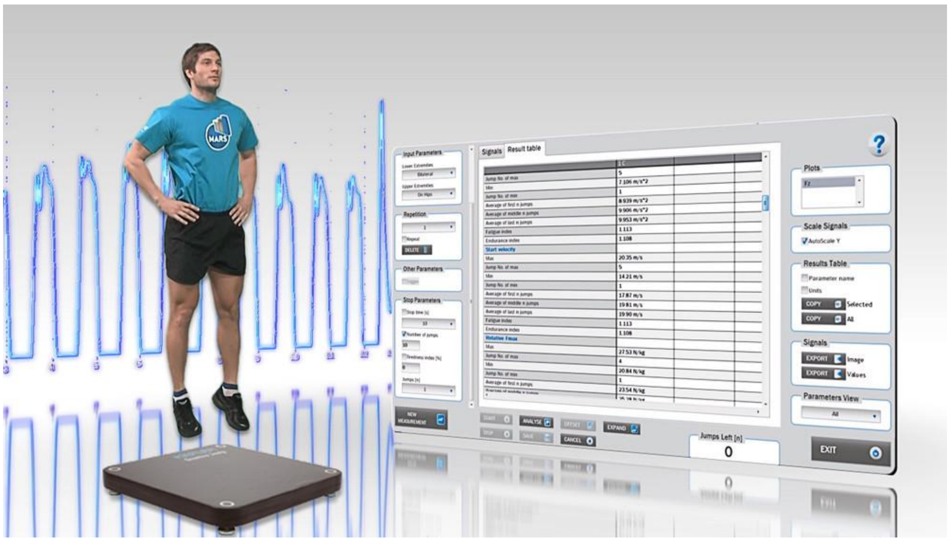
Body composition - assessment of body composition was performed using: The InBody 230 (Biospace Co. Inc., Seoul, South Korea) Bioelectrical Impedance Analyzer (BIA) with the following output data:

body mass (kg), muscle mass (kg), fat tissue (kg), body fluids (kg), lean tissue (kg), minerals (kg), protein (kg), body mass index (BMI), fat percentage in to body (%), waist to hip ratio WHR, basal metabolic rate BMR (kcal), weight control, fat control, muscle control, impedance for each segment and frequency, visceral fat level, obesity level, target weight.

The following tests were used to assess motor skills:

2. Explosive leg power

Vertical jumping was tested on a tensiometric platform (Kistler Quatro Jump) and includes the performance of individual jumps and a series of jumps:



SJ - squat jump with hands on hips

Output data obtained by measurement and calculation include:

jump height (cm)

jump duration (s)

absolute and relative maximum jump power (W and W/kg)

maximum, average and minimum values of the parameter

fatigue factors - degree of anaerobic threshold (FAnZ)

SJ represented in centimeters (cm) is taken .

3. Speed

Speed 5, 10, 20m - was performed by a 20m running test in a maximum sprint from a high start. Within this test, variables of running speed and starting acceleration were also monitored, i.e. the time needed to run the first 5 and 10 meters as well as the time needed to run the second 10 meters.

Running speed was measured using a computerized, wireless photocell system (Microgate - Witty-GATE).

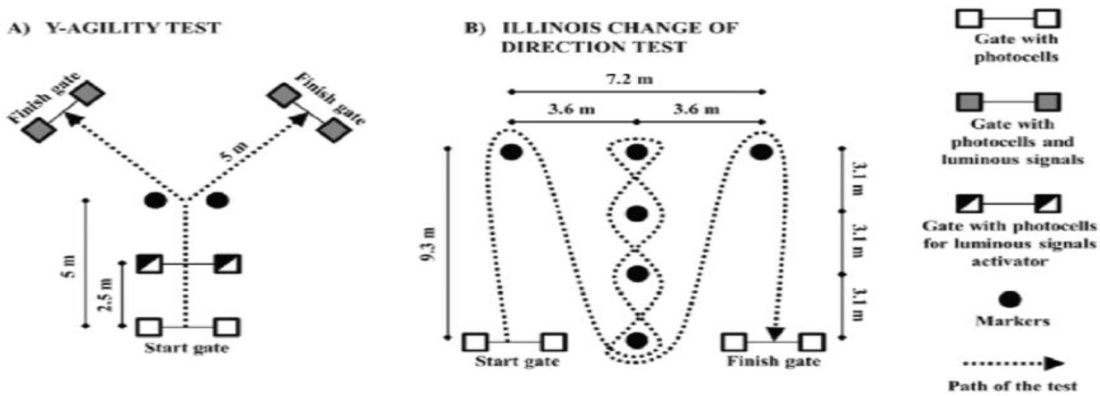
Due to the influence of the speed itself, in this paper, the value of the running speed at 20 meters is taken, presented in seconds (s).

4. Agility (pre-planned)

Several tests were used to assess the speed of the pre-planned change of direction of movement:

a) **COD (Change of Direction)** known in the literature as **the Y agility test** evaluates the speed of changing the direction of movement of the athlete to the left and right side at a turning angle of 45 degrees. Witty-GATE photocells were used to obtain the results of this test. According to the protocol, the athlete has 3 attempts where the best time is recorded at the end.

b) **The Illinois Agility Test** consists of running a short section with 2 changes in the direction of movement of 45 degrees with a slalom run between the cones. It was carried out in two categories, in the test without the ball and the test with ball control. According to the protocol, the athlete has 3 attempts where at the end the best time is recorded as a result.



5. Reactive (reaction) agility

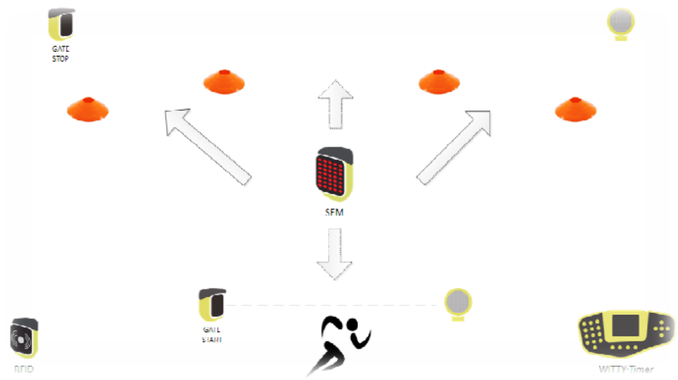
RAT test (Reactive Agility Test) – reactive agility, in addition to the ability to quickly change the direction of movement, also includes the athlete's motor-cognitive domain.

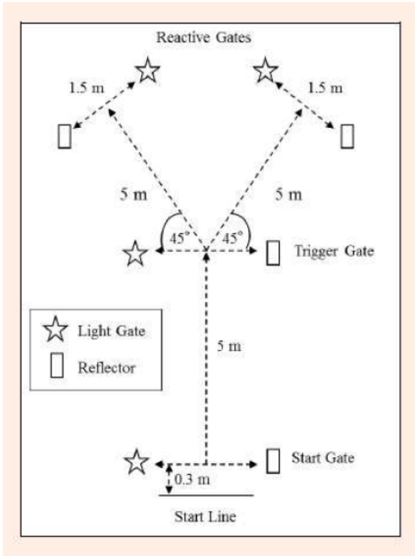
This ability is actually an extremely important element for success in the game, especially when it comes to top sports. This ability is characterized as the ability to quickly change the direction of movement in relation to an external stimulus, i.e. the signal projected by the monitor at the time of running; or in another case given by the coach with his movement.

In the first variant of this test, the subject runs a short section in a straight line, where after 5m the signal on the monitor is turned on (in the form of an arrow to the left or right) and shows in which direction the athlete must continue moving. During the performance, the athlete must register and process the signal and, with the fastest possible reaction, continue moving in the given direction.

In the second variant of this test, the coach replaces the role of the monitor and by stepping to one side or the other gives a signal to the athlete that he must continue moving in the opposite direction from the step.

Witty SEM photocells were used to obtain the results of this test. According to the protocol, the athlete has 3 attempts, where at the end the best time is recorded as well as the time of reaction speed from the moment the signal is turned on until passing through the finish line.





6. Sit and reach - flexibility

To assess flexibility, a standardized Sit & Reach box (S&R Box) was used, and the subjects were seated with their feet resting on the vertical front wall of the box. The knees must be bent. By leaning forward, the examinee should push the partition on the box as far away from him as possible. The result is read and recorded with an accuracy of 0.1 cm.

Description of the measurement procedure

The entire collection of data on anthropometric measures (body composition) and motor skills (explosive leg strength, speed, speed of changing the direction of movement, reaction agility) is carried out on the open fields of the football club "Spartak" from Subotica. In addition to the authors of the research, coaches from the mentioned club as well as a team of experts from the Faculty of Sports and Physical Education from Novi Sad participate in the collection of the mentioned data. Testing is done in the morning.

Data processing methods

The data obtained from this research are processed with the statistical program SPSS 20.0 ("Statistical Package for the Social Sciences"). To obtain the connection and influence in the tests of vertical jump, speed, speed of change of direction of movement and reaction agility of football players, a statistical method of multiple regression analysis was applied, which shows the connection of the variables of vertical jump, speed and speed of change of direction of movement affect the reaction agility of football players. Through Pearson's correlation method, it is shown how the mentioned abilities are interconnected, and by the statistical method of multiple regression analysis (stepwise method), which has the task of showing a unique predictor that has the most influence on reaction agility in this research work on this group of respondents. The results that are presented show the connection of the three mentioned variables to the variable of reaction agility and each one shows how much it affects only reaction agility.

RESULTS WITH DISCUSSION

Table 1. Descriptive statistics of basic characteristics and anthropometric measures football player of cadet age

	N = 53	
	AS	SD
Decimal years	15.9623	.85400
Sports experience (years)	9.5849	1.46016
body height (cm)	178.3962	8.18091
body mass (kg)	66.8811	10.30859
BMI (kg/cm ^{2})	20.9264	2.22790

Legend: **N** – number of respondents; **AS** – arithmetic mean; **SD** – standard deviation; **BMI** – body mass index;

Table 1 shows the descriptive statistics of the respondents that show the arithmetic mean of age in decimal years where the group of respondents is 15.96 years old on average. Other statistics of the experimental group are sports experience 9.58 years, body height 178.39, body mass 66.88 and BMI 20.92.

Table 2. Basic descriptive statistics of tests for the assessment of basic and specific motor skills of soccer players of cadet age

	N = 53			
	AS	SD	MIN	MAX
Vertical jump (cm)	41.05	5.15	29.40	54.40
Speed 5m (s)	1.12	.163	.91	2.09
Speed 10m (s)	1.93	.326	1.66	3.85
Speed 20m (s)	3.24	.2 3 4	2.94	4.50
CoD (left) (s)	2.23	.015	2.05	2.56
CoD (right) (s)	2.27	.018	2.04	2.64
Illinois Agility Test (s)	15.88	.587	14.93	17.45
RAT test(s)	2.81	.024	2.38	3.20
Sit & Reach (cm)	32.29	7.33	12.00	48.00

Legend: **N** - number of respondents; **AS** - arithmetic mean; **SD** - standard deviation; **MIN** - minimum value; **MAX** - maximum value; **CoD** – change of direction (change of direction of movement); **RAT** - reactive agility test

Table 2 shows the basic descriptive statistics of the tests for the assessment of basic and specific motor skills when measuring a group of players. By observing, we can see what is the arithmetic mean of these motor tests as well as the standard deviation, what is the minimum result of the examinee (in the variables of speed, agility and anaerobic endurance) that is positive, the lower the results, the better, and in the variables (vertical jump and flexibility) the higher the score the better.

Most clubs in the preparation phase apply a fitness program that is not adequate, not enough work is done on strength components, primarily explosive strength is thought of, despite the fact that, according to various data in the literature, players only spend 9-11% of the time in the game sprinting (Bangsbo et al., 2010: Reilly and Thomas, 2006) which amounts to 3 or 5% of the total effective time of a match (Ali and Farrally, 2006: Bangsbo, 2006: O Donoghue, 2008). Most of the time during the game, the players walk and trot, which is also proof of the importance of the cardio-vascular system (the midfielder walks 4.0 km, jogs 4.5 km, and sprints 1.5 km, plus the rest of the movement structure allows him to cover a total of from 11 to 13 km) Verheijen, (2009). We must remember that soccer players sprint every 90 seconds, and each sprint lasts on average from 2 to 4 seconds and makes over 1000-1400 changes of direction during the game, 600-800 different turns, 20 to 30 different jumps, and 100 to 140 ball activities (Mohr, Krustrup and Bangsbo 2009, Bangsbo, Norregaard and Thorso 2006, Rienzi et al., 2000, Reilly and Thomas, 2005).

Modern match tracking technology has allowed coaches to have a clearer view of player activities during the match, so coaches are able to deactivate inactive players and determine which player makes the most mistakes, which led to the knowledge that poorly prepared players are not able to follow the competition calendar that clubs require regardless of their quality or technical ability.

Table 3. Correlation between the variables of vertical jump, speed, speed of change of direction and reaction agility of players Pearson's correlation method

N = 53

	Vertical jump	Speed 20m	Illinois Agility Test	Change of Direction **(right)**	Change of Direction **(left)**	WAR
Vertical jump		.006	.014	.000*	.224	.129
Speed 20m	.006		.000*	.000*	.001*	.003*
Illinois Agility Test	.014	.000*		.000*	.000*	.000*
Change of Direction **(right)**	.000*	.000*	.000*		.000*	.000*
Change of Direction **(left)**	.224	.001*	.000*	.000*		.000*
WAR	.129	.003*	.000*	.000*	.000*	

Legend: **N -** number of respondents; **RAT** – reactive agility test (reaction agility test); * **-** correlation;

Table 3 shows the correlation between vertical jump, speed, speed of change of direction of movement and reaction agility from the test using the Pearson correlation method of all key variables for this work. Every variable is closely related to almost every one, especially where we see that the correlation coefficient in all agility tests is related to 20 meter speed with correlation coefficients of .000* and .001*. The only place where the number of the correlation coefficient is higher, that is, which shows a lower correlation, is the vertical jump with the speed of changing the direction of movement to the left with a correlation coefficient of .224 and vertical jump and reaction agility with a correlation coefficient of .129.

In 2014, Paul Comfort et al performed studies looking at jump performance, relative and absolute power and their correlation with sprinting. The goal was to examine the relationship between strength, sprinting and jumping in well-trained soccer players. The results showed that vertical jump and speed are highly correlated and show the importance of developing high levels of lower body strength, explosive leg strength to improve speed performance and that players with better leg strength scores have superior results in sprinting and jumping. In this part of the paper, we will look at the very concept of agility, which is present to a large extent in the game.

The ability that most often manifests itself in game conditions is agility (Gr. Agilis – nimble, quick, brisk). The position of agility in the general motor space has so far been discussed differently. Agility can be viewed as an isolated motor ability, but due to its complex and still insufficiently researched structure, and cognitive demands, it may be more optimal to view agility as a very complex and open motor skill (Jeffreys, 2006). In the latest research and works, agility is included as one of the motor abilities, and as such it is included in the educational program for training UEFA license coaches.

Agility as a term has been defined by different authors in different ways:

- The ability to quickly change the direction of movement (Gredelj et al., 1975);
- The ability to accelerate, decelerate and quickly change the direction of movement while maintaining control of movement and not losing speed (Brittenham, 1996, Graham, 2000);
- The ability to change the direction of movement without losing balance, speed, strength and movement control (Pearson, 2001);
- The ability to perform fast coordinated and connected movements (Drabik 1996):
- Agility allows the athlete to react to the stimulus, start quickly and efficiently, move in the right direction and be ready to change the direction of movement or to stop quickly in order to perform the sports technique in a fast, smooth, efficient and repeatable way (Verstegen and Marcello 200l);
- Sheppard and Young (2006) based on years of research gave a definition that fast movement of the whole body with a change of speed or direction of movement in response to an external stimulus is considered agility, but the movement should not only contain a change of speed or direction of movement, but must it is also an open skill, in which the reaction to the stimulus is included.
- The ability to achieve movements of the type: stop and go, inclusion of stops, reactive-elastic movements and sudden acceleration (János Matlák 2016)

The definition that is taken today and best describes agility is that agility as a motor ability represents the ability to quickly move the body at a variable speed and direction of movement that occurs in response to an external stimulus (Young, 2006).

Table 4. Correlation between the variables of vertical jump, speed, speed of change of direction of movement with reaction agility of players through multiple regression analysis

N = 53

WAR		
Coefficients - .Sig	R	
Vertical jump	.705	
Speed 20m	.701	
Illinois Agility Test	.311	.616*
Change of Direction **(right)**	.082	
Change of Direction **(left)**	.235	

Legend: **N -** number of respondents; **.Sig** – correlation coefficient; * - correlation; **R -** multiple correlation coefficient; **RAT -** reactive agility test

Table 4 shows the relationship between vertical jump, speed and speed of change of direction of movement on reaction agility. As we can see in the table, the results from the vertical jump test with a value of .705 have the least impact on the reaction agility of soccer players, then the speed at 20 meters has a greater impact on the reaction agility with a value of .701. The speed of changing the direction of movement, which is agility, in this case pre-planned, where the players knew in advance where they should go (right and left), as well as the well-known Illinois test, have an impact on the reaction agility of soccer players with a correlation coefficient of .235 to the left. and the highest association of the correlation coefficient with the speed of change in the direction of movement to the right with a value of .082. correlation coefficient.

As a rule, multiple regression analysis has a positive value ranging from -1 to +1, where in this case the association between the independent variables (vertical jump, speed at 20 meters, Illionois test, Change of Direction (right and left) on the dependent variable Reactive Agility Test - reactive agility coefficient of multiple correlation **R -** .616* which shows the connection and positive influence of the selected variables, i.e. the predictor on the dependent variable. Since the value is closer to +1, it indicates a higher multiple correlation of the connection of the predictor system with the criterion.

Table 5. Correlation between variables of vertical jump, speed, speed of change of direction of movement with reaction agility of players through multiple regression analysis of stepwise model

N = 53		
	R	.Sig
CoD (right)	.567*	.000*

Legend: **N -** number of respondents; **.Sig** – correlation coefficient; **R -** multiple correlation coefficient; **CoD** – change of direction (change of direction of movement); * **-** correlation

Multiple regression analysis using the **stepwise** method shows the unique association of variables and how and which predictor affects the dependent variable, with the fact that in the stepwise method it discards the predictors that are weakest associated with the dependent variable and gives a picture of which unique predictor and how much it affects the dependent variable and removes the associations among other variables.

In this case, in table 5, in the multiple regression analysis (stepwise), one predictor was singled out, which is the previously known speed of change in the direction of movement to the right (CoD – Change of Direction) and that makes her a unique predictor for reaction agility of soccer players.

With this result, in this group of respondents consisting of 53 cadet-age players of the football club Spartak from Subotica, we conclude that the greatest correlation between the previously known speed of changing the direction of movement to the right and the reaction agility of the football player is due to the influence of the dominant leg, and to the mechanics of running itself due to the first step after the change of direction movements, in this case the right leg. There were 53 soccer players in the group of respondents, of which 14 were left-foot dominant, and 39 were right-foot dominant. For this reason, in the mechanics of running, after a quick change of direction of movement by kicking off from the left leg to the right, with the first step, the dominant leg makes a greater force and explosive force in the first step and thus shows a slightly better passing time in the reaction speed test.

Also, one of the earlier studies by Greg J Henry et al (2016) showed that the dominant leg during jumps was associated with reaction agility in changing the direction of movement (4.5%; $p = 0.04$) compared to the non-dominant leg, which in this case supports the results obtained in this work.

Testing and measurements are means of gathering information with which to plan future activities and make decisions. They are necessary when programming the training process and performance control during the implementation of that program. On the other hand, the test results contain huge amounts of data about what happened in the past, how many athletes progressed, and where mistakes were made. A player's constant progress is unthinkable without these activities, and that's why such information is invaluable for any coach. The constant progress of football and the game itself, which can be seen even with the naked eye of the observer, is that the game has greatly advanced from the past to today in the speed of the game, and the speed of the individual, i.e. the player. The very speed and speed of movement have influenced that the training process has also changed a lot from some training process that was used in the earlier past (Baldi, M. et al. 2017). The reaction of the player is faster, the movement of the player's body is faster, so the decision-making in the game itself must be faster. In this paper, it is shown that agility, i.e. quick change of direction of movement affects the reaction speed, the more agile we are, the easier it will be for us to change the direction of movement to some external stimulus, which in this case is the traffic light and the movement of the coach. The correlation coefficient with other motor abilities, i.e. vertical jump and speed itself is also very close, which logically tells us that maybe not to the greatest extent, but it affects reaction agility. The higher the vertical jump shows us that the greater the explosive strength of the legs, the more explosive, faster, and therefore more mobile the player is. Running speed is influenced by many other factors, one of them is the running technique itself, which in some training processes is forgotten to be learned as if it is not important, but it is very important. Dennis-Peter Born et al. (2016) tested 19 soccer players in the under-15 age category (U15) where they investigated the relationship between repetitive sprints (RSA), change of direction (CoD), vertical jump, and the Illinois Agility Test. and speed where it is shown through 6 training sessions that the results are related to each other. The results showed that the speed of changing the direction of movement is related to the reaction agility of football players with a correlation coefficient (p = 0.03), but with repetitive sprints the connection is not so significant (p = 0.46) and it was concluded that for the speed of changing the direction of movement, i.e. agility, you should work in the training process of specific exercises for the development of this ability.

Agility depends on two factors: the factor of speed of change of direction and the factor of perception and decision-making, which is the main topic of this paper. Today, in the training process, we can see a lot of new methods for the development of functional and motor abilities, and also for speed and agility, the new method is SAQ training (Pearson 2001), that is, the SAQ method. SAQ is an abbreviation from English that stands for (Speed, Agility, Quickness), which in our language is translated as (speed, agility, quickness). This training method consists of 7 components: dynamic warm-up, mechanics of movement, innervation, accumulation of potential, explosiveness, expression of potential, calming the organism. These 7 components represent a rounded whole and in them are present the development of motor skills in a short time, which gave good results. However, not everything has to be implemented, it also depends on the training program. This method includes the development of explosiveness through explosiveness, jumps, movement mechanics (running technique), technique with the ball, coordination, agility, speed. The first 4 components are most often performed during the competition period and can be done almost every day for 20-30 minutes per training session.

CONCLUSION

Through the analysis and interpretation of the obtained results, several conclusions follow. In accordance with the goals and objectives of the research, the following conclusion can be drawn after checking the hypothesis. Based on the obtained results and the hypothesis of the research, it can be concluded that the vertical jump, speed and speed of change of direction of movement have a positive effect on the reaction agility of cadet age footballers and that the hypothesis was partially confirmed. In the vertical jump test, the results showed that reaction agility had the least impact, while in the speed tests there was a greater correlation. The greatest influence, unique in relation to the influence of other variables, on reaction agility is the agility itself, which is predetermined and the unique predictor for reaction agility is the speed of changing the direction of movement to the side where the dominant leg (CoD right) is present, in this work and in the case of the right leg, which was also shown in the research by Greg J. Henry (2016) on a sample of 31 football players of Australian citizenship. For more accurate and better results, a larger number of samples will be required.

The research showed a significant connection between the variables through the Pearson method of mutual connection between all variables and the coefficient of multiple correlation, which individually affects reaction agility. What remains as an unwritten rule is that one cannot do without the other, as this research has shown. The vertical jump test shows us the explosive power of the legs, which to a large extent has a direct impact on the soccer player's speed. Agility as a motor ability represents the ability to quickly move the body with a variable speed and direction of movement that occurs in response to an external stimulus (Young, 2006). In the research, two types of agility tests were performed, predetermined and reactionary, where the scoreboard in one case and the coach in the other case determined by their movement in which direction the player would continue moving. Reaction agility is therefore very important since it is most present in the game itself, where based on the opponent and his movement, the position of the ball, that is, the external stimulus determines our movement. The results showed that the vertical jump, speed and speed of changing the direction of movement will have a positive effect on reaction agility, therefore coaches should necessarily include the development of these motor skills in their training process and work plan.

Certainly, it would be best if the coaches in their clubs had the help of a fitness coach who would cooperate with and implement this program throughout the year.

If we want to develop a child, a player with the goal of being able to play senior football in professional football, we must not allow him to not develop his maximum in running speed, and especially teach the child the correct mechanics of movement, correct running, stopping and correct change of direction . There will always be different types of players, some slower, some faster, but the most important thing for coaches is that the child learns by correctly performing all the elements that are present in the football game.

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EFFECTS OF YOGA EXERCISES ON PHYSICAL FITNESS: SYSTEMATIC REVIEW

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ABSTRACT

Physical fitness refers to the ability of your body systems to work together efficiently to ensure that you are healthy and able to perform activities of daily living, and it is important to be able to perform these activities with minimal effort. Yoga is an ancient philosophy of life with origins in India, and today it is considered as a comprehensive exercise program that affects the mind with proper body positioning and combines concentration, relaxation, breathing and physical exercises. The aim of this study was to conduct a systematic review of the literature examining the effects of yoga exercises on physical fitness. The study was conducted by systematic review of the relevant literature according to the general survey model. The findings of the study were obtained by searching the keywords "yoga" and "physical fitness" in PubMed, Web of Science and EBSCO databases for English studies published in the last five years as of September 2023. Eleven articles that met the selection criteria determined by the researcher were included in the study. In the majority of the articles reviewed, it was concluded that yoga exercises improve physical fitness parameters, have positive effects especially on strength, flexibility and balance parameters, and are an exercise approach that can be applied in various age and disease groups. In conclusion, yoga exercises are an effective exercise approach that can be used to improve physical fitness.

Keywords: Yoga, Physical Fitness, Strength, Flexibility, Balance

INTRODUCTION

Physical fitness refers to the ability of your body systems to work together efficiently to keep you healthy and able to perform activities of daily living. Being efficient means doing daily activities with the least possible effort. A fit person can do schoolwork, fulfill household responsibilities and still have enough energy to enjoy sports and other leisure activities (Human Kinetics, 2023). Individual-specific physical fitness includes muscular strength and endurance, cardiovascular endurance, flexibility and body composition, which are health-related, and coordination, agility, strength, balance, speed and reaction time, which are performance-related. Affecting one of the physical fitness parameters related to health or performance affects physical fitness (Alkan & Mutlu, 2020).

It is possible to maintain and improve physical fitness by performing the recommended amount of physical activity and regular exercise according to the age group and health status of the person. Yoga is an ancient philosophy of life based in India, whose philosophy is based on body balance, physical, mental and emotional well-being. The practice involves a set of postures (asana) that are maintained over a certain period of time. Yoga also consists of voluntary breath control (pranayama), voluntary concentration on thoughts (meditation) and repeated verbal expressions (Atilgan et al., 2015). Today, yoga is seen as an exercise approach that requires flexibility, strength and meditation (Arnold, 2023). Yoga is considered as a comprehensive exercise program that affects the mind with proper body positioning and uses concentration, relaxation, respiration and physical exercises together (Atılgan et al., 2015). Yoga is now starting to be included in physical activity guidelines. The current National Physical Activity Guidelines of the United States of America consider yoga exercises as mild or moderate intensity physical activity, as they vary in intensity from mild (e.g. Hatha yoga) to moderate (e.g. Vinyasa, power yoga) due to the many different styles. In addition, depending on the style and postures practiced, yoga can be considered both aerobic and strength exercise. The guide recommends 150-300 minutes of moderate-intensity yoga exercise per week for adults (Piercy et al., 2018; Onen & Karabudak, 2021). The American College of Sports Medicine, on the other hand, evaluates yoga in the neuromotor exercise class and recommends yoga exercise ≥2-3 times a week, ≥20-30 min/day without discriminating intensity (Pescatello, 2014; Onen & Karabudak, 2021).

Yoga is known to have several health benefits, including lowering blood sugar for people with type 2 diabetes; improvement in symptoms of depression and anxiety; reduction of pain; improvement of sleep disturbance; and improved quality of life. Yoga combines physical, mental and emotional dimensions to improve health. Many people prefer yoga practice because it is easy to learn, can be practiced effectively in a confined space without special equipment, and can be practiced by various age groups to manage health (Schin, 2021).

In this context, the aim of this study was to review, compare, and evaluate the results of studies examining the effects of yoga exercises on physical fitness. Thus, the effects of yoga exercises on physical fitness will be revealed in a systematic way.

METHODS

Research Methodology

The study was conducted according to the general survey model. For the systematic review, the guidelines for preparing a systematic review by Rico-González et al. (2022) were used.

Study Population

Studies were included if they included patients or healthy subjects aged 4 years and older.

Data Collection Tools

In the literature review, PubMed, Web of Science and EBSCO databases were used through the online databases system of Izmir Democracy University Central Library and the keywords "yoga and physical fitness" were searched in these databases. English-language randomized controlled and clinical studies published in the last five years starting from September 2023 were examined and the relevant ones were included in the study. Studies in which yoga exercise method was used but the effect on physical fitness was not examined were not included in the study. Eleven studies that met these criteria and were relevant to the subject were included in the study. Details about the screening process are presented in Figure 1.

Data Analysis

Data analysis was conducted by analyzing the 11 articles included in the study under different headings: purpose, sample, method, findings and conclusion.

Figure 1. Study Selection Process

RESULTS

The results are presented in a table with the name of the author and year of publication, title of the study, purpose of the study, sample (number of participants, gender of the participants and age), method (training program, training frequency, parameters evaluated and evaluation method), findings and results are presented in Table 2.

Table2. Included Studies

Author, (Year)	Title of the Study	Aim of the Study	Sample			Method			Results	Conclusions
			The number of participants	Gender	Age	Training Program	Training Frequency	Measured Parameters and Measure Method		
Yao et al., (2023)	Effect of Chair Yoga Therapy on Functional Fitness and Daily Life Activities among Older Female Adults with Knee Osteoarthritis in Taiwan: A Quasi-Experimental Study	To examine the effectiveness of chair yoga therapy on improving functional status and daily life activity scores in older female adults with knee osteoarthritis	N: 85 Experimental Group (Chair yoga therapy): 43 Control Group: 42	Female: 85	65 years old or above	Chair yoga therapy: 15-min warm-up 50-min yoga 10-min break 20-min yoga 15-min cool down	12 weeks 2 days/per week 110-min	Physical Fitness: Senior Functional Fitness Test	Hand grip strength, lower- and upper-limb muscle strength, static balance, agility and dynamic balance and lower-limb flexibility, significantly improved in the experimental group when compared with the control group at post-test	Chair yoga program is effective in improving the functional fitness of community-dwelling elderly females with knee osteoarthritis
Ayán et al., (2023)	Effects of stretching vs. in Hatha yoga people with mild to moderate Parkinson's disease: A randomized controlled trial	To compare the impact of Hatha yoga versus stretching on physical outcomes, quality of life and motor function in individuals with Parkinson's disease	N: 23 Hatha Yoga Grup: 12 Stretching Group: 11	Female:7 Male:16	Unspecified for all participants	Hatha yoga: 10-min warm-up 30-min Hatha yoga 20-min breathing exercises Stretching program: 10-min warm-up 40-min stretching exercises 10-min	8 weeks 1 day/per week 60-min	Flexibility: Chair Sit and Reach, Back Scratch Lower body muscular strength: Sit to Stand Standing Balance: Stabilometer Functional autonomy: Timed Up and Go Walking speed : 10-m Walk Tests	The intra-group analysis indicated that stretching led to significant changes in motor function, upper-limb flexibility and lower-limb muscular strength. Significant improvements were observed in functional autonomy and walking speed in both groups.	Hatha yoga program is effective in improving the functional autonomy and walking speed of in individuals with Parkinson's disease

						breathing exercises				
Phung et al., (2023)	The Effects of 12 Weeks Yoga Training on 4-5-Year-Old Preschoolers' Fitness Components	To examine the effectiveness of a twelve week yoga practice program on 4-5-years old preschoolers' balance, agility, flexibility, and core strength development	N: 61 Experimental Group (Yoga): 30 Control Group: 31	Female: 27 Male: 34	4-5-years old	Yoga: 30-min 26 yoga asanas and sun salutation	12 weeks 3 days/per week 30-min	Balance: One-Leg Balance Standing Agility: 4x5m Shuttle Run Flexibility: Shoulder Flexibility Test, Sit and Reach Core strength: Standing Long Jump Test, Sit Ups Test	The yoga training significantly improved balance, flexibility and muscular strength when comparing the yoga group with the control group. Agility of the two groups was not found to be significantly different.	The twelve-week yoga program could be employed as a form of practice that could help improve the physical fitness components of children in their early childhood
Csala et al., (2021)	Is Weekly Frequency of Yoga Practice Sufficient? Physiological Effects of Hatha Yoga Among Healthy Novice Women	To investigate whether weekly frequency of beginner level hatha practice is sufficient to evoke beneficial changes in indicators of physical fitness and heart rate measures among healthy female adults	N: 82 Experimental Group (Yoga): 49 Control Group: 33	Female: 82	Yoga Group: 21.49 ± 2.3 years Control Group: 22.75 ± 5.32 years	Yoga: Short body and breath scan Asana practice Relaxation practice	10 weeks 1 day/per week 90-min	Body fat percentage: OMRON BF-511 body composition scale Balance: One-Leg-Stand Test, Functional Reach Test Flexibility: Side Bend Test, Modified Sit and Reach Test Core muscle strength: Plank Test	Yoga group showed improvement in flexibility and balance compared to the control group. The yoga group showed also increased core muscle strength.	Weekly setting of a 10-session long hatha yoga training leads to improvements in balance, flexibility and core muscle strength among healthy young women
Gohel et al., (2021)	Effect of Long-term Regular Yoga on Physical Health of Yoga Practitioners	To explore the effect of long-term regular yoga on physical health of yoga practitioners	N:50 Yoga Group: 50	Female: 37 Male: 13	29-49 years old	Yoga: 4 h (Theory and practical, 2 h each) on every Sunday 1 h in 5 days a week at home	1 year 1 day/per week (course) 4 h 5 days/per week (self practice) 1 h	Aerobic Fitness: Pulmonary Function Tests, Bruce Treadmill Test Flexibility: Sit and Reach Test Body Composition:OMRON Body Composition Scale	The aerobic capacity (FVC, FEV1, PEFR, Flexibility score and endurance (Vo2, tread mill time) improved signifcantly whereas body mass composition were similar before and after the intervention	Regular yoga practitioners demonstrated the improvement in pulmonary functions, cardiorespiratory fitness, endurance, and flexibility.
Widjaja et	Benefts of Thai	To evaluate the	N: 22	Female: 22	55-70	Thai yoga:	8 weeks	Flexibility: Sit and reach	Signifcant improvement	An 8-week thai yoga

al., (2021)	Yoga on physical mobility and lower limb muscle strength in overweight/obese older women: A randomized controlled pilot trial	effects of 8-week Thai yoga training on physical mobility, including flexibility, dynamic balance, walking ability, and lower extremity muscle strength in overweight/obese older women	Experimental Group (Thai yoga): 11 Control Group: 11		years old	15-min warm-up 30-min yoga 15-min cool down	3 days/per week 60-min	test Dynamic balance: Functional reach test Lower extremity strength: 30-second chair stand test, isokinetic muscle strenght (Biodex) Aerobic fitness: 6-minute walk test Power, agility, speed, and dynamic balance: 8-Foot up and go test	was found in all variables within the thai yoga group, but no change was observed in the control group.	program appears to provide benefcial improvements in physical fitness in overweight/obese older women
Seguin-Fowler et al., (2020)	Feasibility of a yoga intervention to decrease pain in older women: a randomized controlled pilot study	To evaluate the feasibility of a flow-restorative yoga intervention designed to decrease pain and related outcomes among women aged 60 or older	N: 38 Experimental Group (Flow-restorative yoga): 19 Control Group: 19	Female:38	60 years or older	Flow-restorative yoga: 5-min breathwork 40-min standing and seated flow postures 15-min restorative postures	12 weeks 2 days/per week 60-min	Physical Fitness: Senior functional fitness test	Participants in both groups improved across functional fitness measures of upper body flexibility (back scratch test) and strength (arm curl), although changes were not significant.	Flow-restorative yoga is an effective method for reducing pain and improving energy and social function in women aged 60 and over, but it does not improve physical fitness
Boraczyńsk i et al., (2020)	The effects of a 6-month moderate-intensity hatha yoga-based training program on health-related fitness in middle-aged sedentary women: a randomized controlled study	To examine the effects of a 6-month Hatha Yoga-based training program on health related fitness components in sedentary middle-aged women	N: 80 Experimental Group (Hatha yoga): 42 Control Group: 38	Female: 80	30 to 45 years old	Hatha yoga: 10-min warm-up 40-min progressive series of Vinyasa flow standing and seated poses 10-min cool-down	6 months 3 days/per week 60-min	Body Composition: Bioelectrical Impedance Analysis Static-Dynamic Balance: Ellipsis Static-Dynamic Test Muscular Strength: Handgrip, Biodex-3 Pro (isometric) Cardiorespiratory Fitness: 5-minute submaximal Workloads protocol with	Hatha yoga group demonstrated signifcant improvements in every variable tested	By participating in a moderate-intensity 6-month Hatha yoga based training program, middle-aged women can signifcantly improve their health related fitness status

								submaximal Workloads protocol with cycle ergometer (Karpman formula) Flexibility: Modifed Sit-and-Reach Test		
Reina et al., (2020)	Yoga for Functional Fitness in Adults with Intellectual and Developmental Disabilities	To examine the benefts of a group yoga intervention on the functional ftness of adults with intellectual and developmental disabilities	N:8	Female: 4 Male: 4	18 years old or older	Yoga: Seated, standing and floor yoga postures	7 weeks 2 days/per week 60-min	Physical Fitness: Functional Fitness Test	Signifcant improvements was found in lower-body strength , upper-body strength, agility and balance	Yoga intervention may enhance functional ftness for people with intellectual and developmental disabilities
Bucht & Donath, (2019)	Sauna Yoga Superiorly Improves Flexibility, Strength, and Balance: A Two-Armed Randomized Controlled Trial in Healthy Older Adults	To investigate whether sauna yoga at a moderate temperature (50 ∙C) beneficially affects flexibility, strength, balance, and quality of life in healthy elderly community dwellers	N: 21 Experimental Group (Sauna yoga): 11 Control Group: 10	Female: 19 Male:2	60 to 80 years old	Sauna yoga: 30-min: Asana practice in a moderate temperature of 50.5 ± 2.4 ∙C	8 weeks 1 day/per week 30-min	Flexibility: Chair Sit and Reach, Back Scratch, Lateral Flexion Test Strength: Five Times Sit-to-Stand Test Static Balance: Sharpened Romberg Test	Statistically significant improvement in favor of the sauna group was observed only for the chair sit-and-reach test	Sauna yoga may serve as a promising and feasible means to improve flexibility in elderly people
Young et al., (2019)	The Effects of M2M and Adapted Yoga on Physical and Psychosocial Outcomes in People With Multiple Sclerosis	To investigate the effects of two 12-week exercise training interventions, movementto-music (M2M) and adapted yoga (AY), on physical and psychosocial outcomes in people with multiple sclerosis	N: 81 M2M Group: 27 AY Group: 26 Control Group: 28		18 to 65 years old	M2M: Multiple movement routines accompanied with music AY: Warm-up phase (Mountain 1) Work Phase:(Mountain 2) Cool-down phase:(Mountain 3)	12 weeks 1 day/per week 60-min	Mobility and balance: Timed Up and Go Test Walking endurance: 6-Minute Walk Test Lower Extremity Functional Strength: 5 Times Sit-to-Stand Test	AY group did not show any significant improvement in any parameter compared to the control group	A 12-week M2M intervention may be effective in improving mobility and walking endurance in participants with MS but AY not

DISCUSSION AND CONCLUSION

In this systematic review, the effects of yoga exercises on physical fitness were investigated. Articles in which different sample groups were examined were included in the study, so that it was aimed to make a general comment on the effects of yoga exercises on physical fitness. Articles in which yoga exercises were compared with other exercise approaches were also analyzed. These studies, conducted in the last five years since September 2023, were conducted in different countries of the world.

While it was concluded that yoga exercises improved physical fitness parameters in the majority of the studies reviewed, no significant difference was found in only two studies (Young et al., 2019, Seguin-Fowler et al., 2020). However, the limitations of these studies should be taken into consideration when evaluating these results (such as the fact that the study was a pilot study or the physical activity participation of the control group was not followed).

In the included studies, the sample consists of participants from different age groups, including children, elderly and adults. Studies in which elderly participants were selected as the sample group constitute approximately 45% of the total 11 included studies. In addition, studies in which participants from various disease groups such as osteoarthritis, Parkinson's disease, obesity, intellectual and developmental disabilities and multiple sclerosis were considered as the sample group constitute approximately 45% of the total 11 studies included. This may be thought to be since yoga is an accessible and easy exercise approach that can be easily adapted to individuals from various age groups and disease groups.

In all the studies analyzed, participants performed yoga exercises for at least 8 weeks and at least once a week. In addition, the results of two studies examining the effects of long-term, regular yoga exercises for 6 months and one year showed that yoga improved physical fitness parameters (Boraczyński et al., 2020, Gohel et al., 2021). In addition, in two of the included studies, the effects of yoga exercises were compared with different exercise approaches such as stretching and move to music, but the superiority of yoga exercises in improving the evaluated parameters was not revealed (Ayán et al., 2023, Young et al., 2019).

In the included studies, the most frequently evaluated physical fitness parameters were strength, flexibility and balance. It is seen that the physical fitness parameters with the most significant improvement after yoga exercises are again strength, flexibility and balance. There are also studies that evaluated body composition, aerobic fitness and agility parameters and found significant improvements in these parameters after yoga exercises.

In conclusion, the results of the studies examined in this systematic review revealed that yoga exercises are effective in improving physical fitness parameters. To support the positive effect of yoga exercises on physical fitness with stronger evidence, studies in which the sample size is determined by power analyses and sufficient number of participants is reached, longer-term interventions are preferred to observe chronic adaptation to exercise, including effect size in statistical analysis and comparing the effect of yoga exercises and other exercise approaches on physical fitness will contribute to the literature.

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Session 3

TRAINING PROGRAM FIRST STAGE IN THE RECOVERY OF AN ATHLETE (SWIMMER) AFTER MYOCARDITIS - A CASE REPORT

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ABSTRACT

The coronavirus infection can affect different organs and systems. One of the most common complications are myocarditis. Swimming is a sport that requires good functioning of the respiratory and cardiovascular systems. Monitoring the response of the cardiovascular system to exercise can be followed with various tests such as the treadmill test, the Martinet test and the Lean test. The purpose of this report is to present a program for restoring the functional capabilities of the cardiovascular system in an athlete (swimmer). The program we implement includes running and climbing stairs. The duration of the applied program is 17 days. During the first 8 days, the load includes running 2 km, and climbing 63 steps with a height of 14 cm. During the remaining 9 days, the subject runs 5 km and climbing of 126 steps. The heart rate is monitored before training, immediately after it and in the first, second and third minutes. The time for which the distance is covered is also tracked. Before the intensive training, the ejection fraction was 60%, and then – 62%. According to the treadmill test, the patient recovered the values of arterial pressure and heart rate at the 4th minute. The applied Martinet test shows a recovery of the values again at the 4th minute. In the Lian test, the score equates to poor cardiovascular health. The application of running exercises and exercises on stairs leads to adequate training of the cardiovascular system. The functional condition and endurance to load improves.

Keywords: Cardiovascular system, myocarditis, test, heart rate, blood pressure

INTRODUCTION

Cardiological complications after passing SARS-CoV-2 in athletes and young and healthy subjects are of recent interest. Doing a study, van Hattum et al. (2021) reported that in athletes, the risk of pericardial or myocardial involvement in this infection is low (0%–5%), and the application of exercise to viral myocarditis may exacerbate the problem (van Hattum et al., 2021).

Cardiac rehabilitation is recommended for patients with cardiovascular disease as a means of improving quality and length of life. Besides regulating risk factors, according to Zheng et al. (2022), it can improve cardiopulmonary function, vascular endothelium, ventricular filling, and ventricular remodeling. Cardiorehabilitation includes aerobic and resistance exercises, as well as endurance exercises. Aerobic training can be of low, medium and high intensity. In the US and Canada they recommend high and medium intensity exercise, in Japan and Australia - low to moderate intensity, and in Europe - moderate intensity (Zheng et al., 2022).

The Liane and Martinet tests were created in 1916, during the First World War, to determine the physical fitness of soldiers. According to the WHO, physical fitness is the ability to perform muscular work under aerobic conditions. Stress tests can detect latent heart or respiratory failure. The Lian and Martinet tests give an approximate estimate of cardiac capacity during athletic efforts. They are recommended to be used when there are contraindications to exercise with maximal loads (DAH, 1991).

The purpose of this article is to present methods for assessing the state of the cardiovascular system in an active swimmer who has experienced myocarditis, as well as a training program for his recovery.

METHODS

We followed the state of the cardiovascular system by applying two stress tests - Martine's and Lian's.

Martine's test - Monitors the recovery of heart rate and blood pressure after a short exercise. These values are measured in a lying position (at rest). Without removing the cuff, the seated person performs 20 squats in 40 seconds. Heart rate and blood pressure values are monitored in the 1st, 2nd and 3rd minutes after exercise. The obtained values are compared with the initial values. Blood pressure response and recovery time are recorded. For active sportsmen, the heart rate increases by 20-25 bpm at the end of the exercise. Recovers in 1-1.5 minutes. Systolic blood pressure increases by 15-20 mmHg and recovers after 3-4 minutes. Diastolic blood pressure does not change or falls by 5-10 mm Hg and restores baseline values after the 3rd minute.

Lean's test- Tracks heart rate recovery after a one-minute exercise. The examined person runs in place for 1 minute at a pace of 120 steps per minute. Heart rate is measured at rest and for 6 minutes. The recovery of the starting values for athletes training for endurance should be done by the 2nd minute, and by the 3rd minute for other sportsmen.

Subjects

The study involved an 18-year-old athlete training to swim. The patient reported that in January 2023, during a training camp, he had Covid 19 asymptomatically, without complications, for the third time. After recovery, he returned to a normal training regimen, but noticed that he got out of breath and tired more easily. After consultation with a cardiologist, it was established that he had myocarditis. Suspends training for about three months. After his return, he shared about easy fatigue and shortness of breath while exercising. Active training with maximum physical effort is suspended. The condition of the examined person is monitored monthly.

Procedure

The subject is familiar with the nature of the procedure, and after obtaining written informed consent, we proceed with the application of assessment tests and the training program.

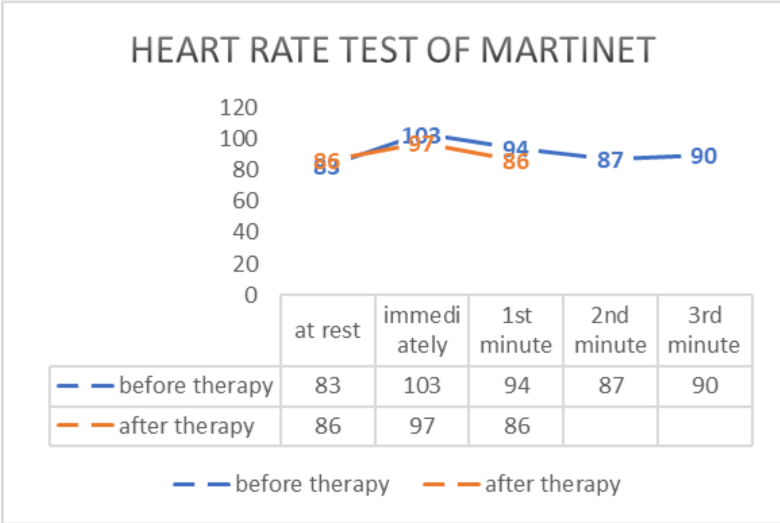
Learning the history and conducting the tests to assess the reactivity of the cardiovascular system, we thought it appropriate to apply endurance training. We recommended that the subject include running and stair training, tracking their heart rate before exercise, at the first, second and third minutes after exercise. It also counts the time for which he did the training. The training program lasts 17 days. During the first 8 days, the subject ran 2 km and climbed 63 steps with a height of 14 cm. In the following days, he ran 5 km and climbed 126 steps.

Statistical analysis

We have used descriptive and deductive statistics. We have presented graphically the changes in blood pressure and heart rate.

RESULTS

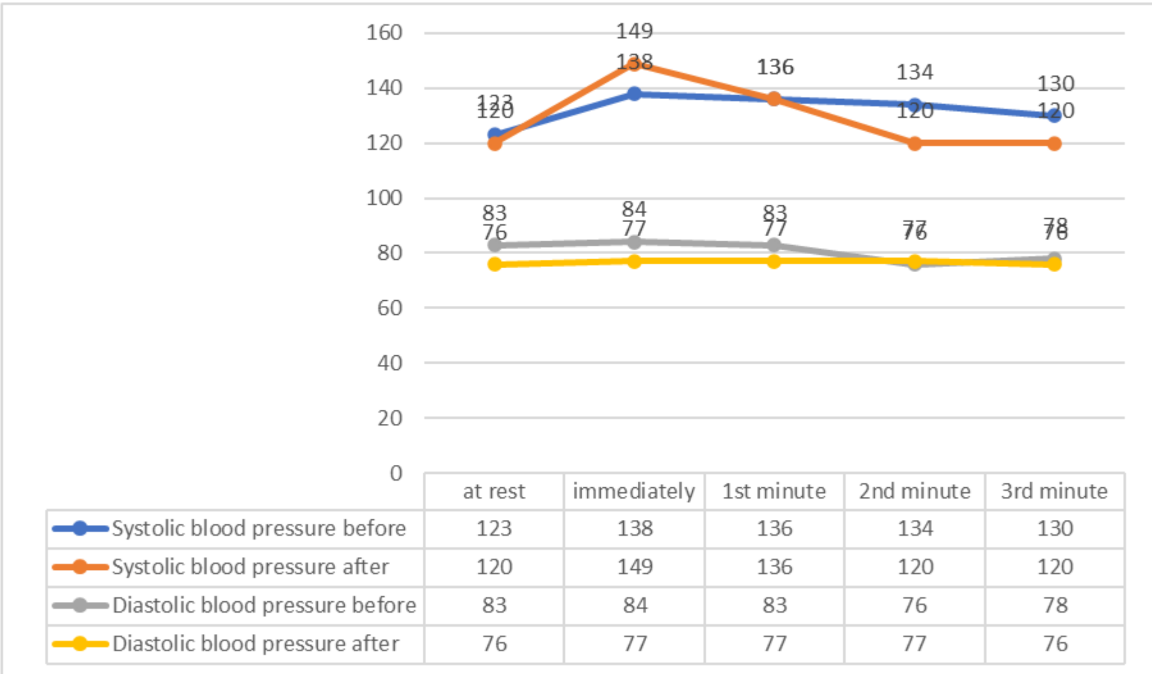
We report the values of blood pressure and heart rate when testing the subject according to two tests - the Martinet test and the Lian test. The results of changes in heart rate in the Martinet test before and after the applied therapy are presented in graph 1.



	at rest	immediately	1st minute	2nd minute	3rd minute
before therapy	83	103	94	87	90
after therapy	86	97	86		

Graph 1 Heart rate values in the Martinet test before and after the therapy

From the heart rate values (graph 1) before therapy, we notice a sharper rise after the exercise and a slow decrease in the values, not normalizing to the baseline values for the follow-up period. Baseline values are restored at the fourth minute. After the therapy, we find that the initial values are reached in the first minute.

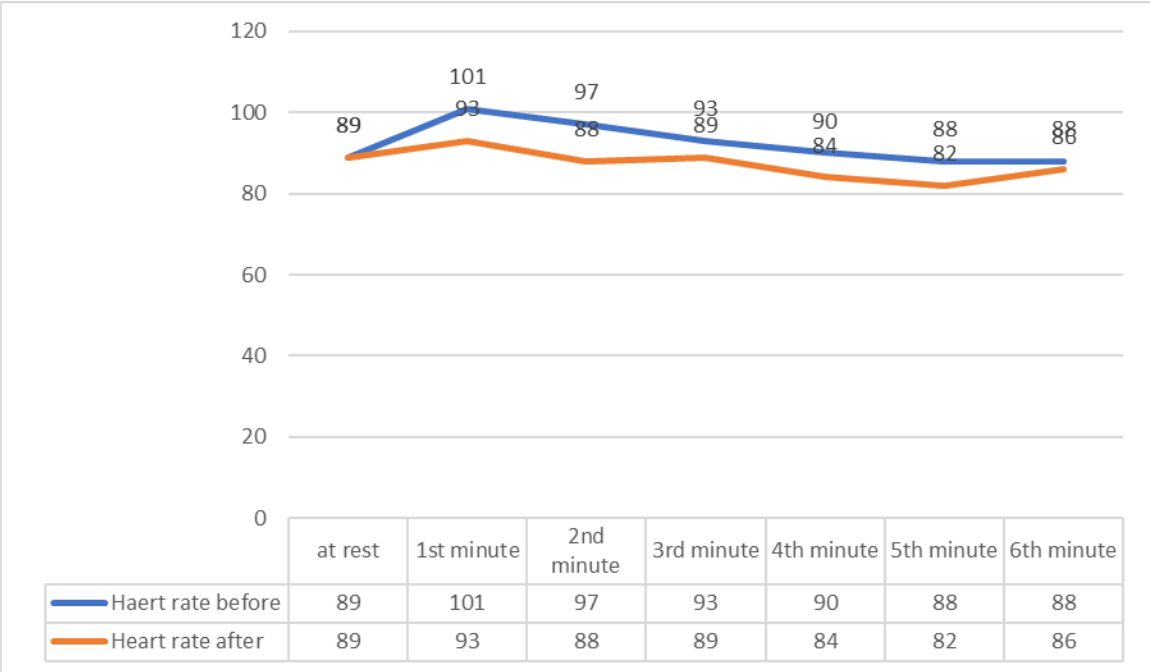


	at rest	immediately	1st minute	2nd minute	3rd minute
Systolic blood pressure before	123	138	136	134	130
Systolic blood pressure after	120	149	136	120	120
Diastolic blood pressure before	83	84	83	76	78
Diastolic blood pressure after	76	77	77	77	76

Graph 2 Values of arterial pressure in the Martinet test before and after the therapy

It can be seen from graph 2 that the values of the systolic blood pressure before carrying out the therapeutic program, immediately after the load, rose by 15 mmHg and gradually decreased, not recovering during the studied period. In the values of systolic blood pressure after carrying out the therapeutic treatment, we notice an increase after the exercise by 29 mmHg and a recovery to the initial values in the second minute. Diastolic blood pressure can be noted to remain constant.

In Lian's test, it is noticed that the heart rate at rest is the same before and after the therapy. From graph 3, it is observed that before the therapy the heart rate recovers in the fourth minute, and after it - in the third minute.



Graph 3 Graph 1 Heart rate values in the Lian test before and after the therapy

DISCUSSION

According to Amoretti and Toussaint (2013), myocarditis can occur in any subject who develops a viral syndrome. Athletes should avoid competitive loads and intense loads for 6 months. After this period, the athlete's condition is reassessed by ultrasound and a stress test.

Analyzing the results of Martine's test before carrying out the described therapy, we find that the examined person recovers the values of heart rate and blood pressure at the fourth minute. Before we started therapy, he was given a treadmill test, which also noted that he was recovering at the fourth minute. After the therapy, the heart rate was restored in the first minute, and the systolic pressure in the second minute. This may testify to the better adaptability of the cardiovascular system to light-intensity loads.

In Lean's test values, we notice a smooth rise and fall of the values. Recovery occurs at the end of the fourth minute in the baseline test and the third minute in the posttest. This is another proof of improvement in the functional state of the cardiovascular system.

In terms of distance covered, we notice an improvement with each passing day, which is more visible with the longer distance. On the first day, he runs 5 km in 28.49 minutes, and on the last day - 23.54 minutes.

The subject returned to active maximal effort training activity 3 months after the diagnosis of myocarditis, without having performed a constant-load training program. This provokes pronounced symptoms of myocarditis. That is why we believe that athletes should be gradually introduced, reaching the maximum load should be done after an ultrasound examination with a cardiologist and the absence of subjective complaints (fatigue, shortness of breath, tightness in the chest area).

For the short period of the training program (17 days), the subject reported a reduction in fatigue and the time it took to cover the set distance. An ultrasound examination showed an improvement in the condition, with the ejection fraction improving by 2%. However, loading with maximum capabilities should take place after 6 months.

The research is not over yet. In research, the training regimen was changed, including swimming 400 m with 60% load of his maximum. The results will be published at a later stage.

CONCLUSION

The Lian and Martinet tests have been used for many years to determine the functional capabilities of the cardiovascular system. They are easily reproducible and reliable. The application of intensive training, including running and climbing stairs, leads to the improvement of the activity of the cardiovascular system. The return of athletes after a period of myocarditis to active training and competition activity should be done carefully, with increased workload and compliance with the deadlines for limiting physical activity.

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SPINE INJURIES IN VOLLEYBALL – LOW BACK PAIN

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ABSTRACT

Volleyball is a limited contact sport that requires a combination of fitness and technical skills. Players must be able to master various skills, including serving, passing, setting, hitting (or spiking), blocking and at the same time have the strength and endurance to repeat the same skills several times during the match. The highly explosive nature of the game creates numerous opportunities for acute injury, while the repeated jumping, moving and hitting required as part of volleyball-specific skills contribute to the often-encountered overuse injuries. Spine injuries in volleyball are not uncommon, with the incidence of low back pain estimated at between 10-14% of all volleyball-related injuries, making it the fourth most common injury in volleyball. In addition to the stresses that a volleyball player commonly encounters via the kinetic chain and alterations in normal mechanics, a volleyball player's spine is also subjected to stresses through the repetitive volleyball-specific motions required in the sport, in particular the spike. An attacker will often repeat the hitting motion hundreds of times a week during the season through practice, warm-up, and games. The rapid extension during the approach, combined with the hyper-rotation and oblique extension to cock the hitting arm followed by the rapid counter rotation and forced flexion, produce forces that will cause strains, sprains, and possibly overload of bone-causing stress fracture. Repetitive hitting in volleyball players has been associated with overuse injuries of the back, including lumbar strains, facet syndrome, pars fractures, and even disc herniations. Other factors that can contribute to spinal injuries in volleyball include different ages, skill levels, and the variety of surfaces on which volleyball is played.

Keywords: Spine, kinetic chain, joint, foot, volleyball.

INTRODUCTION

Volleyball is a limited contact sport that requires a combination of fitness and technical skills. Players must be able to master various skills, including serving, passing, setting, hitting (or spiking), blocking and at the same time have the strength and endurance to repeat the same skills several times during the match. Although volleyball is often seen as a team sport with limited contact, it is not without frequent injuries. Studies of Scandinavian athletes revealed that the frequency of injuries in elite volleyball players was similar or slightly lower than that of basketball players, but significantly higher than the incidence in football, handball and ice hockey, which makes volleyball a high risk of injury (Bahr & Bahr, 199).

The highly explosive nature of the game creates numerous opportunities for acute injury, while the repeated jumping, moving and hitting required as part of volleyball-specific skills contribute to the often-encountered overuse injuries. Spine injuries in volleyball are not uncommon, with the incidence of low back pain estimated at between 10-14% of all volleyball-related injuries, making it the fourth most common injury in volleyball (Aagard et al., 1997; Briner & Benjamin, 1999). .

Other factors that can contribute to spinal injuries in volleyball include different ages, skill levels, and the variety of surfaces on which volleyball is played. All of these factors increase the potential for injury to volleyball players. Solgard et al. (1995) found that the occurrence of injuries depends on the age of the players, their ability level and gender. Based on all of the above, this paper has two goals: 1. to diagnose the most common injuries in the lumbar spine; 2. to give recommendations for the rehabilitation and treatment of the most common injuries of the lumbar spine in volleyball players.

Lumbar disc injury

The intervertebral disc is a hydrodynamic elastic structure that has two components: the annulus fibrosus and nucleus pulposus. In early life and into the late 30s, the blood vessels that pass to the endplate are progressively obliterated, with most nutrients being provided through the process of absorption, where compression and distraction push nutrients into the disc. The annulus fibrosus consists of layered sheets of collagen fibers with individual fibers improving overall mechanical efficiency. The annulus fibrosus consists of a homogeneous mucopolysaccharide matrix containing a network of fine protein-based fibers. From a biomechanical perspective, the internal disc pressure functions to separate the vertebral endplates and maintain tension within the annular fibers. Flexion and extension forces are well tolerated by the annulus, whereas the addition of rotational forces causes excessive stress to the annulus, leading to failure.

Lumnar disc injury is a relatively rare injury in young athletes (Tertti et al., 1999). Michell & Wood, (1995) reported that 11% of adolescents compared to 48% of adults with back pain had a diagnosed disc injury. Unlike non-athletes, athletes may experience significant changes in disc structure. Sward et al. (1991) noted disc degeneration in 75% of male gymnasts compared to 31% of age-matched non-athletes, where different sports were assessed for potential increased risk of disc herniation. Mundt et al. (1993) found a weak association between bowling and lumbar disc herniation, with no significant association in other sports such as baseball, softball, golf, swimming, weightlifting, and racquet sports. Volleyball athletes suffering from acute disc herniation with radiculopathy may complain of pain in the legs and back at the beginning, where the pain is noticed to pass through the knee. On examination, sensory loss in a dermatomal distribution, loss of myotome strength, and decreased or absent muscle stretch reflexes may be noted. Provocative maneuvers such as the straight leg raising test are often positive between the 30-70° range, causing the pain to be referred distally below the knee. Other provocative maneuvers include the use of neck flexion, dorsiflexion of the ankle joint, or compression in the popliteal fossa (ie, “Bowstring maneuver”) that worsens symptoms of pain referred to the extremity.

Table 1. Lumbar disc herniation/radiculopathy treatment algorithm

Initial phase (pain control)
Activity modification
Anti-inflammatory medication with muscle relaxants
Therapeutic modalities
Soft tissue mobilization
Epidural steroids
The McKenzie Program
Reactivation phase (correct postural, flexibility and strength imbalance)
Continoue McKenzie program
Active modalities - continuous low-level heat wrap therapy
Spinal Stabilization-progressive
Nerve gliding techniques
Stretching hamstrings
Squat program
Address remaining issues pertaining to the entire kinetic chain
Advance to overall core strengthening
Sport-specific training
Maintenance phase (functional adaptations)
Continue with core stabilization maintenance
Upgraded sport-specific training with return to play
Comprehensive independent exercise program

Diagnostic testing may include X-rays, computed tomography (CT), magnetic resonance imaging (MRI), and electromyography. X-rays are of limited value in the diagnosis of lumbar disc injury, but may show evidence of disc space narrowing, osteophyte formation, or evidence of spondylolisthesis that may predispose to the development of radiculopathy. A CT scan can be used to identify a herniated disc, but has limited use in this regard due to the superior anatomical imaging provided by MRI. MRI provides great anatomical detail, visualization of disc herniation or focal stenosis that predisposes to radiculopathy (Malagan & Nadler, 1998). Jensen et al. (1994) reported that in asymptomatic individuals, more than 27% younger than 50 years and 67% older than 50 years had multiple abnormalities on MRI. Based on this, it is necessary to carefully evaluate the results of MRI in combination with the history and physical examination. Electrodiagnosis provides a dynamic picture of any pathological process affecting the lumbar nerve root. It is used at the onset of injury, with pathological changes noted on H-reflex imaging and motor unit engagement. It is recommended to use it 3 weeks or more after injury, when spontaneous (abnormal) activity in axial and peripheral musculature can be applied. The initial recovery strategy should focus on reducing pain using pharmacologic agents, including McKenzie evaluations in an attempt to centralize symptoms, Table 1. Epidural steroids may be helpful in reducing symptoms enough to allow progression of a spinal stabilization program.

Lumbar facet syndrome

The lumbar zygopophyseal joints are true synovial joints and are subject to inflammation. It is crucial to understand the anatomy of these joints because it affects diagnostic and treatment decisions (Bogduk & Engle, 1984). The lumbar facet joints maintain a sagittal orientation from L1-L4, with a more coronal orientation at L5-C1. These joints are innervated by the posterior primary ramus, which supplies at least two zygopophyseal joints, each joint receiving innervation from at least two spinal levels. The joints allow between 2-3 degrees of rotation in each segment within the lumbar spine and account for between 12 and 24% of the compressive load, the remainder being absorbed by the intervertebral disc. The amount of compressive load increases as the height of the intervertebral disc decreases. The facet syndrome may thus result from degeneration of the disc or the joint itself, positional overload such as may be seen with any repetitive overuse injury and secondary to trauma (Schwartzer et al., 1994).

Volleyball players often describe a sudden flexion/extension maneuver, often combined with rotation/side bending as the perceptual event. Lumbar facet syndrome occurs in volleyball where sagittal and transverse movement are combined in the end range. No significant research has been conducted to identify the true incidence and prevalence of facet syndrome, which is most likely secondary to difficulties in obtaining reliable objective testing (Lenard & Crabtre, 2005). Volleyball players with facet syndrome can vary significantly in the presentation of symptoms, while treatment can vary from simple pharmacological and non-pharmacological measures to the use of osteopathic manipulation and steroid injections, Table 2. Volleyball players can respond quickly to manipulative treatment with or without the use of drugs, so this should be attempted before using interventional procedures. Return to play should be dictated by response to treatment and the ability to perform all warm-up exercises without pain and good biomechanics of the movement.

Table 2. Lumbar facet syndrome treatment algorithm

Initial phase (pain control)
Activity modification
Anti-inflammatory medication with muscle relaxants
Therapeutic modalities
Soft tissue mobilization
Muscle energy techniques
Consider intra-articular steroid injection into the dacet joint for refractory pain
Reactivation phase (correct postural, flexibility and strength imbalance)
Active modalities
Spinal Stabilization-progressive
Stretching hamstrings, hip flexors, quadriceps
Advance to overall core strengthening, including hip extensors abductors
Sport-specific training
Maintenance phase (functional adaptations)
Continue with core stabilization maintenance
Upgraded sport-specific training with return to play
Comprehensive independent exercise program

Lumbar spondylolysthesis/spondylolisthesis

Spondylolysis or fracture of the pars interarticularis can be related to an acute traumatic event or an overuse phenomenon causing stress fracture (Jackson et al., 1981). Micheli & Wood, (1995) reported spondylolysis as the final diagnosis in 47% of adolescents aged between 12 and 18 years who complained of low back pain. Sports that require repetitive hyperextension more often predispose to the development of a pars fracture. Rossi (1988) states that 63% of divers, 36% of weightlifters, 33% of wrestlers and 32% of gymnasts have been diagnosed with spondylolysis compared to 5% of the general population. Spondylolisthesis is defined by a forward or backward subluxation of one vertebra on another. There are several types of spondylolisthesis: isthmic has an anatomic defect in the pars interarticularis; dysplastic types have structurally inadequate posterior elements; degenerative types are the result of significant degenerative changes of the zygopophyseal joints and deficient supporting ligaments; traumatic types are the result of fracture of the posterior elements other than the pars; and pathological types are the result of metabolic, malignant, or infectious diseases (Wiltse et al., 1975). Meyerding's classification system separates slippage in 25% intervals, with grade I defined as 0-25% slippage; grade II with slippage of 26-50%; grade III with slippage of 51-75%; and grade IV with slip of 76-100% (Wiltse & Winter, 1983). Spondylolisthesis is an uncommon occurrence in competitive volleyball players most likely secondary to superior dynamic muscle stabilization and skeletal maturity. Wiltse et al. (1975) stated its occurrence in skeletally immature adolescent volleyball players between the ages of 9 and 14, while its rare occurrence in athletes above this age range.

Volleyball players presenting with these fractures will complain of various symptoms, including localized lower back pain, worsening of pain with back extension, pain with standing, walking, or lying prone, with pain relieved with sitting, bending, or lying supine. Based on physical assessment, volleyball players may have hyperlordotic posture, tight hip flexors or hamstrings, weak abdominal muscles, pain, tenderness, and lower back muscle spasm. Spondylolysis is diagnosed by physical examination, along with X-ray and/or specialized bone scan studies (Read, 1994). A newer approach uses activity modification (avoidance of extension activities) in combination with stretching involving the lower extremity musculature and core strengthening in a neutral position while the fracture heals, Table 3. Research supports the concept that if this condition is diagnosed at an early stage, a significant percentage of early fractures will heal (Morita et al., 1995). On the other hand, as the fracture becomes older, the possibility of bone healing is reduced. The ultimate goal of treatment is to return the athlete to sport without pain and to prevent the likelihood of recurrence.

Table 3. Spondylolysis/spondylolisthesis treatment algorithm

Initial phase (pain control)
Activity modification - avoid extension activities
Analgesics if necessary
Therapeutic modalities for local muscle spasm
Use soft lumbosacral support for protection and proprioception
Reactivation phase (correct postural, flexibility and strength imbalance)
Stretch hamstrings, hip flexors, quadriceps
Strengthen abdominal musculature
Spinal stabilization - progressive
Address remaining issues pertaining to the entire kinetic chain
Sport-specific training - modify technique
Maintenance phase (functional adaptations)
Continue with core stabilization maintenance
Upgraded sport-specific training with return to play
Comprehensive independent exercise program

Sacroiliac joint dysfunction

The sacroiliac (SI) joints are weight-bearing joints between the articular surfaces of the sacrum and ilium which are located on the lateral surface of the sacrum. They are part synovial joint and part syndesmosis, with the synovial portion being the anterior and inferior one -third of the joint (Fortin, 1993). There is hyaline cartilage on the sacral side and fibrocartilage on the iliac side. There are no muscles that directly control the movement of the sacroiliac joints, but many indirectly affect the movement. The movement of the sacroiliac joint is mostly passive in response to the action of the surrounding muscles. The psoas and piriformis muscles pass under the sacroiliac joint and an imbalance of these muscles in particular can affect the function of the sacroiliac joint. An imbalance in the length and strength of the piriformis strongly affects the movement of the sacrum. Sacroiliac joint dysfunction occurs when there is a change in the structural or positional relationship between the sacrum and the normally positioned ilium (Lavignolle et al., 1983). The sacroiliac joint plays a small but significant role in lower back and buttock pain, although the true frequency is unknown. In addition to volleyball players, it occurs in skiers, rowers and gymnasts (Lindsay et al., 1993; Barakatt et al., 1996; Timm, 1999). The sacroiliac joint is a synovial joint with extensive innervation from the lumbosacral region, which explains the difficulty in differentiating dysfunction of the sacroiliac joint from dysfunction of the surrounding structures. Various medical conditions such as rheumatological disorders, infections, and neoplasms can also affect the joint, and it is important for a sports physician to rule out the possibility of a sacral stress fracture.

The diagnosis of sacroiliac joint dysfunction can be difficult and can be improved by using a combination of provocative maneuvers (eg, Patrick's, Gaenslen's) and motion tests (eg, standing flexion, Gillet's) (Laslet, 1998; Cibulka & Koldehoff, 1999). Provocative single and double blind joint injections can provide improved specificity (Schwartzer et al., 1995; Slipman et al., 1988). Treatment should include a similar procedure as used for facet syndrome with the addition of sacroiliac bracing in athletes with hypermobility. In addition, stretching and strengthening of the piriformis, gluteus maximus, and psoas should be included in a comprehensive rehabilitation program, Table 4. The recovery program should progress from the pain control phase to the reactivation and maintenance phase as symptoms and function improve.

Table 4. Sacroiliac joint dysfunction treatment algorithm

Initial phase (pain control)
Activity modification
Anti-inflammatory medication with muscle relaxants
Therapeutic modalities
Sacral mobilization
Stretching of piriformis, gluteus meximus and psoas
Consider sacroiliac bracing for hypermobile individuals
Muscle energy techniques
High-velocity, low-amplitude manipulation
Consider intra-articular steroid injection into the sacroiliac joint for refractory pain
Reactivation phase (correct postural, flexibility and strength imbalance)
Active modalities
Spinal Stabilization-progressive
Stretching hamstrings, hip flexors, quadriceps
Advance to overall core strengthening, with attention towards hip extensors, piriformis
Address remaining issues pertaining to the entire kinetic chain
Sport-specific training
Maintenance phase (functional adaptations)
Continue with maintenance core stabilization, stretching program
Upgraded sport-specific training with return to play
Comprehensive independent exercise program

Sacral stress fracture

An atypical cause of pain in the lower back and buttocks in volleyball players is a fracture of the sacrum (Johnson et al., 2001). Unlike volleyball players, it is more common in premenopausal female volleyball players and is difficult to diagnose because radiographs are usually normal (McFarland & Giangarra, 1996; Johnson et al., 2001), while triphasic bone scanning is the best way to diagnose these fractures. (McFarland & Giangarra, 1996). The most significant risk factor for its occurrence has been described as an increase in impact activity due to a more vigorous exercise program (Johnson et al., 2001). It has been described in athletes participating in volleyball with the significant impact forces generated with landing from spikes, blocks, and serves as the probable etiology (Shah & Stewar, 2002). These stress fractures must be carefully evaluated, with historical information pertaining to a previous history of stress fracture, calcium intake, and evidence for the female athlete triad of anorexia, amenorrhea, and osteoporosis (Zeni et al., 2000).

Biomechanical problems such as excessive pronation or supination of the foot, varus and valgus of the forefoot, unequal leg length, and reduced hip rotation pose a risk of recurrent stress fractures (Korpelainen et al., 2001). Volleyball players must be educated about the problems of stress fractures by sports physicians and it is important that they are told to report any localized continuous pain that lasts longer than 2-3 days. Low bone mineral density has been implicated as a potential risk factor and screening with a DEXA scan may be appropriate to assess those who may be at greater risk of osteopenia and subsequent stress fracture (Korpelainen et al., 2001; Nattive, 2000). More research is necessary to further define this phenomenon. Most stress fractures respond to relative rest, correction of underlying biomechanical issues, and reduction in training intensity, especially the practice of jumps with greater rotations, table 5. A nutritional assessment is essential to clarify healthy eating attitudes and foods. Psychological support and counseling are equally important to those female athletes identified as suffering from the female athlete triad or those with predisposing risk for this triumvirate of conditions.

Table 5. Sacral stress fracture treatment algorithm

Initial phase (pain control)
Activity modification
Anti-inflammatory medication
Reactivation phase (correct postural, flexibility and strength imbalance)
Stretching of piriformis, gluteus maximus and psoas
Spinal stabilization-progressive
Advance to overall core strengthening
Address kinetic chain issues, including leg length discrepancy, hip rotation, foot mechanics
Sport-specific training
Maintenance phase (functional adaptations)
Continue with maintenance core stabilization, stretching program
Upgraded sport-specific training with return to play
Comprehensive independent exercise program

CONCLUSION

Volleyball is a sport that requires strength, speed, endurance, and agility. The repetitive nature of the game, along with the requirements for high-velocity hitting and contact with the playing surface, may lead to significant spine-related problems. Athletes must be carefully evaluated, with treatment addressing not only the injured region but also the entire kinetic chain.

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METHODS FOR ASSESSING MICROCIRCULATORY, HEMORHEOLOGICAL CHANGES AND OXYGEN TRANSPORT IN ATHLETES OF VARIOUS SPORTS DISCIPLINES

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ABSTRACT

Studies on microcirculation, hemorheological changes and oxygen transport occurring during physical activity and sport are overviewed. The aim of the work is to make a comparative analysis of the methods for researching the microcirculatory and hemorheological changes in athletes from different sports disciplines and different physical activities and ages. Assessment of microcirculatory changes in athletes practicing cyclical sports (running - marathons and skiing) and acyclical sports (weightlifting (weightlifting) and figure skating), highly skilled rowers, during the period of high-intensity sports training, as well as at rest was done. An analysis of the adaptation reserves of the microvascular bed in individuals with different physical activities and exercises was performed. The density of functioning capillaries, the average diameter of capillaries, microvascular perfusion, the blood flow velocity in the capillaries, heart rate, as well as the influence of low-energy laser radiation on the blood microcirculation system, age, duration of training, type of sports disciplines was evaluated. Based on the results, maximal oxygen consumption (MOC - VO2 max) was calculated and used to determine the level of physical performance. The body's functional reserves are restored to an anaerobic support mechanism as a result of training. The revealed changes that occur directly during muscle activity are stored in the body subsequently even after its completion. Accumulating for a long time, they gradually lead to the formation of a more economical type of microvascular response, which, in turn, can be a criterion for the athlete's functional sports orientation. The hemorheological changes during physical exercise were analyzed depending on the type, duration, intensity, and cyclicity of the physical activities. to develop additional indicators and criteria for the assessment of physical and functional orientation and workability and their applications.

Keywords: training, perfusion, oxygen supply, blood viscosity, physical efficiency

INTRODUCTION

At rest, when the muscles are not loaded or are resting, the work of all body systems is aimed at maintaining homeostasis. The main link in maintaining homeostasis is microcirculation. With regular physical activity, changes occur in the microcirculation system, due to the need for an optimal supply of oxygen to the body, which leads to a persistent change in homeostasis. At the present time, the adaptations of the body to physical loads at the level of the heart and large vessels are sufficiently well studied, but at the same time, the complex of rheological characteristics of blood, which determine transport possibilities, remain insufficiently studied.

The aim of the work is to conduct a comparative analysis of studies of microcirculatory and hemorheological changes in athletes from different sports fields and areas to develop additional parameters and criteria for assessing physical and functional orientation and efficiency.

I. Microcirculatory changes during exercise

Vascular reactivity is an important characteristic of the functional state of the circulatory system. Several authors note the presence of features of adaptive reactions in the microcirculation system (MC) depending on gender, age and physical exercise.

An analysis of the adaptation reserves of the microvascular bed in subjects of different physical exercise and age was carried out by P.V.Mihaylov et al. in [1] in four groups: 1A – non-training subjects 20-30 years; 1B – training subjects 20-30 years old; 2A – non-training subjects 50-60 years and 2B – training subjects 50-60 years old. Microcirculation (MC) indicators were determined at rest and after exercise on a bicycle ergometer. Microcirculation was studied using nail bed biomicroscopy and laser Dopplerography (LDV). In the examined individuals from groups 1A and 1B, the density of functioning capillaries (FCD) in some cases did not differ significantly. Moreover, the average capillary diameter (DC) in group 1A was 20% less than in group 1B ($p < 0.01$). After the exercises, the FCD in group 1A increased by 5% ($p<0.05$), and in group 1B - by 7% ($p<0.05$). DC in group 1A increased by 14% ($p < 0.01$), and in group 1B by 1%. The average value of microvascular perfusion (MP) was 19% less ($p<0.05$) in group 1B than in 1A. After physical exercise, an increase in MP was observed in group 1A by 49% ($p<0.01$), in group 1B by 86% ($p<0.01$). In individuals in groups 2A and 2B, the FCD did not differ significantly. DC was 13% ($p<0.05$) higher in 2B than in 2A. After physical exercise, the FCD in individuals in group 2A increased by 15% ($p<0.01$), and in group 2B - by 11% ($p<0.01$). DC in individuals from group 2A increased by 6% ($p < 0.05$), and in group 2B it remained virtually unchanged. Resting blood pressure was 24% ($p<0.05$) higher in individuals in group 2B than in group 2A. After the load, the increase in MP in group 2A was 39%, and in group 2B - 65% ($p < 0.01$). The authors conclude that the higher aerobic potential of the body is combined with a large adaptive reserve of the MC system. In both age groups, the increase in perfusion in trained subjects was almost twice as great as in untrained subjects.

An assessment of microcirculatory changes in athletes of various sports disciplines was done by P.V. Berezhanskiy et al. [2] in 45 athletes aged 12 to 18 years. The authors observed 45 athletes from 12 to 18 years old: marathon runners, skiing, weightlifting, and figure skating. The observations were carried out during a period of high intensity sports training, as well as at rest for 20 minutes. They found that at the athletes' group 1, the expressed morphological disturbances of the microcirculatory course were noted: 1) increase in diameter of venous part of capillaries from 5,3±0,19 mcm; 2) reduction of arterio-venular coefficient (AVC) from 0,253; 3) reduction of the velocity of blood flow from 515,83±24,5 mcm/sec. Athletes engaged in cyclical sports have a lower arterio-venular coefficient (AVC) than in power sports representatives, respectively 0.53±0.14 and 0.81±0.1 ($p<0.05$), due to pronounced dilations of the venular section of the capillary bed [2].

Cyclical sports (group I) and Acyclic sports (group II)	Blood flow velocity in the capillaries, mcm/sec	Frequency of heart contractions, beats/min	Diameter of the arterial department of capillaries, mcm	Diameter of the venular department of the capillaries, mcm
I.Running (Marathon runners and Ski Sports)	515,83±24,5	61±2,5	5,3±0,19	9,95±0,2
II.Heavy athletics (weightlifting) and Figure Skating	580,83±40,5	82±4	7,05±0,25	8,6±0,1

Table 1. The parameters of the microcirculatory changes in athletes of various sports disciplines - Blood flow velocity in the capillaries, Frequency of heart contractions, Diameter of the arterial department of capillaries and Diameter of the venular department of the capillaries [2].

This is since as endurance develops, the functional reserves of the body are restored to an anaerobic support mechanism. The revealed changes that occur directly during muscle activity are stored in the body consequently even after its completion. Accumulating for a long time, they gradually lead to the formation of a more economical type of microvascular response, which, in turn, can be a criterion for the athlete's functional sports orientation (Table 1).

The study of A.A. Domozhilova et al. [3] aimed to evaluate the microcirculation and physical presentation of skiers at different stages of the preparatory period. The study involved 10 ski runners. The anthropometric performance and parameters of systemic hemodynamics (SBP, DBP, heart rate) in all athletes at rest were recorded. The PWC170 test, based on results, calculated maximum oxygen consumption (MOC - VO_2 max) was used to determine the level of physical performance. The microcirculation was evaluated by counting the number of functioning capillaries of the nail bed (FPC), using the biomicroscopic method before and after the test load. The study was conducted at the beginning of the general preparatory stage (1 stage), repeated - at the end of the preliminary preparation stage (Stage 2). The results show that physical presentation with respect to the relative index of the IPC in the second stage of the study is 63.5 ± 5.2 ml/min/kg, which is 15% more than the first stage ($p < 0.05$) (Table 2). In turn, the evaluation of the microcirculation parameters before and after functional examination made it possible to identify a significant increase in FPC by 15% ($p < 0.05$) during the first study, while the increase in this indicator is only 9%. It was found less pronounced changes in the parameters of microcirculation at the end of the stage of preliminary special preparation. After the test load compared to the indicators obtained during the study at the beginning of the preparatory stage.

10 cross-country skiers	VO_2 max	Number of functioning capillaries in the nail bed (FPK) by the biomicroscopic method
Stage 2	63,5±5,2 ml/min/kg, 15% more than stage1(p<0.05)	15% (p<0,05)

Table 2. Microcirculation and physical performance in cross-country skiers at different stages of the annual training cycle [3]

The influence of low-energy laser radiation on the blood microcirculation system in highly skilled female rowers was investigated by T. M. Brook et al. in [4] by a Laser Doppler flowmetry using LAKK-M apparatus (LAZMA Russia), UzorMed-K laser emitter. The work was performed on 14 (OG) and 8 (control group - CG) highly skilled rowing athletes. The first group athletes (OG) were irradiated with NILI for 8 minutes around the carotid arteries. CG athletes were passively installed sensors without including the results. Infrared laser radiation has a powerful bio stimulating effect on the microvasculature. There is dilation of micro vessels as evidenced by a statistically reliable increase in perfusion index (PM perf. units) by 38% ($p<0.05$). Membrane cell diffusion of oxygen from the blood into the tissues is facilitated. As a result, the mixed blood oxygen saturation index (SO_2,%) decreased by 16.1% ($p<0.05$), and its utilization by tissues (U, relative units) increased by 49.2% ($p<0.05$). Spasmolytic and metabolic effects are based on the activation of internal and external regulatory mechanisms. In particular, the amplitude of endothelium-dependent oscillations (A_e perf. units) increases by 62.1%, neurogenic (A_n) - by 40.0%, myogenic (A_m) - by 53.3%, pulse (A_p) - by 35.9% ($p<0.05$), respiratory (BP) - by 12.5% ($p>0.05$). In athletes from CG during the experiment, a trend of increasing the studied parameters was registered, in which PM increased by 5.0%, SO_2 - by 2.1%, U - by 1.7%, Ae - by 8.8 %, A_n - 4.4%, A_m - by 3.3% ($p>0.05$), A_d - by 29.9% ($p<0.05$) and decrease of A_p - by 11.5% ($p >0.05$). Course low-energy laser radiation has been shown to improve perfusion and cellular metabolism in the microcirculatory system (Table 3).

Perfusion index (PM perf. units)	Mixed blood oxygen saturation index (SO_2,%)	Tissue O_2 utilization (U, relative units)	The amplitude of endothelium-dependent oscillations (Ae perf. units)	The amplitude of oscillations in the neurogenic frequency range (A_n perf. units)
38% (p<0,05) ↑	16,1%(p<0,05) ↓	49,2%(p<0,05) ↑	62,1% ↑	40 % ↑
5,0 % (p<0,05) ↑	2,1% (p<0,05) ↓	1,7%	8,8 %	4,4 %

Table 3. Effect of low-energy laser radiation on the blood microcirculatory system in highly qualified female rowing athletes [4].

II.Hemorheological changes during exercise

II.1. Age-related changes in hemorheological characteristics in persons with different modes of motor activity

P.V.Mikhailov et al. [5] investigated age-related changes in the rheological characteristics of blood in persons with different modes of motor activity. All subjects were divided into 4 age groups, in each of which a control subgroup (untrained subjects) and a subgroup of trained subjects were allocated. The results show that the average value of blood viscosity in the group of untrained persons 31-40 years old was higher than in the group 20-30 years old by 18% ($p<0.05$), in the group 41-50 years old by 25% ($p<0.01$), in 51-60 years at 30% ($p<0.01$). In trained subjects, there was a tendency to increase blood viscosity at relatively low shear stress with age, but the rates of increase were significantly lower than in the controls. With age, a change in the rheological characteristics of blood is observed: viscosity increases, erythrocyte aggregation increases, and erythrocyte deformability decreases. Both in trained and untrained persons age-related changes have a similar direction, but in persons with higher aerobic capacity they are registered later and expressed to a lesser degree. The transport potential of blood in trained persons remains higher in all age groups. At the same time, positive differences from given physically less active persons in most rheological characteristics are preserved in all age groups where observation was conducted.

The review of P. Connes et al. [6] focuses on the past and recent knowledge in the field of exercise hemorheology and presents some unresolved issues for opening discussion. Acute exercise is associated with a rise in hematocrit which results in an increase in blood viscosity. Whereas increased blood viscosity was previously viewed as having negative consequences for cardiovascular function and aerobic performance, recent findings suggest dynamic changes in blood viscosity might be useful for vascular function during exercise by increasing nitric oxide production. Other determinants of blood viscosity are altered by exercise (e.g., decreased red blood cell deformability, increased red blood cell aggregation and plasma viscosity) and may, independent of the associated effect on blood viscosity, directly modulate aerobic capacity. However, the data published on the effects of exercise on the hemorheology are not consistent, with some studies showing decreased, unchanged, or increased red blood cell deformability/aggregation when compared with rest. These discrepancies seem to be related to the exercise protocol investigated, the population tested or the methodogy utilized for hemorheological measurements. Finally, this review focuses on the effects of exercise training (i.e. chronic physical activity) on the hemorheological profile of healthy individuals and patients with cardiovascular and metabolic disorders.

The effect of different types of exercise on blood viscosity measured at several shear rates in the same trained individual (maximum oxygen consumption, VO_2max = 64 ml/kg/min) was presented in [7]. The maximal treadmill and cycling tests consisted of progressive and maximal exercise conducted to VO_2max and performed under laboratory conditions (temperature: 24 ºC). The 10 km run was performed outdoors (20 ºC) and at the highest intensity at which the subject could run (77% of his maximal aerobic speed determined on the treadmill and reached a heart rate of 92% of his maximal heart rate). The subject did not drink water during each test. For all three tests, blood was sampled immediately at the end of exercise, and blood viscosity was measured with the same conical plate viscometer within 1 h of sampling [7].

M. Karsheva et al. [8] investigated the rheological behaviour of the whole blood of volleyball players and healthy untrained persons in relation to its determinants (hematocrit, hemoglobin and RBC). It was found that the whole blood exhibits non-Newtonian behaviour which can be described by the power law rheological model. The apparent viscosity values of the blood of volleyball players before training increase after 15 min of maximal physical effort with about 15%. The authors concluded that the short-term effect of physical exercise on the rheological properties of blood is characterized by hemoconcentration and hyperviscosity.

On the other hand, it was proved that the athletes exhibited almost twice lower values of the blood apparent viscosities in long-term period than untrained subjects. The number of all formed elements increases in short term period after exercise. It was found that the consistency index K decreases after exercise together with an increase in the flow index n of the power law (or the blood becomes more Newtonian). This behaviour could be explained with changes in RBC rigidity. The dependencies of the rheological parameters K and n on the hematocrit (HCT) values are found. Both dependencies could be described by linear relationship with HCT.

At the same time, the authors concluded that physical training leads to a decrease in blood viscosity, or that blood becomes more Newtonian after exercise than before. A comparison between the blood rheology of healthy untrained individuals and athletes shows a decidedly much less viscous blood in athletes. This leads to a decrease in blood circulation resistance in the vessels and to increased oxygen transfer.

II.2. Changes in blood plasma proteins (fibrinogen, albumins, globulins) in different training regimens in sports

It is known that the immediate systemic physiological response to intense exercise is closely dependent on the type, duration, intensity, cyclicity and duration of physical activity. In addition, the individual level of training (training status) of individuals influences the body's adaptive response (ability to adapt to long-term changes in the whole body in response to repeated physical exertion) [9]. There is extensive research analyzing the specific bodily responses to various training regimens and their relationship with age, gender, fitness level, health status (obesity, various chronic inflammatory diseases) (Huffman et al., 2008 [10]; Gokhale et al., 2007 [11]; Lara Fernandes et al., 2011 [12]). From a biochemical point of view, the fact that aerobic and anaerobic training reduces the level of serum triglycerides, increases "good" cholesterol (HDL-C) and simultaneously lowers "bad" cholesterol (LDL-C) is also interesting - the importance for the prevention of socially significant diseases arterial hypertension and atherosclerosis (Tambalis et al., 2009 [13]). In this aspect, the individual design of the training programs and the plans for the training, the intensity of the physical load according to the objective physiological (cardiovascular) indicators, the duration of the load, its intensity and volume, etc. (Thompson et al., 2013 [14]). The most effective and recommended for the treatment of arterial hypertension is aerobic exercise training involving dynamic physical exercises.

Many authors find a direct relationship between physical exertion and lowering fibrinogen levels. One of the first results in this direction was reported in Russia by Dudaev et al. (1986) [15]. A group of 30 patients with cerebrovascular disease underwent regular exercise for 30 days. As a result, fibrinogen levels are significantly reduced (Dudaev et al., 1986) [9,15].

Stratton et al. (1991) [16] formed two target groups – one consisting of 10 young men aged 24–30 years and the other of 13 older men (60–82 years). All have been examined clinically healthy as demonstrated by routine physical and laboratory tests (Table 4).

	Young, n=10			Old, n=13		
	Before	After	p	Before	After	P
Fibrinogen, g/l	2,27 ± 0,5	2,17 ± 0,45	NS	3,57±0.79*	3,57±0.79* 52*	0,002

Table 4. Changes in plasma fibrinogen concentration in young and older subjects performing same training program, *p < 0.05 [16]

II.3. Changing in blood volume after training

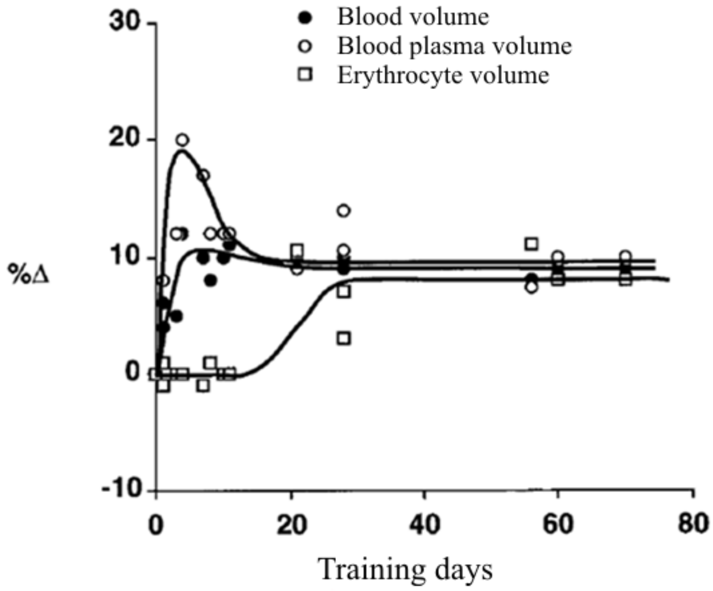

Figure 1. Percentage change over time of three volumes – blood, plasma and erythrocytes, depending on the duration of physical exertion in 23 study participants (Sawka et al., 2000 [18])

The change in blood volume in the body is an important adaptive process (Convertino, 1991) [17] occurring because of from the impact of various factors: physical exercises, external stressful influences (thermal acclimatization and thermoregulation), injuries and diseases (Sawka et al., 2000) [18]. An increase in blood volume (hypervolemia) has been demonstrated after systematic training and physical endurance exercises (Convertino, 1991) [17]. Normally, the increase in erythrocyte volume occurs slowly (over several weeks to months, regular physical exertion), whereas the increase in plasma volume can occur rapidly (within hours or days) (Sawka & Coyle, 1999 [19]) (see Figure 1).

The results of Doppler ultrasound measurement of peripheral blood flow of athletes with a high sports category are presented by A. S. Bakhmetyev et al. [20]. The diagnosis of blood flow was carried out based on the results of measuring the arterial blood flow rate in conditions of reactive hyperemia of the brachial artery and in relation to the reverse volumetric blood flow to the volumetric systolic blood flow. The measurements have shown that the ratio of the volumetric velocity of the reverse blood flow to the volumetric velocity of the systolic blood flow is significantly higher in athletes. In addition, unlike the well-known test method for reactive hyperemia of the brachial artery, the new method has the greatest sensitivity to the state of the endothelium in athletes at rest.

DISCUSSION and CONCLUSION

An overview of studies of microcirculatory, hemorheological changes and oxygen transport that occur during physical activity and sports was done. Analysis of the adaptation reserves of the microvascular bed in subjects with different physical activity and exercise was carried out. The assessment of the microcirculatory changes in athletes of various sports disciplines during the period of high intensity sports training as well as at rest was done. Hemorheological changes during exercise were analysed in dependence on the type, duration, intensity and cyclicity of the physical activities. Blood rheology and vascular function interact continuously to provide adequate oxygen and nutrient delivery to tissues: they should be considered in parallel. Comparison of age-related changes in the rheological characteristics of blood, which determine transport possibilities were presented.

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EFFECTS OF SUPERVISED EXERCISE ON BODY COMPOSITION IN PATIENTS SUCCEEDING BARIATRIC SURGERY 1 YEAR LONGITUDINAL STUDY

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ABSTRACT

This study aims to investigate whether a supervised, multicomponent exercise program can provide additional benefits on body composition after bariatric surgery. 18-65 year; body mass index (BMI) >35 kg/m^2; 54 patients (Exercise Group 29; Control Group 25) who had mini gastric bypass or Gastric Sleeve Surgery were included in the study. A verbal suggestion was made to the CG to increase physical activity, but this suggestion was not taken into consideration. The exercise group participated in a supervised multicomponent exercise program, 3 days a week, nonconsecutively, lasting 60 minutes each, for 11 months, starting 1 month after surgery. All variables were tested with two-way ANOVA test according to the effect of exercises on body weight (BW), fat mass (FM), fat-free mass (FFM) and BMI. After completion of descriptive statistics (mean ± SD), an independent t test was used to examine between-group differences in anthropometric components at baseline. Accordingly, there was no significant difference between the groups at baseline, including age, BW, BMI, FM and FFM ($p>.05$). Both groups experienced significant initial BW and FM loss, but these changes did not differ significantly between groups ($p>0.05$). On the other hand, FFM changes showed significant differences between groups ($p<.05$). Although there was no statistical difference in BW, FM and BMI values of the exercise group and the control group in this study, the positive change in the FFM of the exercise group was found to be significant compared to the control group. This clearly shows the importance of exercise in our study.

Keywords: Bariatric surgery; Exercise; Fat Free Mass; Fat Mass; Obesity

INTRODUCTION

Obesity is becoming an important global health problem, not only in healthcare but also increasingly in the economy (Cawley, 2015). There is increasing evidence that being overweight negatively affects functions like standing, walking, and stabilization of balance (Gonzalez, Gates, & Rosenblatt, 2020; King et al., 2016). It has been known that individuals who are obese or overweight face negative health problems such as diabetes, cancer, hypertension and cardiovascular disease (Guh et al., 2009; Wang, McPherson, Marsh, Gortmaker, & Brown, 2011) depression and other psychological disorders (McElroy et al., 2004). In addition, studies showing that obesity and overweight individuals, together with other diseases caused or accompanied by obesity, increase the rate of morbidity and mortality are increasing day by day (Abdelaal, le Roux, & Docherty, 2017; Flegal, Kit, Orpana, & Graubard, 2013; Lenz, Richter, & Mühlhauser, 2009). The data of the Ministry of Health Nutrition Research and TURDEP-II (Turkiye Diabetes, Hypertension, Obesity and Endocrinological Diseases Prevalence Study) studies report that 2/3 of adults in Turkey are overweight or obese. The prevalence of metabolic syndrome accompanied by central obesity is monitored in 36.6% of the Turkish adult population. It is estimated that 3% of the adult population in our country (approximately 2.5 million adults) is morbidly obese (Sabuncu et al., 2018).

If bariatric and metabolic surgery is to be implemented in the treatment of obesity, it is considered in patients with a body mass index (BMI) ≥ 40 kg/m2 or in cases where BMI ≥ 35 kg/m2 is accompanied by cardio metabolic diseases (De Lorenzo et al., 2016). Although it is stated that routine exercise is an important parameter in non-operative obese patients, exercising alone does not provide a significant reduction in body weight (BW) in such patients (Jakicic, 2009). There is limited information that exercise provides additional improvement in patients after bariatric surgery (BS). Still, when it comes to metabolic health, exercise is thought to provide greater improvement than BS (Coen & Goodpaster, 2016). The main reason why little is known about the positive results of exercise after BS is the lack of follow-up studies (Puzziferri et al., 2014).

In light of the above information, current study aims to search whether a supervised, multi-component exercise method can provide additional benefit such as BW, BMI, fat mass (FM) and fat free mas (FFM) after BS.

METHODS

Subjects

Patients on the waiting list for BS were contacted, written informed consent was given, and a pre-surgical baseline assessment was performed 1 to 3 months prior to BS. Between the ages of 18-65; BMI >35 kg/m^2; Patients referred by a physician for mini gastric bypass (MGB) or Sleeve Gastrectomy (SG) surgery are included. The exclusion criteria were: health condition that prevented participation in exercise; amputation, amenorrhea >3 months, pregnancy or breastfeeding, and revisional bariatric surgery. This study is approved by the Şırnak University Ethics Committee (Approval Number: 2021/55). All participants gave their written informed consent, and our study was carried out following the Helsinki Declaration.

Procedure

Verbal suggestion to increase physical activity was given to the control group, but it was not observed. In addition to usual medical care, the exercise group participated in a supervised multicomponent exercise program, 3 days a week non-consecutive, lasting 60 minutes each, for 11 months, starting 1 month after surgery. When designing the exercise program, The American College of Sports Medicine (ACSM) exercise recommendations for the obese were considered. (Pescatello, Riebe, & Thompson, 2013). The exercise program was organized as follows: warm-up (5 minutes); moderate-intensity aerobic exercise (25 minutes) resistance exercise (20 minutes) flexibility exercises and cool-down (10 minutes).

The 1-year nutritionchart of theparticipatingpatients is as follows.

Table 1. Nutrition Plan

Stage 1: First day after surgery in the hospital	Non-Stop
Stage 2 2. and 3. Day after surgery	Water, Tea, Herbal Tea, Protein Smoothie, Ayran, 100% Fruit Juice Diluted with Water
Stage 3 Liquid Nutrition 2 Week For 3–18 days after surgery 60–80 grams of protein everyday.	In Addıtıon To The Lıquıds Consumed On The Second Day: Lactose Free Milk, Soup, Protein Smoothie, Sugar-Free Pudding, Yogurt, Kefir etc.
Stage 4 Soft Foods 2 Week For19-30 day after surgery 60–80 grams of protein daily	Egg, Soft Cheese, Fish, mashed potatoes, ground forms of white meat, soft, ripefruit; Avoid tough peels, skin orseeds, Fresh vegetables cooked to softetc.
Stage 5 Regular Solid Diet 1 Month For 30-60 days after surgery 60–80 grams of protein daily	Scrambled eggs, omelets, alltypes of cheese, chicken, meatball, legumes etc.
Stage 6 Optimal Nutrition Life-long Nutrition Plan	Protein: 60- 80 gram/day Carbohydrate: 40-45%of total energy Planned according to the patient

Aerobic exercise started at low intensity for the first 2 months (Heart rate reserve (HRR) 50%). Moderate intensity (HRR 50-65%) aerobic exercises were performed at 4, 5 and 6 months and high intensity (HRR 65-85%) aerobic exercises were performed from the end of 6 months. Resistance exercises were organized with 40-55% of 1 repeat of maximum (RM), 2-4 sets and 8-12 reps, with machines or free weights, to work large muscle groups. Flexibility exercises were performed as static, dynamic and/or proprioceptive neuromuscular facilitation (PNF).

Anthropometric Measurements

The heights of the volunteers included in the study were calculated with a stadiometer (Holtain, UK), and their weight, skeletal muscle mass, lean mass and body fat percentage were calculated with a body impedance analyzer (A-401 Tanita, Japan).

Statistical Analysis

After the completion of descriptive statistics (mean ± sd) an independent t-test was used to examine between-group differences in anthropometric components at baseline. All variables, according to the effect of exercises on BW, BMI, FM and FFM was tested with a two-way ANOVA test.

RESULTS

Exercise and control groups baseline characteristics of pre-intervention are reported in Table 2. There were no significant differences between the groups at baseline, including age, BW, BMI, FM and FFM a result of the independent sample t-test (p>.05).

Table 2. Baseline descriptive characteristics of participants

Variables	Exercise group (n = 29)	Control group (n = 25)	p
Age (yr)	40±10	40.4±9	.280
Weight (kg)	123.5±23.6	123±22	.557
FM (%)	57,6±17.3	56,2±13.4	.267
FFM (%)	62.2±13.1	63.7±16.2	.993
BMI (kg/m2)	44.6±8.3	44.7±7.4	.360

The effects of the intervention on anthropometric measures and body composition are shown in Table 3. Both groups lost a significant amount of initial BW, BMI and FM however, these changes did not significantly differ between groups (p>.05). On the other hand, FFM changes was significantly differ between groups (p<.05).

Table 3. Time-dependent change of body weight and body composition

	Exercise group (n=29)			Control group (n=25)			
	Pre	6. month	12. month	Pre	6. month	12. month	P
Weight	123.5±23.6	88.8±18	79.9±16	123±22	87.8±16.9	79.9±14.5	.827
FM	57,6±17.3	30.1±11	19.5±8.2	56±13.4	29.4±10.4	23.7±10.3	.069
FFM	62.2±13.1	59.4±12.5	60.5±12.2	63.7±16.2	55.2±12.4	52.5±8.5	.001*
BMI	44.6±8.3	31.8±6.5	29.9±6.2	44.7±7.4	31.9±5.7	29±4.9	.992

P<0.05 FM: fat mass; FFM: fat free mass; BMI; body mass index

DISCUSSION

BS is the most effective weight loss method among the interventions against obesity today. In a 2015 study, physicians concluded that they can benefit by directing patients to exercise after BS (Miller, Hale, & Dunlap, 2015). The American Society for Metabolic and Bariatric Surgery (ASMBS) specifically recommends a progressive walking program that includes pre-operative exercise and aerobic and strength exercises lasting 30 minutes or longer per day, starting on the first postoperative day (Petering & Webb, 2009). In some studies with patients who exercised 12-24 months after BS, it was reported that exercise-induced muscle strength and mass increased (Herring et al., 2017; Mundbjerg et al., 2018). In contrast, other studies investigating the effect of various forms of exercise after BS have not observed a significant increase in FFM or a significant decrease in FM (Andre et al., 2021; Bellicha et al., 2022; Daniels et al., 2018; Fagevik Olsén, Wiklund, Sandberg, Lundqvist, & Dean, 2022; Huck, 2015).

The main aim of the current study was to investigate whether exercise has a role in the change of body composition of patients undergoing BS. As a result of the study, there was a significant decrease in the FM and BW of the participants, measured before and 12 months after the BS operation, but no significant difference was found between the groups. On the other hand, the decrease in FFM of the exercise group was less than that of the control group.

Studies indicate that exercise affirmatively affects body composition after sudden weight loss caused by BS. Exercise usually changes body composition by increasing FFM and decreasing FM, not the percentage of total body mass lost after surgery. Relatively longer-term results are needed to evaluate whether the effect of exercise after BS is permanent (Metcalf, Rabkin, Rabkin, Metcalf, & Lehman-Becker, 2005). In the study by Daniels et al., 16 female patients after bariatric surgery were randomly divided into 2 groups and the intervention group underwent 12-week resistance exercise. At the end of the study, the exercise group showed an increase in the amount of strength compared to the control group, but no increase in FFM or muscle cross-sectional area was observed. Daniel et al. stated that the reason why they did not observe a change in FFM may be due to the severe decrease in calorie intake and the insufficient dietary protein necessary to stimulate protein synthesis. However, in the aforementioned study, 12 weeks of resistance exercises may not be sufficient to observe the muscle development of patients after bariatric surgery (Daniels et al., 2018).

In the current study, although there was no statistical difference in the BW, FM and BMI values of the exercise group and the control group, the positive change in FFM of the exercise group was found to be significant compared to the control group. This clearly shows the importance of exercise in our study.

CONCLUSION

As a result of the current study; It has been observed that the exercise program after obesity surgery is effective in increasing muscle mass but not losing fat mass. The reason why the exercise group did not show more decrease in fat mass then control group may be associated with the strong effect of the surgical intervention. When designing an exercise program, the fact that strength exercises are not progressive and the age group is wide range may limit the generalizability of the study's findings for all patients after bariatric surgery.

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SENSATION SEEKING AND ANXIETY IN SPORTS CLIMBERS - A SYSTEMATIC REVIEW

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ABSTRACT

The aim of this paper was to determine, by summarizing and reviewing published research, the need for sensation seeking and anxiety in sport climbers, as well as how it affects success in sport climbing. For the purposes of the research, the available literature published in the period from 1980 to 2023 was analyzed. The results showed that there is a positive relationship between climbing abilities and higher self-esteem, competitiveness, perfectionism, satisfaction with life, the individual's tendency towards exhibitionism and the difficultness towards sensations on the risk tendency indicated. Also, sports climbers have low anxiety both in daily training and when it comes to competitive situations, they are more social and anti-structural than the "normal" population and reacting to group events, controlling subjects at the local level, striving for experience, excitement and adventures. In addition, sensation seeking affects the perception of anxiety and arousal as regular companions of sports performances. The pronounced need for sensation seeking will affect the perception of stressors and anxiety, and people with a pronounced need for sensations (which climbers certainly are) will primarily perceive anxiety as a positive, facilitative factor of sports performance.

Keywords: sensation seeking, anxiety, sports climbing

INTRODUCTION

The popularity of high-risk sports such as skydiving and rock climbing (Zuckerman, 1983) has been growing for a long time (Clough et al., 2016). Skiers, climbers, parachutists and other similar "extreme" athletes risk everything and show no inhibitions in their attempt to reach the top result and become the best in their discipline. A common feature of all those who engage in high-risk sports is a rush for excitement and adventure (Zuckerman & Kuhlman, 2000). High-risk sports are mostly practiced in nature and they require cognitive ability/originality, courage, and the ability to act in environments that pose a risk to life (Guszkovska & Bołdak, 2010). In the Western world, the strict and safe working conditions and the convenience of city life have naturally removed the need for learning and adventure. Perhaps out of a desire to fill the gaps, a new level of recreation has emerged that includes greater physical risks, which has been gaining popularity since the seventies of the last century (Creier, Ross & Evers, 2003).

Sensation seeking is a personality dimension marked by the need to seek excitement and the search for new, diverse, layered and intense stimuli from the environment and includes a certain level of risk in the physical, social and financial areas, most often in connection with the experiences themselves (Zuckerman, 1994). A high need for excitement is associated with seeking and participating in a variety of intense activities, for example extreme sports such as mountaineering, parachuting and car racing, seeking challenges through the mind and senses, use of psychostimulants, disinhibited social behavior, intolerance of boredom, preference for exotic food etc. (Aluja, Garcia & Garcia, 2003; Bratko & Butković, 2004).

In sport psychology, anxiety is generally accepted as an unpleasant emotion that potentially increases when an individual begins to doubt their ability to cope with internal and external demands (Woodman &

Hardy, 2001). An elevated level of anxiety leads to disruption of complex mechanisms of control, intelligence and response strategy and usual behavior in general, and is manifested most often in the form of somatic disorders or behavioral changes. Among the physical manifestations that are characteristic of this emotion or personality state, are: tachycardia, rapid breathing, sweating, tremors, less salivation, pain, disgust, vomiting. In addition to this manifestation, an anxious response is observed, where the individual becomes irritable, nervous, inhibitory, and often aggressive, or even the opposite, the individual becomes isolated, excessively dependent, avoiding social interactions. Extreme athletes (and athletes in general) are often faced with great and not infrequently contradictory demands of the type, he must be unique and unrepeatable, but he is equally expected to be like everyone else; should demonstrate as much dominance as possible in relation to the opponent, but at the same time respect him; he should set his competitive aspirations very high, but also be realistic at the same time (Lazarević, 1981).

The aim of this work is to summarize and review published research to determine the need for sensation seeking and anxiety in sport climbers, as well as how they affect success in sport climbing.

METHODS

The Google academic electronic database was searched to collect previous research on psychological factors that influence success in sport climbing. All works published in the period from 1980 to 2023 have been searched.

When searching the databases, the following keywords were used: rock climbing psychology, free climbing psychology, sensation seeking in climbing, anxiety in climbing. The found research titles, abstracts and full texts were translated, read and analyzed. Research on subjects of both sexes was analyzed. The methods used in this work are: descriptive method, analysis method, comparison method and synthesis method.

RESULTS

First author and year of publication	Sample of respondents		Monitored variables	Results
	Number	Age		
Zuckerman (1983)	T = 12	x	SS, TA, EXP, DI, BO	SS↑
Hardy & Whitehead (1984)	T = 8	x	ANX, HR	ANX↑
Ewert (1985)	T = 460 M = 372 F = 78	29.65	CH, CA, RE, CR, LC, PH	SS↑
Robinson (1985)	M = 30	27.26	SS, ANX, NA	SS↑ ANX↑
Levenson (1990)	M = 18	28±4.17	SS, SAP, ED, IN, EM, MR	SE↑
Freixanet (1991)	T = 374	30.9±8.50	SS, ANX, EM, IM, SO	SS↑ ANX↑
Rossi & Cereatti (1993)	x	x	SS, BO, DI, EXP	SS↑
Slanger & Rudestam (1997)	T = 60	x	SS, ANX, PS, RP, SEF,	SS↑ ANX↑
Feher et al., (1998)	T = 57 M = 35 F = 22	28.5±7.00	SS, ANX, LC, SA, PMS, PER	SS↑ ANX↑
Jack & Ronan (1998)	T = 166 M = 119 F = 47	29.2±11.86	SS, TA, EXP, BO, DI	SS↑
Zarevski et al., (1998)	M = 188	29.6	SS, TA, DI, EXP, BO	SS↑
Pijpers et al., (2003)	T = 13 M = 8 F = 5	20 - 30	ANX, HR, MF, HG	ANX↑
Lafollie & Le Scanff (2008)	x	x	SS, ANX, DEP,DI,	SS↑
McEwan et al., (2019)	T = 39	x	SS, EXT, IM	SS↑

Legend: ↑ - statistically significant influence; T – total number of respondents; M – male; F – female; x – no information; ANX – anxiety; SS – sensation seeking; CH –challenge/risk; CA – catharsis; RE - recognition; CR – creativity; LC - locus of control; PS – physical setting; NA - need for achievement; SAP - substance abuse proclivity; ED - emotionality and depression; IN - independence; EM – empathy; MR - moral; SO – socialization; IM – impulsiveness; BO – boredom; DI – disinhibition; EXP – experience; RP - repression-sensitization; SEF - self-efficacy; SA – sports attitude, PMS – profile of mood states; PER – personality inventory; TA - thrill and adventure; HR – heart rate; MF – muscular fatigue; HG – hand grip; DEP – depression; EXT – extraversion.

The research on sensation seeking and anxiety among sports climbers was conducted by means of analysis, comparison and synthesis of 14 collected works related to the subject of the research, which were published in the past forty years.

DISCUSSION

Although initial studies indicated that professional sport climbers show a commitment to training and skill improvement, similar to any other professional athlete (Haas and Meyers, 1995), research referring to the psychological aspects of climbers, however, is lacking. Studies have been based on topics such as risk-taking and personality (Levenson, 1990), stress-seeking (Robinson, 1985; Rossi & Cereatti, 1993; McEwan et al., 2019)), self-esteem (Ewert, 1985; Iso- Ahola, Freixanet, 1991; Freischlag & Freischlag, 1993; Ewert 1994), and psychophysiological connection (Edwards, 1967; Ryn, 1971; Hardy & Whitehead, 1984; Missoum et al., 1992; Delignieres et al., 1993).

Studies have also suggested a positive relationship between various personality traits and climbing ability. Those attributes are increased self-esteem, competitiveness, perfectionism, life satisfaction and sensation seeking (Zuckerman, 1983; Freischlag & Freischlag, 1993; McEwan et al., 2019). This is supported by an individual's tendency towards exhibitionism and a high level of striving for sensations, which indicate a tendency to underestimate risk (Zuckerman, 1983; Rossi & Cereatti, 1993). Top sport climbers are also characterized by having low anxiety both in everyday training and when it comes to competitive situations (Robinson, 1985). Regardless of skill level, research indicates that climbers are more social and anti-structural than the "normal" population (Levenson, 1990), and respond more strongly than controls to the subscales of sensitivity to boredom, disinhibition, striving for experience, excitement, and adventure (Rossi & Cereatti, 1993; Zarevski et al., 1998; McEwan et al., 2019).

The scientific studies listed in the chapter on previous research clearly indicate two facts related to the terms that define the topic of this paper: participants in riskier sports (which certainly includes sport climbing) have a more pronounced need to seek sensations, but are also characterized by relatively low levels of anxiety. Nevertheless, the univocity and simplification of the results of the aforementioned studies interpreted in this way must, from the theoretical side, be viewed critically. In the framework of the discussion, we will try to give an interpretation of the possible relationship between sensation seeking and anxiety in sports climbers as representatives of a group of athletes who prefer sports that involve risk to their own physical health.

Critical observation refers first of all to the often incorrect equating of anxiety and arousal in the sports context. The state of anxiety can be seen as a part of arousal, that is, the moment when arousal crosses a certain optimal limit. Which of the arousal theories is most applicable to high-risk sports?

One of the theories of the relationship between stress and sports performance is the so-called "drive" theory (Hull, 1952; Spence & Spence, 1966), according to which a linear relationship between arousal and performance is expected - the more an athlete is "excited", the performance is usually better. This theory has been contested because it is often overlooked that it was designed to only apply to top and experienced performers in the sport and not to novices who find it difficult to perform well under pressure.

The Inverted U Theory developed by Robert Jerks and John Dodson in 1908 is another approach to the relationship between arousal and performance. According to this model, low pressure or low stress levels result in a stress response corresponding to "boredom or lack of challenge", but also if the pressure becomes too high or too high a stress level is activated, it results in feelings of unhappiness, stress and anxiety. An athlete performs best at average levels of arousal.

Catastrophe theory (Hardy, 1996) is the third theory about the relationship between the expression of arousal in an athlete and his performance. This theory also talks about cognitive and somatic arousal, which, if they coincide, lead to a sudden drop in the quality of performance. Within this theory, it is argued that performance will reach its highest quality only if cognitive arousal (anxiety) is low.

Whichever of the three offered theoretical explanations is related to sensation seeking in high-risk sports, we will not get the right picture, because sensation seeking actually affects the perception of anxiety and arousal as regular companions of sports performances. Therefore, the most adequate explanation is probably the theory of Jones (Jones, 1995), which states that the relationship between the intensity of anxiety and possible overcoming is indirect, and that there are various psychological factors that influence the mediation of this relationship.

He accepts that anxiety, as a dominant emotional state in people due to stress, can have a facilitating, favorable (facilitative) effect as well as an aggravating (unfavorable) effect. Therefore, stress and anxiety are not important, but their subjective perception, and as the dominant factor of the consequent action of competitive anxiety (whether it will be perceived as favorable or not) in athletes, he cites the experience of controlling their own skills and the demands of the environment. From the nature (more precisely, theoretical assumptions and practical operationalization) of the psychological variable of sensation seeking, it is logical to hypothesize that the pronounced need for sensation seeking will affect the perception of stressors and anxiety (they will experience a less pronounced state of anxiety), as well as that people with a more pronounced need for sensations (which climbers certainly are) anxiety is primarily perceived as a positive, facilitative factor of sports performance.

CONCLUSION

The following conclusions can be reached by reviewing previous research, their analysis, comparison and systematization:

- There is a positive relationship between climbing abilities and increased self-esteem, competitiveness, perfectionism, satisfaction with life, an individual's tendency towards exhibitionism and the pursuit of sensations that indicate a tendency to underestimate risk. Also, sports climbers have low anxiety both in daily training and when it comes to competitive situations, they are more social and anti-structural than the "normal" population and react more strongly than the control group on the subscale of sensitivity to boredom, disinhibition, striving for experience, excitement and adventures.
- Sensation seeking affects the perception of anxiety and arousal as regular companions of sports performances. The pronounced need for sensation seeking will affect the perception of stressors and anxiety, and people with a more pronounced need for sensations (which climbers certainly are) will primarily perceive anxiety as a positive, facilitating factor in sports performance.

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ACL RECONSTRUCTION IN ATHLETIC PATIENTS WITH ANTERIOR CRUCIATE LIGAMENT INJURIES: AUTOGRAFT VS ALLOGRAFT

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ABSTRACT

Anterior cruciate ligament (ACL) rupture is a common sporting-relates keen injury with a potentially detrimental impact on the athlete's career, yet there is no formal consensus on the optimal graft choice for reconstructing the ruptured ACL in the specific population. Options for reconstruction include autograft and allograft. In this study we included 50 patients. 25 operated with BTB allograft and 25 operated with hamstrings autograft. The patients in the allograft group showed statistically significant better results in the tested categories compared to the autograft group. Comparing the results of the two groups we concluded that allografts are viable option when choosing a graft type for ACL reconstruction.

Keywords: allograft, autograft, ACL reconstruction, active flexion, loss of power, post operative pain

INTRODUCTION

Anterior cruciate ligament (ACL) rupture is a common sporting-relates keen injury with a potentially detrimental impact on the athlete's career, yet there is no formal consensus on the optimal graft choice for reconstructing the ruptured ACL in the specific population. Our operational definition of the athlete is a skeletally mature individual participating in high level activity with the expectation to return to pre-injury level of activity. For the athlete long-term outcomes are of particular importance given on-going mechanical demands on the reconstructed knee. According to Kevin Friedman (2003)[1] one of every 3000 patients in the US suffers from anteromedial instability. Every year 200000 lesions of the ACL are officially registered. Since 1990 reconstructions of ACL have gone from 100000 to 350000. In sport with a lot of cutting maneuvers up to 10% of the participants are affected (L. Eberbretsen 2007). Options for reconstruction include autograft and allograft.

METHODS

For many years the golden standard for reconstruction of the ACL was BTB autograft. In recent years there is a tendency to use alternative graft choices as allografts. The most frequently used grafts in the autograft category are bone-tendon-bone (BTB) grafts harvested from ligamentum patellae proprium of the patient, the tendons of the Semitendinosus and Gracilis muscles (ST/Gr) of the patient and Fascia Lata. On the other hand, the most frequently used allografts are BTB allografts, ST/Gr allografts, Achilles tendon allografts, Fascia Lata allografts, Tibialis anterior tendon.

When choosing the right graft according to Justin Roe et Leo Pinczewski (2015)[2] the needed qualities of the transplants are as follows: biologically active, allowing for accelerated rehabilitation, enough bulk of the graft, giving opportunities to avoid morbidities of the donor site and not affecting the neuro-muscular structure of the knee.

The autografts have various disadvantages. The most used autograft – BTB has the following ones: Femoropatellar joint morbidity, Patellar fracture (1), Fractured bone plug, inability to harvest large bone plug, predetermined graft length, incomplete closure of the tibial tunnel inlet, long skin incision, scaring of the infrapatellar fat pad, irritation of the tibial tuberosity and patellar apex and small ligament cross section.

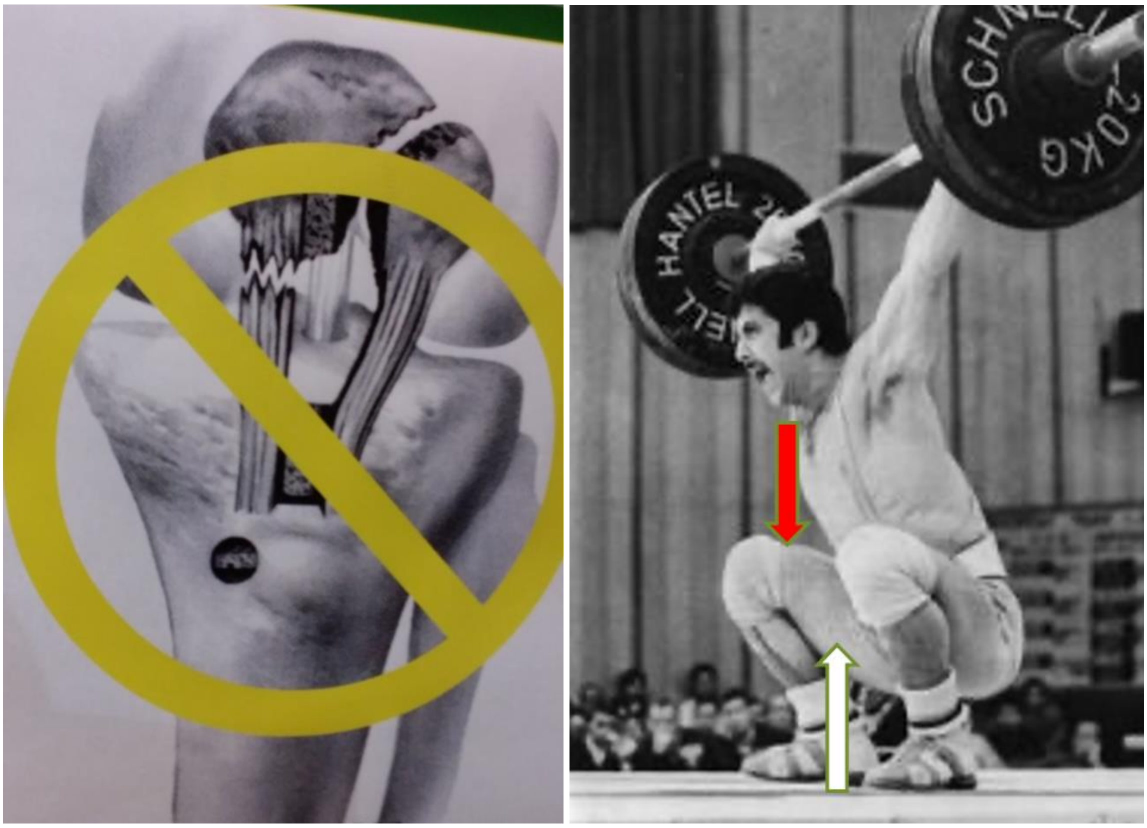

Figure 1. On the left is a diagram of patellar fracture and ligamentum patellae proprium rupture after harvesting a BTB autograft. On the right is a diagram of the balance needed between the flex. And the ext. groups of musculs in order to perform a squat lift

The second most used autograft – ST/Gr has the following disadvantages: soft-tissue hematoma in the donor site, complex graft preparation, losing two ACL agonist musculs, exacerbation of medial instability, complicated graft fixation, prolonged osteointegration of the graft, femuropatellar pain, weakening of knee flexion and losing muscle balance between flex and ext. muscle groups (1).

The most commonly states concerns about the use of allografts are tha thay have higher failure rates (especially in young patients), grater chance of transmissive infection contamination and higher cost compared with the autograft techniques. As is shown in the study of Carter T. et al (2022)[3] in which he and his team evaluated 42 patients, whit a avarage age of 16,2 years followed for avarage of 56 months after sugery, when a strickt rehabilitation program catered for allograft patients is used, when the grafts used are fresh-frozen and non-irradiated the failiure rates are very low. 76% of the partisipents in the study have reached the same level of sports activity as before injury. Non of the partisipents had a transmisive infection. This study goes to show that when surgeons take into account the specifics of the allograft techniques the main conserns can easely be addresed.

When we revied the paper of Bear and Harner (2007)[4] which studies the biomecanical properties of the ACL and the most commanly used allografts we can see that the native acl can withstand 2160N of force similarly ot that of the BTB allografts with respectively 2977N of force. On the other hand the Achilles tendon allograft with its 4617N of force and the Tibialis anterior tendon with its 4122N of force can withstand double the force of the native ACL which makes them even better grafts. Allograft also have other benefits when compared with autografts: they do not lead to donor site morbidity, they allow for shorter procedure time, they can be accurately sized for the needs of the patienet, they do not lead to iatrogenic proprioreception damage and lead to faster pain relieve which allows for early rehabilitation.

Subjects

In our research there are two groups of patients each containing 25 operated with BTB allograft and 25 operated with ST/Gr autograft out of 160 patients. They have been chosen according to these criteria's: isolated lesion of the ACL without other injuries of the knee structures, no previous surgeries of the injured knee, no femuropatellar pain and no injuries to the contralateral knee.

Procedure

For both the allograft and the autograft groups we used single bundle anatomic ACL reconstruction technique. For the autograft group we started by measuring the length of the lateral femoral condyle and then we proceeded with the drilling of the femoral tunnel leaving around 11 mm from the condyle to prevent compromising the lateral cortex of the femoral condyle. After doing the femoral tunnel we drill the tibial tunnel, using a vectoring guide, in the anatomic footprint of the native ACL on the tibial plateau. After drilling the tunnels, we shuttle the graft and fix it proximally using a device for cortical suspension and distally using interference screw. (2)

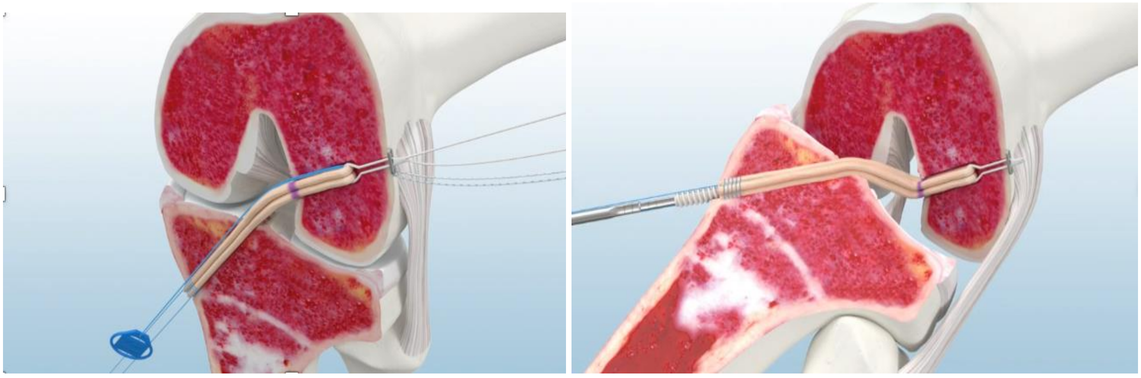

Figure 2. On the left – the proximal fixation of the graft with device for cortical suspension. One the right – distal fixation with interference screw

For the allograft group we started by measuring the length of the lateral femoral condyle and then we proceeded with the drilling of the femoral tunnel making it 2,5 cm in length. After doing the femoral tunnel we drill the tibial tunnel, using a vectoring guide, in the anatomic footprint of the native ACL on the tibial plateau. After drilling the tunnels, we shuttle the graft and fix it proximally and distally using interference screw. (3)

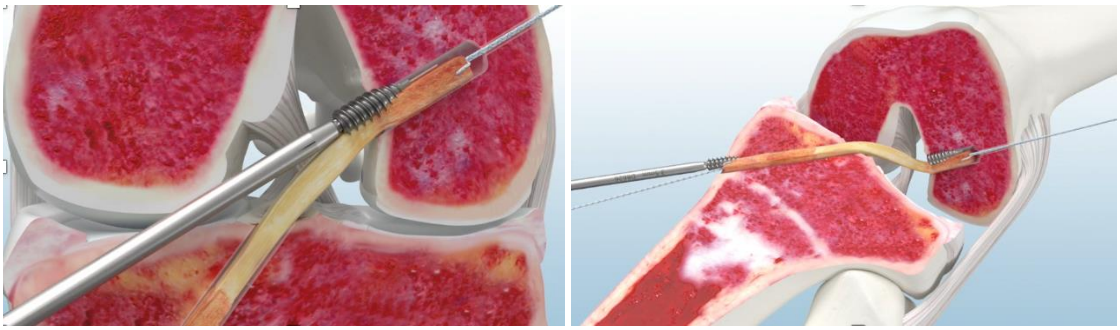

Figure 3. On the left – the proximal fixation of the graft with interference screw. One the right – distal fixation of the graft with interference screw.

Statistical analysis

Data were entered and processed with the IBM SPSS Statistics 23.0 statistical package. For a significance level at which the null hypothesis is rejected, $p<0.05$ is acceptable.

Methods were applied:

1. **Descriptive analysis** – in table view the frequency distribution of the comment signs, is broken down into groups of.
2. **Analysis of Variance** – to assess the characteristics of central tendency and statistical dispersion.
3. **Graphical analysis** – for visualization of the obtained results.
4. **Fisher's exact test** - for testing hypotheses about the presence of a relationship between categorical variables.
5. **Non-parametric Shapiro-Wilk test** - to check the distribution for normality.
6. **Student's t-test** - for testing hypotheses about a difference between two independent samples.
7. **Non-parametric Mann-Whitney test** - for testing hypotheses about a difference between two independent samples.
8. **Friedman's non-parametric test** - for testing hypotheses about a difference between several dependent samples.
9. **Non-parametric Wilcoxon test** - for testing hypotheses about a difference between two dependent samples.

RESULTS

The criteria we used to evaluate the results of the participants after the surgery were as follows: Lachman test, Pivot-shift test, TELOS test (KT1000), Lisholm score, IKDC, Range of motion and power test in knee flexion.

For the autograft group the results were as follows: Lachman test – 25 negative results, Pivot-shift test – 25 negative results, TELOS test – 23 negative results with 2 participants having positive test but with less than 5mm deviation, Lisholm scores – average of 89,28 points and IKDC score – average of 92,82 points.

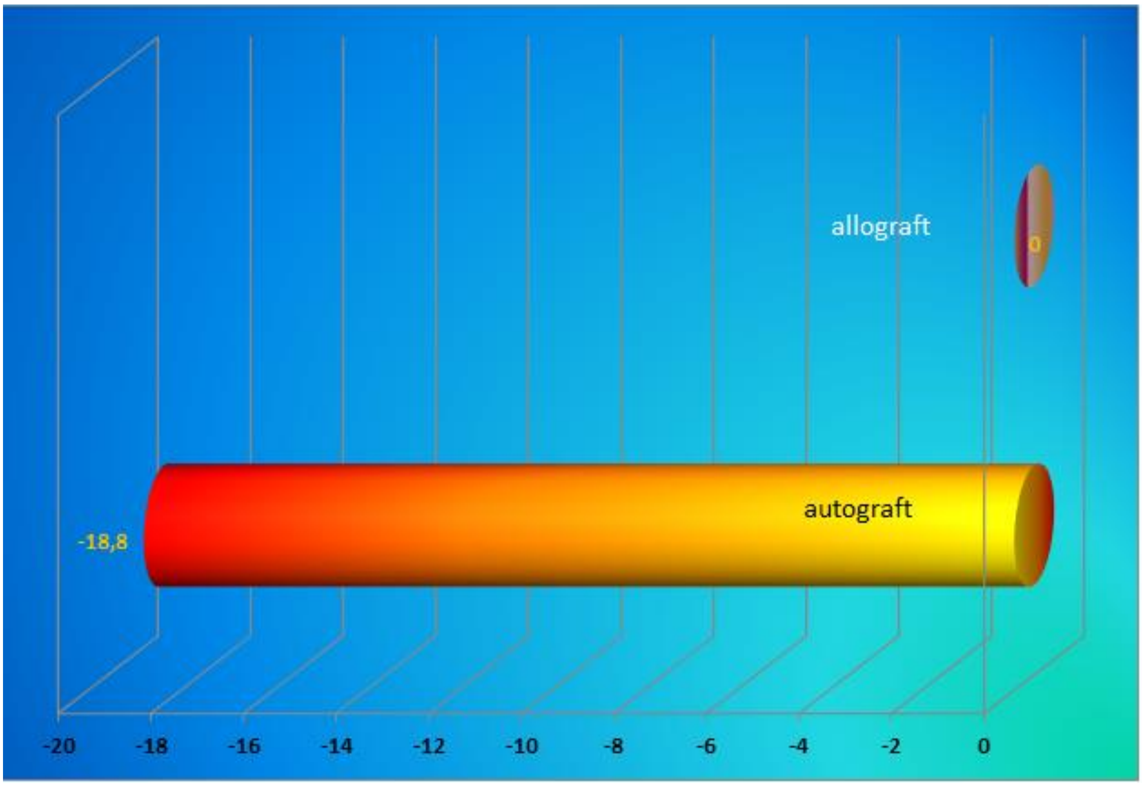

Figure 4. Comparison of power loss in active flexion of the operated knee after ACL reconstruction

For the allograft group the results were the following: Lachman test – 25 negative results, Pivot-shift test – 25 negative results, TELOS test – 24 negative results with 1 participant having positive test but with less than 5mm deviation, Lisholm scores – average of 93,24 points and IKDC score – average of 91,63 points.

For the power loss test in flexion of the knee the results were overwhelmingly in favour of the allograft group with no loss in power in flexion of the knee after surgery (4)

For the range of motion during active flexion of the operated knee we have had better results in the allograft group compared with the autograft group after the reconstruction of the ACL. (5)

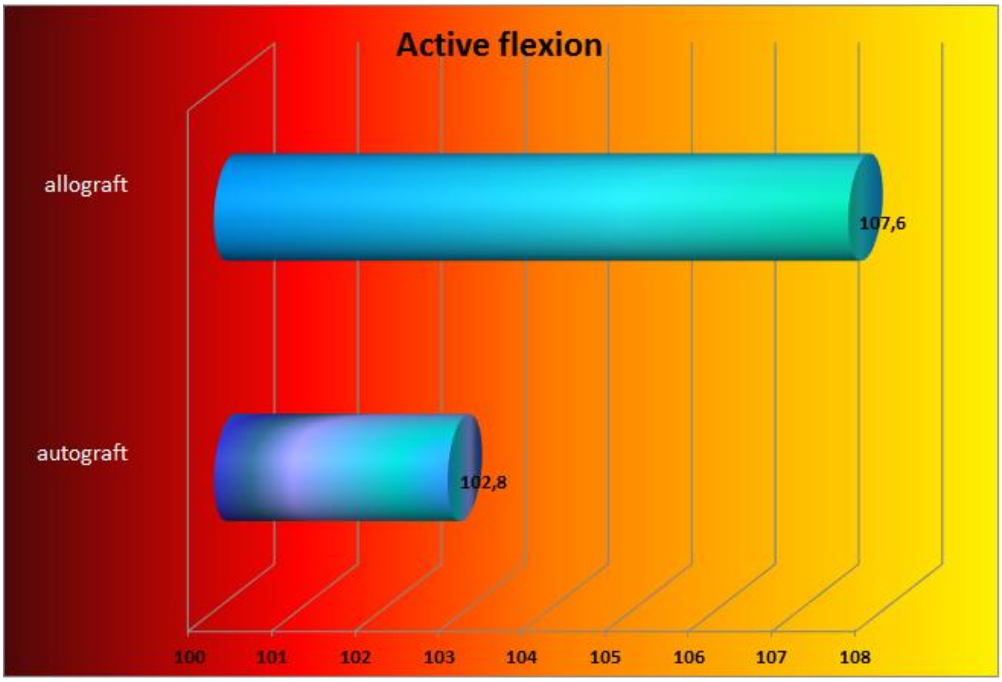

Figure 5. Comparison of active flexion of the operated knee after ACL reconstruction.

And lastly when comparing the two groups in the time needed for rehabilitation and returning to work and doing sports activates the shorter periods were in the allograft group. (6)

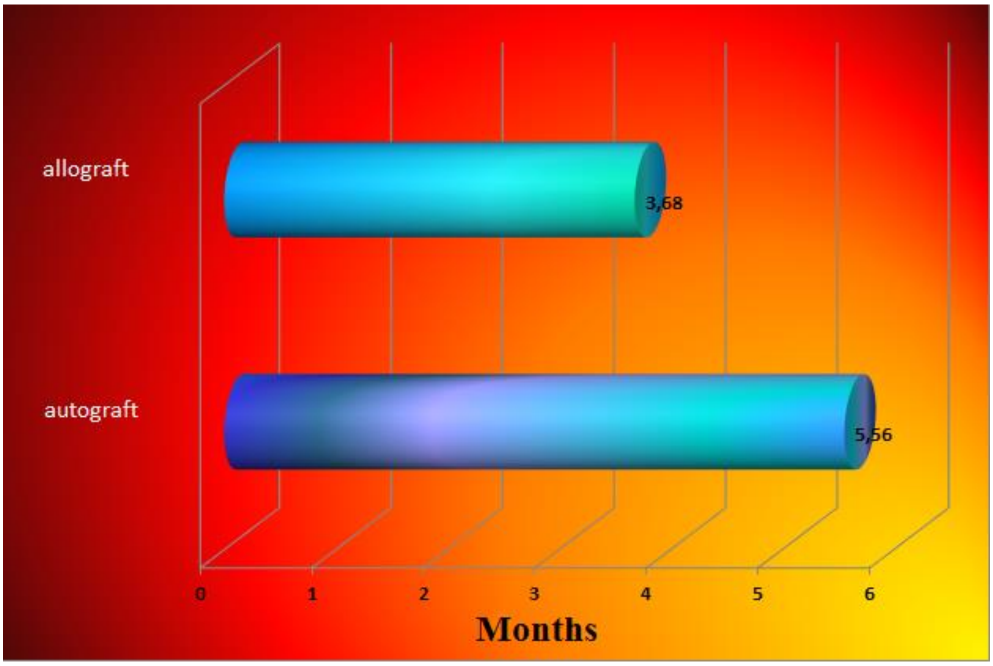

Figure 6. Comparison between the two groups according to time needed to return to work and doing sports.

In both groups we did not have any post operative infection or re-ruptures.

DISCUSSION

In our study we found that when compared the results from ACL reconstruction with BTB allografts to ST/Gr autografts we have similar rate of success. Both groups did not have postoperative infections or postoperative re-ruptures. This goes to show that both autografts and allografts can be reliable options when choosing a graft for ACL reconstruction. However, we also observed some significant advantages of the allografts compared to the autografts. First, the group which had ACL reconstruction with allograft had no power loss in the operated leg and was able to return to level of activities comparable to that before the injury. Second, the allograft group had flexion abilities of the operated knee comparable to that of the non-injured knee (7,8), and lastly the allograft group have needed significantly shorter rehabilitation time compared to the autograft group. All those benefits make allografts better option when treating athletic patients.

Figure 7. On the left - Flexion of the non-injured knee of a patient operated with ST/Gr autograft. On the right – Flexion of the injured knee after ACL reconstruction with ST/Gr autograft

Figure 8. On the left – Flexion of the non-injured knee of a patient operated with BTB allograft. On the right – Flexion of the injured knee after ACL reconstruction with BTB allograft.

The last main concern that surgeon have about allografts that have not been addressed is the cost of the operation. It is true that using allografts add from ¼ to twice the cost fo the operation depending on the cost for the tissue bank of the specific country. However the significant reducont in postoperative pain leaves the patient with little need for pain killer medication which drives the price of the post operative period down. Also costs related to continuous phisical therapy are significantly reduced due to the shorter time needed for recovery after the reconstruction. That also means the healthcare system will incur less burdeon becaouse the patient will returne to work faster. And lastly the cosmetic effect of ACL reconstruction using allografts is significantly better compared with that of autografts which eleminates the need for cosmetic surgery after the reconstruction. (9)

Figure 9. The cosmetic effect after ACL reconstruction with BTB autograft and BTB allograft

CONCLUSION

In conclusion reconstruction of ACL with allograft preserves the anatomy of the knee and allows the retention of the proprioreceptive mechanisms of the flexion and extension muscle groups of the knee. The allograft reconstruction of the ACL allows for more precise quality control of the new made organ (ACL). The right preparation of the graft tissue does not threaten the patient from the prospective of non-compatibility, incorporation, and infectious complications. In prospective of the shorter recovery period, the treatment with allograft tissue is cheaper and more convenient because of the less involvement of public funds. And lastly but not least the absence of a surgical approach to the donor site makes the use of allograft the preferred technque in the prospect of more cosmetical effect.

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THE EFFECT OF EDUCATIONAL STRESS ON ACADEMIC PROCRASTINATION BEHAVIOR

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ABSTRACT

The purpose of this research is to determine the effect of educational stress levels on academic procrastination of students studying at the Faculty of Sports Sciences. The research was designed in the relational scanning model. The study group of the research consists of a total of 196 students, 94 women and 102 men, who continue their education at a public university in Turkey in the 2022-2023 academic year. In the analysis of the data, parametric tests were applied after testing that the data set met normal distribution parameters. Considering the research findings, it can be stated that the academic procrastination and educational stress average scores of the participants are high. As a data collection tool in the research; The Academic Procrastination Scale adapted to Turkish by Çakıcı (2003) and the Educational Stress Scale developed by Seçer, Veyis & Gökçen (2015) were used. It was concluded that the academic procrastination and educational stress levels of the participants did not differ according to the gender variable, but differed statistically according to the grade level variable. In addition, it was determined that there was a significant relationship between academic procrastination and educational stress. Another result obtained from the research is that the educational stress of the participants has a predictive power of 41% on academic procrastination behavior. Therefore, reducing educational stress will contribute to academic success by reducing academic procrastination behavior in students. From this point of view, it is recommended to carry out studies with qualitative research method in order to identify the stakeholders of educational stress in students and to offer solutions.

Keywords: Educational stress, academic procrastination, student, sports.

INTRODUCTION

The importance of education is an undeniable reality today. New methods, perspectives and technological materials used in education alone are insufficient to ensure success for students. It is possible to mention many elements among the educational elements that have the potential to negatively affect the academic success of the individual (Güngör et al., 2022). One of these is academic postponement.

Some reasons that cause academic procrastination are detailed in the literature. Having trouble focusing, expectations above one's potential, thoughts of failure, problems in time management, lack of responsibility, character traits of the person and negative thoughts are the main reasons for academic procrastination (Howell & Watson, 2007; Pfeister, 2002). Negative experiences in an individual's life are another factor that causes academic procrastination behavior by causing loss of self-confidence (Hannok, 2011). At this point, making academic procrastination a habit is seen as a negative situation and brings mental health problems such as depression and anxiety (Aydın, 2023).

Educational stress, on the other hand, can be defined as the pressure created by the student's goals during the continuity of official education, although it has physical and psychological consequences (Akbulut, 2016). While increased stress levels of students negatively affect academic success (Engin, Demirci, & Yeni, 2013), it is known that mild stress increases motivation to learn (Kuyuncu, 2015). Therefore, establishing this balance is important in terms of academic success and educational stress.

When the relevant literature is examined, it is possible to come across studies on educational stress and academic procrastination (García-Ros et al., 2023; Rahardjo, Juneman, Setiani, 2019; Qian, and Fuqiang, 2018). However, no similar research has been found in the Turkish literature, and it seems that the focus of the subject is on stress rather than educational stress. In this context, it emphasizes the importance of the research to both fill this gap in the literature and explain the relationship between educational stress and academic procrastination characteristics on the relevant sample group. Starting from this point, the purpose of the research is to determine the effect of university students' educational stress level on academic procrastination.

METHODS

Research Model

Relational screening model was used in the research. This model; It is used to determine the relationship between two or more variables and to obtain clues about cause and effect (Karasar, 2017).

Study Group

The study group of the research consists of a total of 196 students, 94 women and 102 men, who continue their education at a public university in Turkey in the 2022-2023 academic year. The principles of easy accessibility and volunteerism were taken into account when creating the working group.

Data Collection Tools

In addition to the personal information form, the Educational Stress Scale developed by Seçer, Veyis and Gökçen (2015) and the Academic Procrastination Scale developed by Çakıcı (2003) were used as data collection tools in the study. The maximum score obtained from the measurement tools, both of which are of the liket type, is interpreted as an increase in the relevant features. The Cronbach Alpha coefficient taken from the scales was determined as .92 and .88, respectively.

Statistical Analysis

Shapiro Wilk test was applied to check whether normal distribution criteria were met. Afterwards, skewness and kurtosis coefficients were taken into account. Parametric tests were carried out in data analysis, with the relevant values being between -1.5 and +1.5 (Tabachnick & Fidell, 2013). Afterwards, in addition to descriptive statistics, T-Test, Pearson Correlation and Regression Analyzes were applied.

RESULTS

Table 1. Average Scores of the Participants from the Educational Stress and Academic Procrastination Scales

Scales	N	Min	Max	$\bar{x}$	S
Educational Stress	196	1.00	5.00	3.95	.97
Academic Procrastination	196	1.13	5.00	3.93	1.01

The average score of the participants on the Educational Stress Scale was determined as ($\bar{x}$=3.95) and on the Academic Procrastination Scale was ($\bar{x}$=3.93).

Table 2. T-Test Results of the Average Score from the Educational Stress and Academic Procrastination Scales by Gender Variable

Scales	Gender	N	x̄	S	sd	t	p
Educational Stress	Female	94	3.87	1.03	194	-1.12	.26
	Male	102	4.02	.92			
Academic Procrastination	Female	94	3.84	1.10	194	-1.11	.27
	Male	102	4.00	.92			
	Total	196					

It was concluded that the participants' educational stress and academic procrastination levels did not differ statistically according to the gender variable, $t_1(194)=.26$, $p>.05$, $t_2(194)=.27$, $p>.05$.

Table 3. Examining the Relationship Between Variables Using Pearson Product Moment Correlation

Variables	Educational Stress	Academic Procrastination
Educational Stress	1	
Academic Procrastination	.64**	1

**p<.01

It was determined that there was a moderate positive relationship between the participants' educational stress and academic procrastination ($r_1=.64$, $p<.01$).

Table 4. Regression Analysis Results for Predicting Academic Procrastination

Variables		Standard ize β	Standard Error	Critical Rate	p	R^2
Educational Stress	Academic Procrastination	.64	.42	12.47	***	.41

When Table 5 is examined, a significant effect was detected in the relationship between educational stress and academic procrastination, ($\beta_1=.64$; $p<.01$). Considering the Squared Multiple Correlations (R^2) value in the table, it can be stated that educational stress explains academic procrastination by 41%.

DISCUSSION and CONCLUSION

It is thought that one of the important problems in university education is academic procrastination. In this context, educational stress, which is thought to affect academic procrastination, constituted the independent variable of the research. Considering the results obtained; The increase in the educational stress levels of the participants also increases academic procrastination. In addition, it was concluded that educational stress and academic procrastination did not differ statistically according to the gender variable.

When the research findings are examined, it can be stated that the academic procrastination levels of the participants are above average. Starting from this point; It can be stated that the participants had problems in subjects such as studying regularly, submitting projects on time, maintaining focus during study time, and preparing and implementing a course program. Considering the average score obtained by the participants, it can be stated that they experienced serious educational stress. Therefore; It can be stated that the participants are not satisfied with the grades they received, they think they are given too much homework, they feel too much academic pressure on them, they think the family factor is a stress factor in education, they think there are too many exams, they think they are under pressure when they feel competition in the classroom, and they feel nervous when they cannot achieve the academic success they want.

It was concluded that the academic procrastination level of the participants did not differ according to the gender variable. When the relevant literature is examined, it is seen that there are studies that support the research results (Kutlu and Demir, 2016; Yiğit and Dilmaç, 2015), as well as studies that yield different results (Özer, 2005; Senecal, Julien and Gay, 2003; Washington, 2004). When the education stress level and gender variables were examined, it was concluded that there was no significant difference between the relevant variables for the participants. Göger and Çevirme (2019) concluded in their research that educational stress does not differ according to gender. In their research with university students, Demir and Tektaş (2018) determined that there was no difference between educational stress and gender variables. Considering the relevant literature, it is seen that there are different results (Temel, 2022; Watson, Rehman and Ali, 2017). For this reason, it is not possible to make a general conclusion between the gender variable and educational stress and academic procrastination. It is thought that the differences in the research results are due to the relevant sample groups and socio-economic differences.

Another result obtained in the research is; Educational stress has the power to explain academic procrastination behavior by 41%. When the relevant literature is examined, it can be stated that there are similar research results (García-Ros et al., 2023; Rahardjo, Juneman, Setiani, 2019; Qian, and Fuqiang, 2018). In this regard, it can be stated that educational stress is an important predictor of academic procrastination. It is seen as a stressor when individuals feel pressure and have a negative academic background. If this turns into academic procrastination behavior, it brings with it a serious academic problem. It has been determined as an important result that the stress components must be reduced in order to reduce or eliminate academic procrastination behavior. As a matter of fact, increasing students' stress levels negatively affects academic success (Engin, Demirci, & Yeni, 2013), and it is known that only mild stress increases learning motivation (Kuyuncu, 2015). Increasing academic motivation affects perceived learning (Turan et al., 2022). Therefore, stress acts as an important factor affecting academic success. For this reason, it is recommended to increase the awareness of both students, teachers and families about these components.

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THE ROLE OF NEUROPROPRIOCEPTIVE FACILITATION TECHNIQUES IN FROZEN SHOULDER RECOVERY

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ABSTRACT

Frozen shoulder (stuck shoulder), in medical terms, also known as (secondary) adhesive capsulitis, is a disease characterized by stiffness and pain in the shoulder joint. This diagnosis is based on limitation of shoulder movement. It occurs when the soft tissue surrounding the shoulder joint becomes inflamed and increases in diameter, causing stiffness and, implicitly, pain when carrying out usual activities. This research proposes two hypotheses. The first hypothesis refers to, if full application of myotensive techniques, Slow Inversion (SI), and Slow Inversion with opposition (SIO) can be achieved a rebalancing of the agonist-antagonist muscles as well as an increase in joint mobility. Second hypothesis proposes that by using neuroproprioceptive facilitation techniques, respectively: Isometric contraction in the shortened zone (ICS), Alternating Isometry (AIs) and Rhythmic Stabilization (RS) an increase in muscle strength and stability can be achieved. A series of positive results are identified, such as in terms of improving muscle tone, increasing range of motion, muscle strength and reducing pain on the SPADI scale. **:** We can conclude that the proposed recovery objectives were achieved by the experimental group, where PNF techniques were performed, but also by the control group, where a classical exercise program achieved positive results, however, the results obtained in the 2 subjects of the experimental group are superior, in terms of decreasing pain, increasing joint mobility and muscle strength, and reducing difficulty in performing activities.

Keywords: PNF, Frozen shoulder recovery, active exercises

INTRODUCTION

Frozen shoulder (stuck shoulder), in medical terms, also known as (secondary) adhesive capsulitis, is a disease characterized by stiffness and pain in the shoulder joint. This diagnosis is based on limitation of shoulder movement. It occurs when the soft tissue surrounding the shoulder joint becomes inflamed and increases in diameter, causing stiffness and, implicitly, pain when carrying out usual activities.

Although it affects many people differently, especially depending on the other conditions they suffer from, the movements that are limited, in ascending order, are: external rotation > abduction > internal rotation. (Mitsh J, Casey J, McKinnis R, Kegerreis S, Stikeleather J. Investigation of a consistent pattern of motion restriction in patients with adhesive capsulitis. J Man Manip Ther 2004;12:153-159).

The pathophysiology of frozen shoulder is often well understood as an inflammatory process at the synovial level, followed by fibrosis of the joint capsule, but the factor that starts this condition remains unknown. (Cho, C. H., Bae, K. C., & Kim, D. H. (2019). Treatment Strategy for Frozen Shoulder. Clinics in orthopedic surgery, 11(3), 249–257).

The decrease in mobility occurs gradually and is a pathological development course of the frozen shoulder. The evolution is described in 3 phases: Freezing that lasts between 2 and 9 months, gradually limiting the range of motion of the glenohumeral joint, the pain is unbearable especially at night. Frozen, represents the second phase that lasts between 4 and 12 months, which is represented by stiffness and a persistent limitation in the range of motion, but less painful than in the first phase.

Thawing represents the phase in which the range of motion gradually recovers. (Mezian, K., Coffey, R., & Chang, K. V. (2022). Frozen Shoulder. In StatPearls. StatPearls Publishing.)

METHODS

The research assumes two hypotheses, first assumes that by applying the neuroproprioceptive facilitation techniques, respectively: Myotensive Technique (MT), Slow Inversion (SI), and Slow Inversion with opposition (SIO) a rebalancing of the agonist-antagonist muscles as well as an increase in joint mobility can be achieved.

And the second hypothesis assumes that by using neuroproprioceptive facilitation techniques, namely: Isometric contraction in the shortened area (ICS), Alternating Isometry (AIs) and Rhythmic Stabilization (RS), an increase in muscle strength and stability can be achieved.

In the present research, there are 4 subjects, aged between 48 and 64 years, where 2 groups were created comprising 2 subjects, respectively, the experimental group and the control group.

The methods and techniques used applied to the group of patients had an experimental design, in other words, in the sessions with the control group, a program with classical exercises was applied, and in the sessions with the experimental group, neuroproprioceptive facilitation techniques were used.

The Shoulder Pain and Disability Index (SPADI) is used for assessment of shoulder pain and disability, this assessment contains 13 items covering 2 domains, 5 items measure pain and 8 items measure functional disability. These items are designed to measure the degree of difficulty in carrying out daily activities involving the upper limb. It is carried out through a questionnaire where, on the pain scale, the patient is asked to circle the number that describes the intensity of his pain, 0 representing no pain and 10 the greatest pain; the same applies to the disability scale, where 0 represents no difficulty in achieving, and 10 great difficulty that requires help.

The measurement of the range of motion of the shoulder joint is carried out, in this research, measurements will be made with the goniometer on the movements of flexion, extension, abduction, adduction, horizontal abduction compared to the healthy limb, measured before and after completion of recovery sessions.

Muscle balance (muscle testing). It represents a set of manual examination techniques for assessing muscle strength for each muscle or muscle groups. The assessment of muscle strength is performed on the flexors, extensors, abductors, adductors, internal and external rotators, helping to develop a complete functional diagnosis.

The myotensive technique is applied to the pectoral, trapezius, internal rotators (the deltoid anteriorly, teres major and the subscapular muscle). The slow inversion technique (SI) is applied to the adductor muscles (pectoralis major, long head of the triceps, teres major, latissimus dorsi) followed by SIO to the abductor muscles (anterior, middle, posterior deltoid, and supraspinatus). SI applied to the Internal rotators and external rotators (subscapularis, pectoralis major, teres major and infraspinatus, teres minor, posterior deltoid). Isometric contraction in the shortened area (ICS) is applied for external rotator muscles (infraspinatus, teres minor and posterior deltoid) and abductors (respectively the anterior, middle, posterior deltoid and supraspinatus). Alternating Isometry (AIs) and Rhythmic Stabilization (RS) is applied to abductors, adductors, horizontal abductors and horizontal adductors of shoulder. Afterwards, the technique ICS is used on diagonal 1 kabat of extension and flexion, followed by diagonal 2 of flexion and extension.

RESULTS

Next, we will find the tables with the initial and final results after the recovery program, specific to each group, with their differences of the muscle testing, range of motion, the SPADI test, which includes the pain scale and the disability scale.

Table 1. Range of motion experimental group

Group	NAME	MOTION	INITIAL	FINAL	RECOVERED
Experimental	C.M.	Flexion	52°	68°	16°
		Extension	40°	54°	14°
		Abduction	35°	54°	19°
		Adduction	35°	54°	19°
		Intern rot	40°	50°	10°
		Extern rot	30°	46°	16°
	B.V.	Flexion	70°	86°	16°
		Extension	44°	54°	10°
		Abduction	40°	62°	22°
		Adduction	40°	62°	22°
		Intern rot	40°	48°	8°
		Extern rot	30°	40°	10°

Table 2. Range of motion control group

Group	NAME	MOTION	INITIAL	FINAL	RECOVERED
Control	C.P.	Flexion	48°	56°	8°
		Extension	32°	44°	12°
		Abduction	45°	59°	14°
		Adduction	45°	59°	14°
		Intern rot	34°	42°	8°
		Extern rot	20°	32°	12°
	M.L.	Flexion	70°	84°	14°
		Extension	44°	54°	10°
		Abduction	70°	82°	12°
		Adduction	70°	82°	12°
		Intern rot	48°	54°	6°
		Extern rot	44°	52°	8°

In tables 1 and 2 we have the data related to the initial and final range of motion and the degrees recovered both for the subjects of the experimental group and of the control group. After carrying out the recovery program on the subjects of the experimental group, it shows an improvement in the joint amplitude on flexion by 16°, on extension by 14° and 10°, on abduction by 19° and 22°, on internal rotation by 10° and 8° and 16° and 10° external rotation. Compared to the control group, where an increase in joint amplitude was obtained in flexion by 8° and 14°, by 12° and 10° in extension, 14° and 12° in abduction, 8° and 6° in internal rotation, 12 ° and 8° on external rotation.

Table 3. Muscle strength test experimental group

Group	NAME	MUSCULAR GROUP	INITIAL	FINAL	RECOVERED
Experimental	C.M.	Flexors	3,75	4,25	0,5
		Extensors	3,5	4	0,5
		Abductors	3,5	4	0,5
		Adductors	3,75	4	0,25
		Internal rot	3,5	3,75	0,25
		External rot	3,25	3,75	0,5
	B.V.	Flexors	4	4,25	0,25
		Extensors	3,75	4,25	0,5
		Abductors	3,75	4	0,5
		Adductors	3,75	4	0,25
		Internal rot	3,75	4	0,25
		External rot	3,5	4	0,5

Table 4. Muscle strength test control group

Group	NAME	MUSCULAR GROUP	INITIAL	FINAL	RECOVERED
Control	C.P.	Flexors	3,75	4,25	0,5
		Extensors	3,25	3,5	0,25
		Abductors	3,5	3,75	0,25
		Adductors	3,75	3,75	0
		Internal rot	3,5	3,75	0,25
		External rot	3,5	3,75	0,25
	M.L.	Flexors	3,75	4,25	0,25
		Extensors	3,5	4	0,5
		Abductors	3,5	3,75	0,25
		Adductors	3,75	4	0,25
		Internal rot	3,5	3,75	0,25
		External rot	3,5	4	0,5

In tables 3 and 4 show the data related to the patients' initial, final and recovered muscle strength. Patients show an improvement in muscle strength, respectively on flexors by 0.5 and 0.25, on extensors by 0.5, on abductors by 0.5, on adductors by 0.25, on the internal rotators by 0.25 and on the external rotators by 0.5. In the control group, where muscle strength increased by 0.5 on flexors, by 0.25 and 0.5 on extensors, by 0.25 on abductors, with 0.25 on the adductors, with 0.25 on the internal rotators, and with 0.25 and 0.5 on the external rotators.

Table 5. Pain scale - SPADI

GROUP	NAME	INITIAL SCORE OF PAIN	FINAL SCORE OF PAIN	DIFFERENCE
EXPERIMENTAL	C.M.	52%	20%	32%
	B.V.	48%	22%	26%
CONTROL	C.P.	54%	34%	20%
	M.L.	66%	50%	16%

Table 6. Disability scale – SPADI

GROUP	NAME	INITIAL SCORE OF DISABILITY	FINAL SCORE OF DISABILITY	DIFFERENCE
EXPERIMENTAL	C.M.	56,25%	35%	21,25%
	B.V.	48,75%	27,5%	21,25%
CONTROL	C.P.	52,5%	38,75%	13,75%
	M.L.	63,75%	47,5%	16,25%

In table 5 both subjects of the control group show a decrease in pain by 20% and 16%, and the subjects of the experimental group, recognized a decrease in the painful process by 32% and 26% in activities.

In table 6 a decrease in the disability score of both the experimental group and the control group can be observed. The control group achieved a decrease in disability score by 13.75% and 16.25, and both subjects of the experimental group by 21.25%.

DISCUSSION

The frozen shoulder is a cause of pain, low range of motion and a low strength of the muscles of the shoulder region, which leads to a functional deficit. This deficit is highlighted with the help of evaluations and tests and finally reduced through a recovery program.

Taking into account the data following the evaluations of the muscle testing, the range of motion, the SPADI test with the pain and disability scale, we can discuss the differences between the 2 groups and the different recovery programs. Positive results were obtained in both groups, but still differences can be observed between the 2 groups regarding the range of motion, more precisely in the experimental group where PNF techniques were applied where more degrees were recovered compared to the control group where classical exercises were applied. The results of the muscle strength test also have positive results for both groups of patients, but here too the experimental group with PNF techniques has a greater increase in muscle strength. The control group had an approximately constant increase in muscle strength, the exception being one of the patients who had no increase in muscle strength on the adductors. The pain scale of the SPADI test had better values for both groups, but compared to the control group, the experimental group based on facilitation techniques obtained relatively higher values, in terms of pain reduction compared to the control group control. The disability score from the SPADI test had positive values for both groups of subjects, resulting in a low degree of disability. The experimental group obtained a greater decrease in the disability score compared to the control group.

CONCLUSION

In the presented, we can claim that the proposed recovery objectives were achieved by the experimental group, where PNF techniques were performed, but also by the control group, where a program of classical exercises was performed, however, the results obtained in the 2 subjects of the experimental group, are superior in terms of decreased pain and difficulty in carrying out activities. By presenting the data obtained along the way, the idea can be supported that by using neuroproprioceptive facilitation techniques, Myontensive, Slow Inversion, Slow Inversion with Opposition, it is possible to correct muscle imbalances by relaxing the adductors and internal rotators and increasing joint amplitude. We can also confirm the second hypothesis, where, by using neuroproprioceptive facilitation techniques, respectively: Isometric contraction in the shortened area, Alternating Isometry, Rhythmic Stabilization, an increase in stability and muscle strength on flexion, abduction and external rotation increasing contraction capacity.

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PSYCHOLOGICAL COMPONENTS OF INTEREST IN THE PROFESSION OF SPORTS TEACHER

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ABSTRACT

In the present theoretical presentation, the essence of the professional interest in the sports teacher profession is revealed, by deriving and explaining its main psychological components. It is a complex personal unit that arises and develops in the process of professional self-determination under the influence of the external environment and manifests itself through a comprehensive attitude to the chosen profession. The structure of professional interest consists of four components: emotional, motivational, intellectual and volitional. The mechanisms by which it can be managed in relation to professional development and career growth are indicated: Accumulation and upgrade mechanism, Support mechanism, Contradiction resolution mechanism, Bottom-up mechanism, Top-down mechanism. Their specific action must be taken into account to achieve a match between personality and profession.

Keywords: professional interest, sports and educational activities, psychological mechanisms, professional development of the sports teacher

INTRODUCTION

Interest is a personality quality that is characterised by a persistent cognitive focus on a preferred object or activity. It reveals the inner essence of the subject and stands at the centre of personal orientation. From this point of view, interest permeates the entire psychological chain of activity. It is socially conditioned and especially important for its formation are training, education and work. A person's behaviour is also determined by interests both along the psychological chain of *needs – interests – motives – behaviour* and along the chain of *interests – behaviour – abilities* (Trifonov,T.,1996). As one of the most flexible phenomena in the psychology of personality and its manifestation in professional labour activity, its examination from different aspects is always relevant, because it enriches the theory and practice of this scientific problem.

METHODS

A complex methodology is applied, the center of which is the analytical-synthetic approach. The aim of the present scientific development is to reveal in a theoretical-practical aspect:

- the essence of the interest in the "sports teacher" profession, by presenting and explaining its main components.
- to indicate the main mechanisms by which it can be managed in connection with the professional development and career growth of the sports educator.

DISCUSSION

Interest in the profession of sports teacher is generally defined as a complex personal entity that arises and develops in the course of professional self-determination under the influence of the external environment and manifests itself through the integral attitude to the chosen profession. In itself, it represents a permanent selective attitude that prompts a person to activity, plays the role of a motive for assimilation and deepening of knowledge, for the formation of professionally significant qualities and skills, for the manifestation of activity and readiness for pedagogical work in the field of sports. The physiological basis of interest is the orienting exploratory reflex. The involvement of a second signalling system is a prerequisite for understanding and differentiating interests.

Considered as a professional, the interest in the profession sports teacher develops according to certain psychological mechanisms, which are manifested in a regular sequence based on the processes taking place in the mind of the subject. Their knowledge and study is important in relation to the effective management of the professionalisation process of the sports pedagogue (Tsonkova,D.,2010; Tsonkova,P., 2020) ,as it has been proven that success in a given profession depends both on the interest in it and on the abilities necessary for its exercise (Babushkin, G.,1990; Tsonkova, P., 2020)

The most commonly perceived structure of professional interest is made up of four components: emotional, motivational, intellectual and volitional (Babushkin G.,1990):

- **The emotional** component includes: a positive attitude towards the profession, confidence in the right choice, satisfaction with the choice. Attitude and interest are closely related, and in this sense, we believe that the attitude towards the profession sports teacher is determined by the interest in two main areas: sports and pedagogy. Interest in sports, as a dynamic complex of mental properties and states, is important in all stages of the professionalisation of the sports pedagogue (teacher, coach, sports animator) – from choosing a profession, through preparation for it, to pedagogical activity.

Initially, the interest in the sports-pedagogical activity is manifested with the emergence of positive emotions in the subject towards the profession. Thus, for example, adolescents and especially athletes, observing their teacher or coach, involuntarily, and then more definitely begin to like his profession. This liking is quite general and impulsive, so they cannot explain what exactly attracts them and arouses their interest. At school age, it is characteristic that children who see themselves in the role of their sports teacher experience a number of positive emotions from this.

- **The motivational** component includes: justifying the choice, formulating the factors that determine it. Typically, the dominant motives regarding the professional career, which determine the activity of the person, are different in the individual stages of professionalisation (Tsonkova, D., 2010):

The process of identification of the self-image with the image of the future sports teacher is directly related to highlighting the leading motives and factors determining the professional choice. Initially, it has a diffuse character, it is subject to emotions. Pleasant experiences are the basis on which motivations for professional choice arise. They are in a wide range and are not at all from the so-called significant motives, regardless of the fact that it is the nature of the motives that determines the essence of the professional interest and its preservation over time.

For the young pedagogue, the leading motives are the love for children and for sports, while at a later stage socially significant motives come to the fore, such as: training of prominent athletes, striving to be better than others, responsibility towards students and colleagues (Tsonkova,P., 2020). This expansion and filling with richer content of the motivational component of the interest in the sports teaching profession is possible only with adequate adaptation in the real conditions of its implementation with the support of the team.

- **An intellectual** component is related to getting to know the profession through information about the essence and features of the sports teaching activity. The young person‘s independent intellectual activity is expressed in a thorough and comprehensive analysis of one‘s own interests, abilities, internal potential, etc. We will note that very often the help of both the parents and the sports pedagogue, the older friends, who with their experience can guide him more precisely, is needed to make the right decision about the future profession.

In addition, the natural process of moving from an incompletely determined attitude to the profession to a positive one logically causes a desire for quality training and leads to a restructuring of the elements in the intellectual and volitional component. For example, the search for specialised literature only on a certain occasion is replaced by purposeful and systematic interest in it, which is one of the proofs of increasing personal activity when mastering the profession.

- **The volitional component** is manifested through the activity of the subject and the efforts made on the way to the set goals. It is especially important when overcoming difficulties, some negative emotions, and unfavourable situations in the process of educational and sports activities. The degree of its expression determines not only how goal-oriented the individual is, but also the magnitude of the final success in the various aspects of the sports-pedagogical activity.

The identification of the main components is based on the dialectical unity between personality and activity and on the regularities of the general mental development of man. Each of the specified components includes interrelated elements, but their detailed examination in relation to the topic is not required.

The process of formation, development, and management of professional interest in the profession of sports teacher takes place under the action of several mechanisms, known in the theory of psychology as:

- **Accumulation and upgrade mechanism.** It represents a kind of accumulation and upgrading of the structural components with their constituent elements. It is characteristic that it is observed both in high school students and in students, but it proceeds with specific features. Specifically, during higher education, professional interest is mostly related to the development of the motivational component. The reasons for choosing a profession are superimposed on those related to the desire to master it. Their orientation in the content-resultative aspect is determined by the individual‘s inclination towards sports-pedagogical activity. Especially in the first two years of study, the training has an impact on the emotional and motivational component and specifically on the sustainability of the professional interest, preserving and stabilising it. The intellectual component is also developing intensively. The action of this mechanism has an individual character and depends on the degree of expressed inclination towards pedagogical activity, as well as on the character and mental characteristics of the individual.
- **Support mechanism**. The basis of this mechanism is the positive emotions of the subject (personality), arising from the positive evaluation of the performed activity, which serves as a starting impulse. Thanks to it, the intellectual and volitional component is rebuilt. It should be noted that negative evaluation can also have a supportive meaning, provided that this activity has a meaningful meaning for the person. It evokes the desire to prove oneself, and in this way, it acts as a stimulus.
- **„Contradiction resolution“ mechanism.** It is based on the theoretical proposition that the process of overcoming contradictions in principle leads to development, incl. in the professional interest. The main contradictions found in the students-sports pedagogues during the training practice, as well as in the young specialists are (Tsonkova, P.,2020):
  - between the professional plans and claims of the person and the actual results achieved in the work
  - between the individual‘s desire to appear, prove, assert himself and the social significance of the activities of his colleagues;
  - the capabilities of the person and the requirements for the implementation of the pedagogical activity in physical education and sports;
  - between the formed professional interest and the weakly expressed inclination towards pedagogical activity.

However, the action of this mechanism should not be absolute, because sometimes it is not development, but a decrease in professional interest, leading even to a change of profession. It depends on the character of the person, his drive, ideals, abilities, will, social environment, etc. In this context, the manifestation of the *„preservation of professional interest“* mechanism can be considered as a special case. Although very rare, it is noticed in some sports specialists. They are engaged in sports teaching activity, although they have no sustained interest in it, but at the same time they have no intention of changing the profession. It is assumed that they get used to the contradiction between desire and possibilities, they do not accept it emotionally, but on the other hand, their results in the educational process with students are undistinguished.

- **Bottom-up mechanism**. It is concluded that the specially created conditions and the purposefully organised events, as well as the means used, are a prerequisite for updating the professionally significant motives, for forming a positive attitude towards the profession, increasing the intellectual and volitional activity of the person (Markova A.,1996). The young person is placed in specific situations where he has to make his own decisions. The expectations are to strengthen the action of these structural components, which are a starting point for building interest in sports-pedagogical activities. These include: for high school students – the feeling of admiration for the chosen profession; for students – the state of satisfaction and awareness of abilities; for young specialists – conviction in the right choice of profession.

Stimulation of the „bottom-up" mechanism takes place on the basis of changes in external conditions. So, for example, the practice of students at school and in sports clubs makes them look at themselves from the point of view of professionals and in such a way relate to the pedagogical activity of physical education and sports. This inevitably leads to a reassessment of the motives that activate and encourage them to achieve better results.

- **Top down mechanism.** It is expressed in the assimilation of the „ready-made" goals, tasks, ideals, values, relationships, motives, volitional efforts, etc., which must be formed in the personality, turning from externally understood to internally accepted and functioning. This psychological mechanism is often observed when using the „prediction of professional prospects" method. At its core is an artificially induced (intentional) change in professional interest if its structure does not correspond to pre-set expectations. It is about cases like this: in order to prepare the student in the best way for the future professional activity, he must convince himself of this need and, as a result of external influences, rethink his attitude to the preparation during his studies. This occurs when he is dissatisfied with the teacher's assessment he receives for an activity that is meaningful and valuable in his value system. As a result, the student becomes ambitious, strives for high success, showing greater responsibility and thoroughness in the study and practical activities of the chosen specialty.

CONCLUSION

The theoretical analysis of the professional interest in the sports teacher profession based on its main structural components, as well as the explanation of the mental mechanisms in its construction, gives us the basis for the following **conclusions:**

1. The formation and development of professional interest in the professional activity of the sports teacher is a complex, ambiguous process that is determined by a number of objective and subjective factors. It takes place in a certain logical sequence and covers all substructures of the personality.
2. When managing the professional interest in sports-pedagogical activity, the specific action of the main mental mechanisms must be taken into account in order to achieve a more complete match between personality and profession.
3. Targeted work with youth and athletes will help to make the right professional choice and the formation of sustainable interest among students and young specialists in the field of sports pedagogy.

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SUPPLEMENTATION, SPORT SUPPLEMENTATION, AND ANTI-DOPING

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ABSTRACT

In the contemporary lifestyle, supplements have been extensively used worldwide. This issue calls for an interdisciplinary analysis. In this paper, the author first provides a conceptual definition of supplementation and supplements. Then, the author presents an overview of the comparative legal regulations on supplements, the global market trends, as well as the economic aspects of their production and circulation. Subsequently, the author analyses the use of supplements for medical purposes. The focal point of the paper is the analysis of sport supplementation. The supplements are first analyzed by categories, in accordance with the levels of evidence supporting their use and, then, accoring to the effects of certain types of supplements. At the end of the paper, the author analyzes the international standards of abuse of dietary supplements in sport, the World Anti-Doping Code, and its implementation in the Republic of Serbia.

Key words: supplements, sports supplementation, doping, legislation, international standards, interdisciplinary approach

THE CONCEPT OF SUPPLEMENTATION

The terms ***supplementation*** and ***supplement*** are used to denote something that serves as an addition or a replacement. Etymologically, both terms come from the Latin language (*supplēre* ≈ *supplementum*: to supplement). Thus, supplements are additions or complimentary parts of food, newspapers, books, etc. In daily life, supplements usually imply the products that can help strengthen the body's natural functions due to the presence of active ingredients. Consumers of dietary supplements are most commonly individuals with increased nutritional needs, people with reduced intake of certain food ingredients, as well as special categories of people whose treatment is aimed at acheiving some physiological effects, such as children, pregnant women and athletes.

The definition and legal regulation

As defined by the U. S. Dietary Supplement Health and Education Act of 1994 (DSHEA), "*Dietary supplement is a product (except tobacco) that is intended to supplement the diet, contains one or more dietary ingredients (including vitamins, minerals, herbs or other botanicals, amino acids, and other substances) or their constituents, is intended to be taken by mouth as a pill, capsule, tablet, or liquid, is labeled on the front panel as being a dietary supplement*" (Dietary Supplements: Background Information. Office of Dietary Supplements, US NIH).

In the European Union, dietary supplements are regulated by the Directive 2002/46/EC as follows: "*Food supplements means foodstuffs the purpose of which is to supplement the normal diet and which are concentrated sources of nutrients or other substances with a nutritional or physiological effect, alone or in combination. Such food supplements can be marketed in "dose" form, such as pills, tablets, capsules, liquids in measured doses, etc.*" (Directive 2002/46/EC on food supplements).

In the Czech Republic, dietary supplements fall into the category of food, and cannot be called medicine, whereas they may be claimed to have beneficial effects on the health of the user and are, therefore, desirable in the diet (State Institute for Drug Control of the Czech Republic, official website).

In the Republic of Serbia, nutritional supplements (dietary supplements) are regulated by the following legislative and regulatory acts (by-laws):

a) the Food Safety Act, 2009 (*Zakon o bezbednosti hrane*, „Sl. glasnik RS", br. 41/2009 & 17/2019);

b) the Rulebook on Nutritional Supplements (Dietary Supplements), 2022 (Pravilnik o dodacima ishrani (dijetetski suplementi), „Sl. glasnik RS", br. 45/2022); and

c) the Rulebook on Health Safety of the Dietary Supplements, 2010, (Pravilnik o zdravstvenoj ispravnosti dijetetskih proizvoda, „Sl. glasnik RS", br. 45/2010, 27/2011, 50/2012, 21/2015, 75/2015, 7/2017, 103/2018).

The Food Safety Act of the Republic of Serbia stipulates that "*food is any substance or product, processed, partially processed or unprocessed, which is intended for human consumption or may justifiably be expected to be used for human consumption*."

The Rulebook on Nutritional Supplements (Dietary Supplements) of the Republic of Serbia defines nutritional supplements (dietary supplements) as "*foods that supplement the usual diet, and represent concentrated sources of nutrients or other ingredients with nutritional or physiological effects, used alone or in combination, and are in circulation in dose forms such as capsules, lozenges, tablets, powder bags, liquid ampoules, dropper bottles, and other similar forms of liquids and powders intended for taking in small, dosed amounts."* Under the provided definition, nutrients are vitamins and minerals.

The Rulebook on Health Safety of the Dietary Supplements of the Republic of Serbia defines dietary products as "foods which, due to their special composition or special production method, are clearly different from foods of usual composition, and are suitable for the specially indicated nutritional purpose for which they are put on market". Consumers of dietary products are healthy infants and children, people with disturbed digestion or metabolism, and certain categories of people in special physiological conditions who should be subjected to special treatment in order to achieve a special effect by controlled intake of certain food ingredients.

Based on the presented comparative law review, supplements are defined as foods that complement normal nutrition and are concentrated sources of vitamins, minerals, amino acids or other substances with a nutritional or physiological effect, either alone or in combination. Supplements are available on the market in dosage forms designed to be taken in measured individual amounts (capsules, lozenges, tablets, pills, powder sachets, ampoules of liquid, vials for dosage drops, etc.). Thus, a concentrated form of a bioactive substance that is not in the food matrix is ingested into the body. The doses significantly exceed the amounts represented in foods in the daily diet.

Global market and financial trade in supplements

At the end of the 20th century, there was an increased interest in dietary supplements, as well as a growing number of people using dietary supplements. Only in Europe, during 2003, trade in herbal products (medical plants) had reached the level of 5,3 billion US dollars (including 2,1 billion in Germany, 1,1 billion in France, while all other EU countries spent 2,1 billion dollars for this purpose). This was mostly the result of the increasingly aggressive advertising campaign of supplement manufacturers offering supplements with the aim of improving general health, boosting energy and fitness, and preventing and treating various diseases, especially in light of the COVID-19 pandemic and a whole series of new global diseases. Hence, dietary supplements are most often used by people with various health problems, including severe diseases such as tumors, alcoholism or obesity (De Smet, 2005; Barnes et al., 2004; Ervin, Wright & Kennedy-Stephenson, 1999).

Judging by the data presented at the "Second Congress on Dietary Supplements" held in Belgrade in 2009, the representation of certain foods in the structure of the daily diet and the percentage of nutrient intake are highly worrying and confirm the existence of nutritional deficiencies among the population of Serbia. This imposes the need for proper and rational use of dietary supplements, which can play a significant role not only in the process of self-medication, prevention and diet therapy but also in different medical conditions, in different population groups, and in maintaining good health (Izveštaj sa Drugog Kongresa o dijetetskim suplementima sa međunarodnim učešćem, Beograd, 2009).

In 2022, the size of the dietary supplements market was estimated to be 155,2 billion USD. It is predicted that the average annual growth rate will be 7,3%, and that it will reach 220,8 billion USD by 2027. The growth of the dietary supplements market is believed to be driven by increasing health awareness among consumers (Dietary Supplements Market Size & Trends Report, 2021-2028). More than 50,000 dietary supplement products are produced in the United States (Dietary Supplement Label Database. Office of Dietary Supplements, US NIH, 2017), where they are consumed by about 50% of the American adult population. Multivitamins are typically the most common type of dietary supplements (Park, 2013). The US National Institutes of Health (NIH) states that supplements "may be of value" to those who lack nutrients in their diet and receive approval from their physician (FAQs on Dietary Supplements. Office of Dietary Supplements, US NIH).

Prerequisites to be met for supplements to be placed on the market

In the United States, it is against federal law to claim that supplements prevent or cure any disease. Companies are allowed to use the term "structure/function" if there is scientific evidence that a supplement has a potential health effect (Structure/Function Claims. Office of Dietary Supplement Programs, Center for Food Safety and Applied Nutrition, US FDA, 2017). For example, a dietary supplement may be labelled as follows: "____ helps maintain healthy joints," but the label must include a disclaimer that the FDA "has not evaluated the claim" and that the dietary supplement product is not intended for "diagnosis, treatment, curing or preventing any disease" because such a claimer may be used only on pharmaceutical drugs (medicines) (Structure/Function Claims. Office of Dietary Supplement Programs, Center for Food Safety and Applied Nutrition, US FDA, 2017). The FDA enforces these regulations and also prohibits the sale of supplements and supplement ingredients that are dangerous, or supplements that are not made in accordance with standardized good manufacturing practices.

Dietary supplements are consumed orally and they are generally defined in terms of what they are not: conventional foods (including meal replacements), medical foods (Guidance for Industry: FAQ About Medical Foods, US FDA, 2016), preservatives, or pharmaceutical drugs. Products intended for general use, such as nasal spray or topical sprays and lotions applied to the skin, do not meet the requirements to be classified as supplements. The FDA-approved drugs cannot be ingredients in dietary supplements. Supplements contain vitamins, minerals, amino acids, essential fatty acids and non-nutritive substances extracted from plants, animals, fungi, bacteria, or live bacteria (in the case of probiotics). The ingredients of nutritional supplements can also be synthetic copies of natural substances (e.g. melatonin). All products with these ingredients must be labeled as dietary supplements (Dietary supplements: a framework for evaluating safety, Committee on the Framework for Evaluating the Safety of Dietary Supplements, 2004). As with foods, and unlike drugs, no government approval is required to make or sell dietary supplements. The manufacturer confirms the safety and the quality of the dietary supplements.

Regulatory compliance

The European Commission has published harmonized rules on supplement products in order to protect consumers against potential health risks from the use of dietary products and to ensure that consumers are not misled by advertising. The key achievement of the European Union is the principle of mutual recognition, enabling companies to place a product that is lawfully marketed in one Member State on the market in all other Member States irrespective of national legislation in place (Regulation 2019/515).

In the United States and Canada, dietary supplements are considered a subset of foods and are regulated accordingly. The FDA monitors supplement product accuracy in advertising and labeling. Dietary supplements are regulated by the FDA as food products subject to compliance with current good manufacturing practices and labeling with science-based ingredient descriptions and advertising (Dietary Supplement Label Database, Office of Dietary Supplements, US NIH, 2017; Dietary Supplements Labeling Guide, US FDA, 2018).

The use of dietary supplements for medical purposes

The scientific research from the early 20th century related to the identification of individual nutrients in food, and their production raised hope that their use could contribute to achieving the optimal health outcomes. Although supplementation and food fortification with folic acid have been successfully used in preventing vitamin deficiencies and conditions such as neural tube defects through, no targeted supplementation or fortification strategies have proved to be successful in preventing major diseases such as cancer or cardiovascular disease (Lichtenstein & Russell, 2005).

In more recent research, increased fruit and vegetable intake has been linked to reduced mortality, cardiovascular disease and cancer, while supplementation with key factors found in fruit and vegetables, such as antioxidants, vitamins or minerals, has been found to have no such effect, whereas some have been found to be harmful in some cases (Vitamin E-Health Professional Fact Sheet. US NIH, 2015; Bjelakovic et al., 2012). In research from 2016 to date, there is a lack of solid clinical evidence to show that any type of dietary supplement does more good than harm to people who are healthy and have a proper diet, but there is clear evidence that diet and lifestyle choices are associated with health outcomes (Guallar et al., 2013; Rautianen et al., 2016).

In the absence of high-quality data on supplementation and more reliable data on dietary guidelines, recommendations encourage citizens to have a plant-based, whole-food diet, to minimize processed foods, salt and sugar, and to exercise daily. Outdated diets and decadent lifestyles are increasingly abandoned (Katz & Meller, 2014; Fitzgerald, 2014).

The regulation of foods and dietary supplements by the FDA is governed by various statutes enacted by the United States Congress. Under the Federal Food, Drug, and Cosmetic Act and related laws, the FDA has the authority to monitor the quality of substances sold as food in the United States, and to monitor label claims about the ingredients and health benefits of foods. The production of dietary supplements must be in accordance with the good manufacturing practice established in 2007. The FDA can visit manufacturing facilities, send warning letters (Pace, 2017), stop production if it is not in compliance with the law, and order the company to issue a recall if there is a health risk (Current Good Manufacturing Practices (CGMPs) for Dietary Supplements. US FDA, 2007).

The European Union Directive 2002/46/EC on food supplements requires supplements to demonstrate that they are safe, both in terms of dosage and purity. Only those supplements that have been proven to be safe can be sold in the European Union without a prescription. As a food category, dietary supplements cannot include drug label claims, but can carry health and nutrition claims (European Commission, official website: Food Safety - Labelling and Nutrition - Health and Nutrition Claims, 2012).

Fake products during the outbreak of the COVID-19 pandemic

At the outset and during the COVID-19 pandemic, which has unfortunately persisted for an unexpectedly long time, the US FDA and the Federal Trade Commission kept warning the public against the use of drugs, cannabidiol products, teas, essential oils, tinctures and colloidal silver which were promoted in the treatment of this disease, apart from official drugs (Fraudulent coronavirus disease 2019 (COVID-19) products. US FDA, 2020; Coronavirus: Scammers follow the headlines. Federal Trade Commission, 2020).

Databases containing facts about various supplements are regularly updated, including the Dietary Supplement Label Database (Dietary Supplement Label Database. Office of Dietary Supplements, US NIH, 2017), the Dietary Supplement Ingredients Database (Dietary Supplement Ingredient Database. Office of Dietary Supplements, US NIH & US Department of Agriculture, 2017) and Fact Sheets on dietary supplements in the territory of the United States of America (Dietary Supplement Fact Sheets, Office of Dietary Supplements, US NIH, 2018). In Canada, a license is issued when the manufacturer and the government have proven that the product supplement is safe, effective and of sufficient quality for use, after which it receives an eight-digit number and is entered as a licensed natural product in the database (Licensed Natural Health Products Database Products Directorate. Natural and Non-prescription Health, Government of Canada, 2015). The European Food Safety Authority has a collection of herbal ingredients used in the production of dietary supplements (European Food Safety Authority, 2012. Compendium of botanicals reported to contain naturally occurring substances of possible concern for human health when used in food and food supplements).

Quality and safety of dietary supplements

In order to ensure quality and safety of public use and consumption of dietary supplements, all efforts have been focused on standardization and development of reference substances for the production of supplements (European Food Safety Authority, 2012. Compendium of botanicals reported to contain naturally occurring substances of possible concern for human health when used in food and food supplements; Measurements and Standards for Botanical Dietary Supplements. US NIST, 2016). Reasearchers are particularly drawn by products that are used in high doses (Dwyer, Coates & Smith, 2018; Dwyer et al., 2015), especially in emergency situations, such as Vitamin A deficiency in childhood malnutrition (Iannotti, Trehan, & Manary, 2013), or intake of folic acid supplements in women in order to reduce the risk of breast cancer (Chen et al., 2014).

Clinical studies on dietary supplements

To date, limited human research has been conducted on the potential of dietary supplements and their impact on disease risk. Examples include:

- Vitamin D – in acute respiratory tract infections (Martineau et al., 2017)
- Iron – in maternal iron deficiency anemia and adverse effects on the fetus (O'Brien & Ru, 2017)
- Folic acid – in stroke and cardiovascular diseases (Li & al., 2016)
- multiple supplements - no evidence of benefits for lower risk of death, cardiovascular disease or cancer (Schwingshackl et., 2017)

Research from 2017 indicate an increasing incidence of liver damage due to the use of herbal and dietary supplements, especially those with steroids, green tea extract, or multiple ingredients (Navarro et al., 2017).

Absence of benefits of dietary supplements

The potential benefit of using supplements to reduce disease risk has been refuted by findings in numerous clinical trials on no effect or weak evidence of dietary supplement benefits in treating cardiovascular diseases (Li & al., 2016), cancer (Schwingshackl et., 2017), HIV (Visser et al., 2017), or tuberculosis (Grobler et al., 2016).

Reporting bias

A review of clinical trials registered on Clinicaltrials.gov, which includes drugs and supplements, shows that half of the completed trials are fully or partially funded by the pharmaceutical industry (Dunn & Coiera, 2014). This could mean that selective and biased reporting on results supporting a potential drug or supplement is more likely than publishing results that do not show a statistically significant benefit (Dunn & Coiera, 2014; Knottnerus & Tugwell, 2013). One review shows that less than half of registered clinical trials are published in peer-reviewed journals (Zarin, Tse & Sheehan, 2015).

The future of dietary supplements

Informing the public about the use of dietary supplements means investing in professional training programs, studying the needs of the population, and expanding the database of supplements. Better co-operation between the government (i.e. the Ministry of Health) and the academic community is necessary, as well as translating the scientific research results into useful information for consumers, health workers, scientists and health policy makers in the states (ODS Strategic Plan 2017-2021, Office of Dietary Supplements, US NIH). Future use of dietary supplements requires high-quality clinical research, rigorously qualified products, and compliance with established guidelines for reporting clinical trial results (e.g. CONSORT guidelines) (Dwyer, Coates & Smith, 2018).

Supplementation in sport

Most of the recommendations on the combined use of certain supplements in order to improve the athletes' performance are justified by studies in which an improvement in performance was observed after the introduction of these supplements in isolation. Their effects are sometimes studied when these supplements are used in combination. Supplementation in sport is widely accepted, but very often uncontrolled and unjustified. The results of testing 2.758 athletes at the Olympic Games in Sydney in 2000 indicate the prevalence of this phenomenon. Close to 80% of athletes used supplements, with 542 subjects taking 6-7 products, and one even 26 different substances (Đorđević-Nikić, M., & Macura, M. 2004).

Sport supplements are divided into three categories based on the level of evidence supporting their use to improve sports performance: (1) supplements with proven effects (caffeine, creatine, nitrate, beta-alanine, bicarbonate); (2) supplements with ambiguous and insufficiently proven effects (citrate, phosphate, carnitine); and (3) supplements with developmental effects (Peeling et al., 2018).

1. Supplements with proven effects

Caffeine

Caffeine is consumed in the diet of most adults, and has well-established benefits for athletic performance. Mechanisms supporting these benefits include adenosine receptor antagonism, increased endorphin release, improved neuromuscular function, improved alertness, and reduced perception of exertion during exercise (Burke, 2008; Goldstein et al., 2010; Spriet, 2014).

Caffeine supplementation is known to improve endurance capacity over time, for example, during activities such as treadmill running to exhaustion (French et al., 1991) and resistance exercise repetitions to failure (Duncan et al., 2013).

Ingestion of caffeine during high-intensity exercise lasting equal to or less than 5 minutes showed that approximately 65% of studies resulted in improved performance, with an average task improvement of ~6.5% (±5.5%) (Astorino & Robertson, 2010.)

We may sum up that low to moderate doses of caffeine (~3–6 mg/kg BM), consumed 60 minutes before exercise, have the most consistent positive results on sport performance.

Creatine

Creatine is a widely researched supplement. In the form of creatine monohydrate (CM), which is its most common form, it is used to supplement dietary intake from meat. Within muscles, creatine kinase (CK) mediates the phosphorylation of creatine to phosphocreatine (PCr), a key substrate for high-intensity muscle force generation (Greenhaff et al., 1993), while PCr levels decrease during high-intensity exercise to rapidly resynthesize adenosine triphosphate (ATP) from adenosine diphosphate (ADP) (Rawson & Perksy, 2007).

Creatine loading can significantly improve performance in sport involving repeated high-intensity exercise (eg, team sports) (Lanhers et al., 2017). This type of training leads to an increase in lean muscle mass and strength (Rawson & Perksy, 2007).

Nitrate

Dietary nitrate (NO_{3-}) is a popular supplement that was initially found to improve oxygen uptake kinetics (VO_2) during prolonged submaximal exercise (Bailey et al., 2009).

Dietary NO_3- intake leads to increased nitric oxide (NO) bioavailability via the NO_{3-} -nitrite-NO pathway, a reduction initially catalyzed by bacteria in the mouth and digestive system (Duncan et al., 1995).

NO plays an important role in modulating skeletal muscle function (Jones, 2014).

Beta-alanine

Beta-alanine is a rate-limiting carnosine precursor, an endogenous intracellular (muscle) buffer, and one of the immediate defenses against proton accumulation in contracting musculature during exercise (Lancha Junior et al., 2015).

Daily supplementation with 3,2–6,4 gr. (~65 mg/kg BM) of beta-alanine for at least 2–4 weeks can increase carnosine content in skeletal muscle (~65% above resting levels), thus improving tolerance for maximum 30-second exercise performance up to 10 minutes (Saunders et al., 2016).

Summarily, beta-alanine supplementation divided into doses of 3,2–6,4 gr. (~65 mg/kg BM) daily, consumed for at least 2–4 weeks, can increase high-intensity exercise performance from 30 seconds up to 10 minutes.

Sodium bicarbonate

Additional oral intake of sodium bicarbonate ($NaHCO_3$) increases the extracellular buffering capacity of bicarbonate, which maintains the acid-base balance during exercise and physical fatigue, and thus additionally enhances the ergogenic effect. An increase in the number of bicarbonate ions (HCO_3^-) favors an alkaline environment in the extracellular fluid. At the same time, this amount of bicarbonate increases the extracellular H^+ ion gradient, which in turn stimulates the lactate/H^+ cotransporter. This gradually leads to a greater flux of hydrogen ions (H^+) from the intracellular to the extracellular fluid, allowing the circulating bicarbonate ion (HCO_3) and compensatory buffering mechanisms to reduce the amount of hydrogen ions (H^+), ultimately resulting in an increase in pH (decrease in acidity). Reducing the accumulation of hydrogen ions (H^+) in the exercising muscle would allow the contractile process of the muscle fibers to be maintained longer and to continue the process of resynthesis of ATP through glycolysis. This guarantees a better environment with more favorable conditions, which delays the onset of muscle fatigue during high-intensity exercise (Danković, 2023).

2. Supplements with ambiguous and insufficiently proven effects

Sodium citrate

Sodium citrate acts as a blood buffer by increasing the pH of the extracellular environment and increasing the gradient between blood and active muscle. This is accomplished by the dissociation of sodium citrate into its component ions, leading to a decrease in $[H^+]$ and an increase in $[HCO_{3-}]$ as electrical equilibrium is established (Requena et al., 2005).

Phosphates

There are numerous hypotheses supporting the potential benefits of phosphate supplementation on athletic performance (Buck et al., 2013).

The mechanisms explaining these benefits include an increased rate of ATP and PCr resynthesis (Kreider, 1999), and improved buffering capacity to support high rates of anaerobic glycolysis (Kreider, 1999).

Carnitine

Carnitine is a compound found within skeletal muscle which helps translocate long-chain fatty acids into the mitochondria for beta-oxidation, and provides a drain for excess acetyl-CoA production, thereby aiding the flow of carbohydrates through the citric acid cycle (Stephens, Constantin-Teodosiu & Greenhaff, 2007).

It is hypothesized that carnitine spares glycogen through increased fat oxidation. Due to more efficient oxidation of carbohydrates, lactate accumulation is reduced at higher intensities, delaying the onset of fatigue.

3. Supplements with developmental effects

Supplements may have an indirect effect on factors such as modulation of inflammation, oxidative stress and signaling pathways for adaptation, or by restoring homeostasis between two exercises. For example, the amino acid N-acetylcysteine acts as an antioxidant that can aid in athlete recovery by mediating exercise-induced reactive oxygen species (Braakhuis & Hopkins, 2015).

Polyphenols may act in a similar way, having powerful antioxidant and anti-inflammatory properties (Tsao, 2010) that may be beneficial for recovery. High anthocyanin content in tart Montmorency cherries reduces inflammatory and oxidative stress in marathon running (Howatson et al., 2010) and during consecutive days of stochastic, high-intensity cycling (Bell et al., 2014). Blood biomarkers that suggest such a benefit are presented in the aforementioned studies.

Research on supplementation with antioxidant vitamins C and E has shown a reduction in cellular signaling pathways that support the adaptive response to exercise, reducing the overall response to training and reducing any potential improvements in performance (Gomez-Cabrera et al., 2008).

Dietary polyphenols have direct effects on performance, potentially as a result of mechanisms relevant to flow-mediated dilation, NO production, and adenosine receptor antagonism effects (Somerville et al., 2017).

A daily dose of New Zealand blackcurrant extract (300 mg containing 105 mg of anthocyanins) over a 7-day period improved endurance performance by 2–3% during running (5 km) and cycling (16,1 km) TT activities (Cool et al., 2015; Perkins et al., 2015).

A dose of 500–1000 mg of quercetin (consumed over a longer period ranging from 1–8 weeks) showed clear moderate improvements (+2,8%) in performance when mediated by the type of undertaken sporting event (Somerville et al., 2017).

The World Anti-Doping Code

In the Republic of Serbia, the List of Prohibited Doping Agents is part of the mandatory international protocol and the World Anti-Doping Program and Code (Anti-Doping Agency of the Republic of Serbia, 2006). The List is renewed annually under the auspices of the World Anti-Doping Agency and is valid for the calendar year starting from January 1 of the current year. The List is published in English and French; if situations arise where the English and French versions of the Code are inconsistent, the English version shall prevail.

Specific and non-specific substances

Pursuant to Article 4.2.2 of the World Anti-Doping Code, all prohibited substances are specific substances unless otherwise indicated on the List of Prohibited Doping Agents. No Prohibited Method shall be considered a Specific

Method unless it is designated on the Prohibited Doping List as a Specific Method. It includes substances and methods which are considered to be used and are actually used by athletes for a purpose that is not aimed at improving sports performance.

Substances of abuse

In Article 4.2.3 of the World Anti-Doping Code, substances of abuse are defined as substances that are abused in society outside of sports. Substances of abuse are cocaine, diamorphine (heroin), methylenedioxymethamphetamine (MDMA/"ecstasy"), and tetrahydrocannabinol (THC).

I. SUBSTANCES AND METHODS THAT ARE ALWAYS PROHIBITED

Substances and methods that are always prohibited means that substances and methods are prohibited in and out of competition as defined in the World Anti-Doping Code.

1. **S0.** Unapproved substances.

2. **S1.** Anabolic agents (can be found in medicines for the treatment of e.g. male hypogonadism).

3. **S2.** Peptide hormones, growth factors, related substances and mimetics (can be found in drugs for the treatment of e.g. anemia, male hypogonadism, growth hormone deficiency).

4. **S3.** Beta-2 agonists (can be found in medicines for the treatment of e.g. asthma and other respiratory diseases).

5. **S4.** Hormones and metabolic modulators (they are found in medicines for the treatment of e.g. breast cancer, diabetes, female infertility, polycystic ovary syndrome).

6. **S5.** Diuretics and masking agents (found in medicines for the treatment of e.g. heart failure, hypertension).

7. **M1 – M2 – M3** Prohibited methods.

M1. **MANIPULATION OF BLOOD AND BLOOD COMPONENTS**

The following are prohibited:

1. Administration or repeated administration into the circulatory system of any amount of autologous, allogeneic (homologous) or heterologous blood products or red blood cells of any origin.

2. Artificial improvement of oxygen uptake, transport and delivery

It includes but is not limited to:

Perfluorochemicals; efaproxiral (RSR13); voxelotor and modified hemoglobin products, e.g. hemoglobin-based blood substitutes, microencapsulated hemoglobin products, other than the use of inhaled oxygen.

3. Any form of intravascular manipulation of blood or blood components by physical or chemical means.

M2. **CHEMICAL AND PHYSICAL MANIPULATIONS**

The following are prohibited:

1. It is forbidden to interfere or attempt to interfere in order to change the integrity and validity of samples taken during doping control.

This includes but is not limited to:

Changing samples and/or changing the integrity and quality of urine, e.g. addition of proteases

2. Intravenous infusions and/or injections in an amount greater than 100 ml in a 12-hour period are prohibited except for those legitimately received during hospital treatment, surgical procedures or clinical diagnostic testing.

M3. **GENETIC AND CELLULAR DOPING**

Due to the possibility of improving sports performance, the following are prohibited:

1. The use of nucleic acids or nucleic acid analogs capable of altering genome sequences and/or altering gene expression by any mechanism. This includes but is not limited to gene editing, silencing and gene transfer techniques.

2. The use of normal or genetically modified cells.

II. SUBSTANCES AND METHODS PROHIBITED AT THE COMPETITION

The competition period is considered to be the time starting immediately before midnight (at 11:59 p.m.) on the day before the competition in which the athlete will participate until the end of the competition and the urine sampling process.

1. **S6.** Stimulants (in medicines to treat e.g. severe allergic reactions anaphylaxis, attention deficit hyperactivity disorder (ADHD), colds and flu.

2. **S7.** Narcotics (in medicines for the treatment of e.g. pain, including musculoskeletal injuries).

3. **S8.** Cannabinoids

4. **S9.** Glucocorticoids (often found in medicines for the treatment of e.g. allergies, asthma, inflammatory diseases).

III. SUBSTANCES PROHIBITED IN CERTAIN SPORTS

P1. Beta blockers (can be found in medicines for the treatment of e.g. heart failure, hypertension).

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Session 4

ACTIGRAPH IN ASSESSMENT OF CHILDREN'S PHYSICAL ACTIVITY – A SYSTEMATIC REVIEW

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ABSTRACT

The aim of the these research was to systematize collected research related to the evaluation of different physical activity programs, using actigraph with the analysis of scientific thoughts that were published in scientific and professional journals. Scientific papers that were collected (21) systematized in the following directions: According to the population of participants in research: 14 scientific papers were related to school age, 3 scientific papers was related to high school age and 2 papers was related to adolescents; According to the sex of the respondents: in 15 papers, the research included boys and girls, and in one paper, the research was conducted only in boys; According to the method of research: longitudinal and transversal studies with a representative sample of children in some studies and with more than 1000 respondents; the tests in the works refer to the use of actigraphs in the assessment of physical activities of moderate, medium and high intensity (10), assessment of BMI and FMI and different levels of physical activities (1) and sleep and wakefulness (4). Reliability of the Actigraph accelerometer has been determined under normal wear time criteria in a large sample of subjects and accelerometer units, monitoring adults under long-term free-living conditions (1). Validity of actigraphs accelerometers for assessment of physical activity in adults in laboratory conditions was determened (1). Differences in behavioral aspects of independent sedentary and physical activities in different age groups can also have a significant impact on their measurement. The Actigraph accelerometer can be used to identify sedentary behavior and to distinguish between light, moderate and vigorous activity in children. The accelerometer popularity has been increasing because it is easily portable, non-invasive, interesting for children because it is worn according to the principle of a wristwatch. Its use has great potential for determining children's physical or sedentary activity.

Keywords: actigraph, children, physical activity

INTRODUCTION

Physical activity (FA) is an important aspect of children's physical activity. Through physical activity, children have a positive manifestation on their physical, social and psychological health. Physical activity is often established in early childhood (2-5 years) and has recently been identified as an early risk factor for childhood obesity. The current physical activity patterns of preschool children are a cause for concern, and strategies to promote physical activity should be based on scientific evidence of the correlates or determinants of this behavior. A recent review of the correlates of physical activity in preschool children found few studies in this area, indicating that further quality research using validated measures of physical activity is needed. Therefore, we should start from the factors that can influence the physical activity habits of children in preschool years (Cliff et al., 2009). There is evidence that sedentary behavior and low levels of physical activity in childhood are associated with an increased risk of childhood obesity, as well as a number of risk factors for chronic disease in adults, including hypertension, insulin resistance, and dyslipidemia. Accurate and valid assessment of sedentary behavior and physical activity levels during childhood is therefore integral to understanding their association with later health outcomes, as well as documenting their frequency and distribution within the population (Pulsford et al., 2011). According to the report of the World Health Organization (WHO), insufficient physical activity has been declared as one of the biggest health problem of a nation. According to Trost, et al., 2002, 2/3 of the total population is insufficiently physically active. Data from the 2010 health survey of residents of the Republic of Serbia show that the physical activity of the adult population of Serbia matches the data from most countries in Europe and America. It is thought that the level of physical activity generally declines with age, there is evidence that this decline is particularly pronounced during adolescence (Kemper, Twisk, Koppes, van Mechelen & Bertheke Post, 2001; Kimm, Glynn, Kriska et al., 2002; Nader, Bradley, Houts et al., 2008). In girls, it has been observed that compared to boys, the decline in the level of physical activity occurs earlier (Hoosetal., 2003).

Actigraph is an accelerometer that is widely and successfully used to assess physical activity in children. Accelerometers provide dimensionless results of physical activity in "counts" that are summed over a period of time. By calibrating the accelerometer using an objective "gold standard" of energy expenditure (EE), such as oxygen consumption at various exercise intensities, thresholds for accelerometer data can be established. Threshold values are used to delimit categories of physical activity intensity. Accelerometer-based data are summarized according to these threshold values, and it is determined whether the population's physical activity meets current public health guidelines, which are conventionally expressed in minutes spent each day in moderate to vigorous physical activity - MVPA (Pulsford et al., 2011). According to Caspersen et al., 1985, physical activity is defined as any body movement that is performed by activating skeletal muscles and resulting in energy consumption. Physical activity is a complex behavior that is difficult to measure both in shorter and longer periods of time (Welk, 2002). There are three basic methods for measuring physical activity, namely: criterion, objective and subjective methods. All methods vary in terms of measurement variables, as well as in terms of the results obtained. However, the most important thing is that in most of them, energy consumption can be assessed either as a primary or secondary outcome (Warrenetal., 2010). Assessment of physical activity determines the level of total daily physical activity, the level of activity of low, moderate and high intensity and enables the assessment of relative variables for longevity or for programming appropriate exercise programs (Kisko et al., 2012). According to Warrenetal (2010), the following are used to assess physical activity: objective methods - use of accelerometer, pedometer, monitoring of heart rate, direct observations; and methods based on self-assessment – questionnaires, diaries, daily records.

The aim of the these research was to systematize collected research related to the evaluation of different physical activity programs, using actigraph with the analysis of scientific thoughts that were published in scientific and professional journals.

METHODS

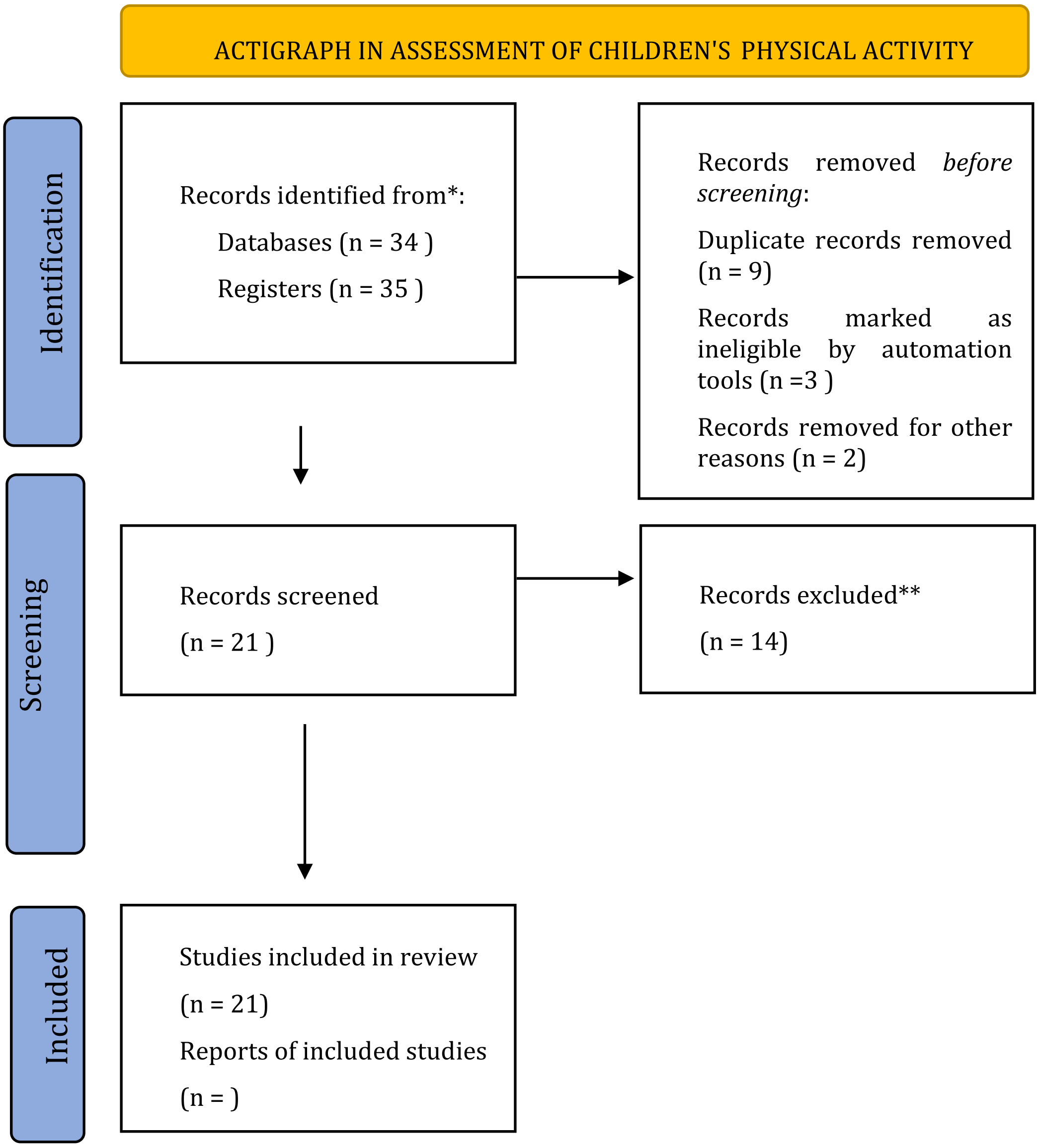
A dialectical approach was used to determen classification path, as well as the following analysis methods and techniques: descriptive method and analysis and systematization. For pictorial presentation a PRISMA 2020 flow diagram was used for new systematic reviews which included searches of databases (Table 1).

In order for the research to be accepted for the final analysis of this work, it was necessary to meet the following criteria:

- The results of the research should be related to the assessment of children's physical activity only using an actigraph, i

- The sub-term "children" should be divided into age groups in relation to their age.

Table 1. Pictorial presentation of researches for actigraph



RESULTS

Scientific papers that were collected systematized in the following directions: According to the population of participants in research: 14 scientific papers were related to school age, 3 scientific papers was related to high school age and 2 papers was related to adolescents; According to the sex of the respondents: in 15 papers, the research included boys and girls, and in one paper, the research was conducted only in boys; According to the method of research: longitudinal and transversal studies with a representative sample of children in some studies and with more than 1000 respondents; the tests in the works refer to the use of actigraphs in the assessment of physical activities of moderate, medium and high intensity (Hjort et all, 2012), assessment of BMI and FMI and different levels of physical activities (Aadland & Ylvisåker, 2015) and sleep and wakefulness (Park et all, 2000). Reliability of the Actigraph accelerometer has been determined under normal wear time criteria in a large sample of subjects and accelerometer units, monitoring adults under long-term free-living conditions (Aadland & Ylvisåker, 2015). Validity of actigraphs accelerometers for assessment of physical activity in adults in laboratory conditions was determened (Kelly, L., et all 2013)

DISCUSSION

After searching the available scientific databases, we were able to collect 102 papers that were initially selected by the actigraph search. After reviewing those papers due to the subject of certain papers that do not include the subject of our research, we had to reject 60 papers because they did not deal with the issue of using actigraphs to assess children's physical activity. Finally, 21 scientific papers were selected that dealt with our topic.

The research discussion tells us that among the group of authors whose research is related to the use of actigraph in the assessment of physical activities of moderate, medium and high intensity, the actigraph is a valid instrument for this type of assessment: Craig & Clark (2019) determined the quality of children's movement while performing FA. Specific objectives of bio-food: 1) verifies the validity and reliability of accelerometry in mechanical and laboratory conditions; 2) determine the characteristics of the quality of movement according to the body mass index (BMI) and 3) to determine the quality of movement characteristics of compass and free play. Sasaki, Dinesh, Freedson (2011) activity numbers from the Actigraph GT3X compared to those from the Actigraph GT1M during walking/running on a racetrack. The secondary goal was to develop a three-axis vector (VM3) to classify the intensity of physical activity (FA). Donaire-Gonazales et al (2013) validate physical activity assessments (FA) and determine usability for large population-based trials of CalFit (CalFit) based on smartphones. Thirty-six subjects from Barcelona (Spain) wore a smartphone with CalFit software and an Actigraph GT3X for 5 days. Usability of measuring physical activity of both devices, including the vertical non-numerical axis (VT) and predicting the duration and energy consumption of slow, moderate and strong intensities using Fridson's algorithm, was determined. McClain, et al (2007) offers a viable monitor alternative to the commonly used Actigraph. This study compared LC and AG accelerometers and the Iamak SV-200 pedometer (DV) under conditions of free movement and measuring children's steps and time of physical activity such as intensity (FA) and moderate-to-vigorous PA (MVPA). Ridgers et al (2012) was to examine the agreement between Actigraph (AG) cut-off points for sitting time and objectively assessed free-living periods: sitting and standing time using aktivPAL (aP); and identify the intersection points as determined by time spent sitting and sitting and standing. Forty-eight children (54% boys) aged 8-12 wore AG in the waist and thighs on two consecutive school days (21-3:30h). AG data were analyzed using 17 cut-off points between 50-850 points, in order to determine the time of the teaching session, break time and the school hour. Limits of agreement are calculated by estimating the bias between AG50 to AG850 sitting time and sitting time and sitting and standing time. Receiver operator characteristic (ROC) analyzes identified AG intersection points that maximize sensitivity and specificity in sitting and standing.

Hamari et al (2017) was to assess the validity of the FitbitOne steps versus the Actigraph Actisleep-BT step count for measuring physical activity habits in children. The study was implemented as a cross-sectional experimental design, in which the participants wore two monitors around the waist for five consecutive days. The participants were randomly selected from three fourth-grade classes (children aged 9 to 10) in two elementary schools. A total of 34 students participated in this study. Therefore, eight participants were excluded from the analysis due to incorrect data. The average daily step difference between the two devices per participant was 1937. The FitbitOne provided more steps for all but the least active participants. According to the Bland-Altman Foundation, hourly step counts had a relatively large mean bias across participants (161 step counts). The differences were partially explained by the intensity of the activity: higher intensity indicated larger differences, and light intensity indicated lower differences. The Fitbit One Step Count is compared to the Actigraph step count of a sample of children aged 9-10 years who engage in usual physical activity in sedentary and light intensities of physical activity. However, in moderate-to-vigorous physical activity, the Fitbit gives a lower number of steps compared to the Actigraph. Janssen et al (2014) evaluate the predictive equation of energy expenditure of the Actigraph and the accuracy of the classification of threshold values of the intensity of physical activity in preschoolers. Forty children aged 4-6 years completed a 150-min indoor calorimeter protocol that included age-appropriate physical activities of light and moderate to vigorous intensity. The children wore the Actigraph GT3X on the right mid-axillary line of the hip. Criterion methods were energy expenditure measured by calorimetry in the room and intensity of physical activity classified by direct observation. Reilly et al (2009) assessed the validity of two equations based on the Actigraph CSA / MTI accelerometer for predicting total energy expenditure (TEE). The criterion was measured using the doubly labeled water method in 85-year-old children, average age 4.6 years, during 7 days in preschool institutions and 10 days in school age. Children wear Aktigraphs during waking hours, during 3 out of 7 days (preschoolers) or 7 out of 10 days (school-aged children). Agreement between predicted and measured TEE assessment using the "Bland - Altman graph". Reliability increased as the number of days and hours of monitoring increased, but only to 10 hours per day. During 7 days of 10-hour daily follow-up, reliability was 80% (95% CI [70%, 86%]). The number of days is as important as the reliability of the number of hours. Including or excluding weekends made relatively little difference. A monitoring period of 7 days during 10 hours a day produced the highest reliability. Surprisingly short follow-up periods can provide adequate reliability for children. Robusto & Trost (2012) conducted a study where the agreements between three generations of the AktiGraf aximeter in children and adolescents were evaluated. Twenty-nine participants (mean age = 14.2 years) completed two 60-minute laboratory activities. During each session, participants simultaneously wear three different models of AktiGraph accelerometers from the following brands:GT1M, GT3X, GT3X +. Agreement between the three models for vertical axis counts, vector counts, and time spent in moderated intensity physical exercise (MVPA) was assessed by calculating intraclass correlation coefficients and Bland-Altman plots. Ottevaere et al (2011) was to compare data obtained from the modified, long version of the International Physical Activity Questionnaire (IPAK questionnaire) with objective data obtained in parallel from Actigraph accelerometers and VO2max in adolescents. The study included 2018 adolescents (46% male) from ten European cities who participated in the HELENA study (HealthyLifestyle in Europe by Nutrition in Adolescence). Physical activity was assessed over seven consecutive days using an accelerometer and expressed as minutes/day of moderate, vigorous and moderately vigorous (MVPA) physical activity (PA). PA is also evaluated by IPAK's questionnaire. VO2max was assessed by the 20-meter shuttle run test.

A group of authors whose research relates to the use of actigraphs in the assessment of BMI and FMI: Griffiths et al (2016) examined whether physical activity (FA) and sedentary time (ST) in primary school-aged children are associated with the onset of adiposity at the beginning of secondary school , and whether these phenomena differ by ethnic group. Children aged 7 who are more physically active have less chance of being obese at that age and at the age of 11. Measuring fat mass provides valuable insight into ethnic differences in the association between adiposity and activity.

In the group of authors whose research is related to the use of actigraphs in the assessment of sleep in children: Paavonen, Fjällberg, et al., (2002) in their research determined whether the placement of actigraphs affects the assessment of sleep in children, motor activity was measured from the waist and random wrist with actigraph, worn three days in a row during the school week. Although actigraph placement had a slight effect on measured activity parameters, its effect on average sleep estimates over 3 nights in children was not statistically significant. Sleep and wakefulness behavior and the effects of aging on night shift tolerance were investigated using wrist actigraphs in a study by Park, Matsumoto, al., (2000).During night duty, total sleep time decreased, the number of naps and naps during duty increased. and non-working time. Hjorth et al., (2012) conducted research to show that accelerometers can be used to assess physical activity and sleep using the same monitor; however, two different positions are commonly used to assess physical activity and sleep (waist and wrist). Meltzer, Walsh, Traylor, Westin (2012) evaluated the validity and reliability of two new commercially available actigraph models.

CONCLUSION

In the included systematization of research that used the actigraph in the assessment of physical activity in children for the purpose of assessing the validity of this instrument - we came to the following conclusions:

1. both sexes, both boys and girls, of different age categories, as well as the exercise of different physical activity programs, were investigated, which enables an easier assessment of the validity of actigraphs in their assessment;

2. most of the research is based on the use of actigraphs in the assessment of physical activity in children, and then on the assessment of BMI and the assessment of sleep and wakefulness;

3. the reliability of the actigraph is valid in the assessment of children's physical activity and the assessment of BMI and FMI, but the actigraph is not reliable in the assessment of sleep and wakefulness.

The variation in cut-off values derived for different age groups may be partially attributable to the different methodologies used. However, differences in behavioral aspects of independent sedentary and physical activities in different age groups can also have a significant impact on their measurement. The Actigraph accelerometer can be used to identify sedentary behavior and to distinguish between light, moderate and vigorous activity in children. The accelerometer popularity has been increasing because it is easily portable, non-invasive, interesting for children because it is worn according to the principle of a wristwatch. Its use has great potential for determining children's physical or sedentary activity. The main pathway linking FA and sedentary behavior to overweight and obesity is energy imbalance, resulting from higher energy expenditure than energy expenditure over time: from a life course perspective one hypothesis relates to a time pathway, whereby lower energy expenditure associated with inactivity leads to a greater weight. Psychosocial or physical difficulties or socioeconomic disadvantages in childhood may contribute to future risk of increased adiposity through inactivity.

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THE RELATIONSHIP BETWEEN NETWORK SOCIETY, PHYSICAL ACTIVITY AND NUTRITION

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ABSTRACT

The inclusion of digital technology and automation in lives due to the increasing spread of digital technology and automation affects lifestyles (physical activity, nutrition, etc.). The age we live in, which is called the network society, allows information, communication and interaction to be faster and easier. On the other hand, technological tools, which have an effect that both facilitates and complicates life in certain aspects, undoubtedly have a negative impact on nutrition and physical activity participation levels. The fact that individuals can access everything quickly and easily causes them to stay in their comfort zone. This brings physical inactivity and can lead to a series of health problems. In this context, this research aimed to investigate and evaluate the relationship between physical activity and nutrition in the network society. The reason for this paradigm is the popular culture. Each of the scientific and technological developments affects the life of the social field. A literature review study was performed to answer the questions regarding the PICO criteria (population, application, comparison and results) by using the keywords "nutrition", "network society and physical activity", and "physical activity" in the context of nutrition, physical activity and network society in various databases (Pubmed, Scopus Web of Science (WOS) and Sport Discuss databases). The articles obtained as a result of the database review were screened and some of them were used in the systematic review. In the results of the research, it was observed that the relationships established in the network society, especially with new media tools at the centre of lives, negatively affect physical activity and nutrition. On the other hand, the wrong nutrition styles shared on social media also affect the habits of individuals. Finally, any information presented on social media can be shared by thousands of people without being checked for accuracy or inaccuracy. This is due to being part of an increasingly widespread network. However, on the other hand, if new media tools are used to share information that a healthy life requires physical and mental integrity and that participation in physical activity and dietary habits can be revised, healthy individuals can be enabled in the social field. In this case, it cannot be ignored that the correct usage of new media tools has the potential to directly affect participation in physical activity and nutrition.

Keywords: Network Society, Physical Activity and Nutrition

INTRODUCTION

There is a complex relationship between network society, physical activity and nutrition. This relationship is shaped by the influence of modern lifestyles, technological developments and digital communication. Some important observations on the relationships between these three factors: Influence of Digital Lifestyle: The network society causes individuals to spend more time on technological devices and the internet. This may lead to a decrease in the amount of physical activity. People may limit their physical movement by spending more time sitting in front of a computer or on smartphones.

Nutrition and the Digital World: In the network society, factors such as online food ordering, fast-food chains and online recipes affect eating habits. While unhealthy foods are more easily accessible, healthy cooking and eating habits may be neglected.

Increased Health Awareness: The network society provides easier access to health information. Digital resources such as health apps, diet tracking apps and exercise guides can guide individuals on healthy living. This can lead to increased personal health awareness and healthier lifestyle choices.

Internet and Awareness Raising: The network society provides opportunities for campaigns, educational materials and public awareness-raising on healthy living. This can increase people's motivation to increase physical activity and adopt healthy eating habits.

In conclusion, the network society reflects a complex relationship between physical activity and nutrition. Technological advances affect people's lifestyles, while digital resources can contribute to increased health awareness and easier access to health-related information. However, these changes have negative as well as positive effects and require an informed and balanced approach.

Network Society in Castells' Perspective

The society of our era is the era in which everyone can connect anywhere and anytime and is defined as a "network society". The most important feature that makes the network society effective is two-way communication, in other words, interactivity. Manuel Castells defines the network society as a network-based social structure, a highly dynamic, open system that can innovate without disturbing its balance. In Castells' thesis, while explaining the network society, Castells argues; "In the network society, personal identity becomes a more open issue. We no longer take our identities from our past; we have to create our identities by interacting with others." clearly emphasises the importance of interaction in the creation of identity in social networks (Ateş, 2009; Özdemir, 2015).

"The emergence of a new technological paradigm, organised around new, more powerful and more flexible information technologies, has allowed information itself to become a product of the production process. By transforming the process of information processing, new information technologies have become active in all spheres of human activity, making it possible to establish an infinite number of links between various spheres, as well as between the representatives and elements of these activities"(Castells, 2008, Güven, 2021).

Relationship between Physical Activity and Nutrition

The main factors for healthy aging and minimising age-related health risks are healthy nutrition and increasing physical activity. Daily regular physical activity is the most important element in the prevention of chronic diseases together with healthy nutrition (Garibağaoğlu et al., 2006; Arslan, 2018).

Nutrition is a behaviour that should be conducted consciously to take the nutrients required by the body in adequate and balanced amounts and at appropriate times to protect, improve and develop health and improve the quality of life (Baysal, 2007). Inadequate and unbalanced nutrition is an important public health problem that may affect not only the current generation but also future generations. Adequate and balanced nutrition should be addressed in the whole life process (Hosseinpoor et al., 2006).

Obesity is a complex disease with serious social and psychological effects. This problem affects people from all socio-economic levels and age groups. The three main factors causing obesity are defined as poor (unbalanced) nutrition, lack of physical activity and genetic reasons (Yıldırım, 2008). Sixty per cent of adult individuals do not perform sufficient physical activity. Sedentary life is more common among women, the elderly and individuals living in low socio-economic status. During adolescence, females are less active than males. A sedentary lifestyle doubles the risk of death due to cardiovascular disease and stroke and doubles the risk of cardiovascular disease, type 2 diabetes and obesity (Yücesan, 2008; Vassigh, 2012).

Today, while technological advances, business life, urbanisation and other factors negatively affect human health, the importance of physical activity increases even more as regular physical activity reduces the risk of mortality resulting from diseases such as obesity, cardiovascular diseases, diabetes and cancer, and increases the quality and duration of life (Branca vd., 2007; Donnelly et al., 2009; Gordon et al., 2009; Can et al.,2014).

Physical inactivity has negative effects on many systems, especially muscle, metabolic, endocrine, nervous and cardiovascular systems, even in a very short time. Increased physical activity and regular exercise are known to prevent health problems caused by physical inactivity and to be used as an effective treatment method for most chronic diseases (Bouchard et al., 2012; Koç and Bayar, 2020). In this respect, Physical Activity is defined as "activities that involve the expenditure of energy by using our muscles and joints in our daily lives, increase the heart and respiratory rate, can be performed at different intensities and result in physical fatigue" (Gordon et al., 2009; Baltacı, 2008).

Along with diet and exercise, sleep is an essential activity that plays a crucial role in emotional and physical development, health and well-being. Good quality sleep is associated with positive health and emotional outcomes in young people, including but not limited to improvements in attention, learning, academic performance, memory, cognition, behaviour and emotion regulation, as well as increased self-esteem and self-acceptance (Allen et al., 2016; Paruthi, 2016; Sampasa-Kanyinga et al., 2017).

A significant body of research shows that being more physically active provides significant benefits for everyone, regardless of age, gender, race, ethnicity, or current fitness level. The US Department of Health and Human Services recommends that preschool-age children (3-5 years) should be physically active throughout the day to maximise growth and development, and children and adolescents aged 6 to 17 years should engage in 60 minutes or more of physical activity each day (3 days per week). The benefits of physical activity, a balanced diet and quality sleep on young people's physical health are generally recognised. Emerging evidence continues to highlight the benefits for young people's mental health and wellbeing, including psychiatric disorders. These benefits appear to arise through multifactorial influences on neurobiological and psychosocial development. Integrating ongoing assessments and interventions related to these lifestyle domains into clinical practice (Daniel et al., 2019).

Physical inactivity and poor nutrition are associated behaviours that affect health, well-being and the maintenance of a healthy weight. These behaviours are the basis for the risk of lifestyle-related non-contagious situations (Abu-Moghli vd., 2010). The risk of ischaemic heart disease, paralysis, type 2 diabetes, osteoporosis, various cancers and depression is associated with behavioural and biomedical health determinants such as physical inactivity, poor dietary behaviours and overweight/obesity (Canberra: AIHW; 2012).

The health benefits of participating in regular physical activity are well recognised for adults (Reiner et al., 2013). Strategies to promote physical activity have become an important public health approach to the prevention of chronic diseases (Bonevski et al., 2014). Given the lack of physical activity and healthy eating, it is not surprising that the prevalence of overweight/obesity has reached epidemic proportions in young adults (Plotnikoff vd., 2015).

METHODS

A literature review study was performed to answer the questions regarding the PICO criteria (population, application, comparison and results) by using the keywords "nutrition", "network society and physical activity", and "physical activity" in the context of nutrition, physical activity and network society in various databases (Pubmed, Scopus Web of Science (WOS) and Sport Discuss databases). The articles obtained as a result of the database review were screened and some of them were used in the systematic review.

RESULTS

As a result; in the network society, individuals in the social sphere have the opportunity to connect with others at any time from any place. In this context, Toffler started to use the concept of prosumer in 1980. This concept has emerged by combining the words producer and consumer. Especially in the new media platforms within the network society, it allows individuals to be both producers and consumers. This area, where information on many issues in daily life takes place, also causes information to change and transform rapidly. In particular, this area, where disinformation about nutrition takes place, causes changes in eating habits depending on new forms of consumption. The network society causes both a new cultural area and new consumption habits to be formed for individuals existing in the social field.

Finally, considering that the eating and drinking patterns in new media tools are based on ready-to-eat food consumption and eating out, this new lifestyle brings new problems. On the other hand, the fact that technology facilitates lives day by day brings along a sedentary life form. When technological developments and network society are considered together according to all this information; in order for societies to be more conscious, it should be helped to settle the idea that every individual should be questioned instead of accepting every information as true and applying it as it is.

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THE DIFFERENCES IN THE PROFESSIONAL WORKING PHYSICAL PREPARATION OF THE FIREFIGHTERS OF THE REPUBLIC OF SERBIA FROM DIFFERENT REGIONS

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ABSTRACT

The aim of this study was to determine the differences in the professional physical preparation of firefighters from the Republic of Serbia from different regions. 101 healthy and physically active firefighters participated in the study. The following tests were applied: Beep test (BP), Modified Step test (MS), Fireman Polygon test (FP), Fireman Equipment Carry test (FEC) and Casualty Drag test (CD). The testing was carried out using a randomized method. The pause between tests was 10 minutes. The results of the analysis of differences showed that in the Fireman Equipment Carry test (FEC) there is a significant difference ($p < 0.05$) between the Belgrade-East Serbia region, Belgrade-Vojvodina, Belgrade-West Serbia, Eastern Serbia-Vojvodina and Vojvodina-Western Serbia; the effect size was d = - 0.891, - 2.424, - 0.754, - 1.074, 1.161 for all regions, individually. In addition, in the Casualty Drag test, significant differences ($p < 0.05$) were determined between the regions of Belgrade-Vojvodina and West Serbia-Vojvodina; the effect size was d = 2.061 and 0.823, individually. Based on the results of the differences and determined effect sizes in the Fireman Equipment Carry test (s), it can be concluded that firefighters from the Belgrade region are more agile and stronger than firefighters from the regions of Eastern Serbia, Vojvodina and Western Serbia. Firefighters from the region of Vojvodina are less agile and strong compared to firefighters from the region of Western Serbia. Based on the established differences and effect sizes in the Casualty Drag test (CD), it can be argued that firefighters from the Belgrade region are stronger and more powerful than firefighters from the Vojvodina region, the same applies to firefighters from the West Serbia region compared to firefighters from the Vojvodina region. It is recommended that the regions that achieved worse results in the Fireman Equipment Carry test (FEC) and Casualty Drag test (CD) include training procedures through work plans and programs in order to improve professional work physical preparation.

Keywords: firefighters, differences, testing, regions, abilities

INTRODUCTION

The job of firefighters is an interesting, but high-risk profession with a variety of complex situations (Melius, 2001). Firefighters work in full personal protective equipment (PPE) weighing more than 40 kg and in an environment with hot air particles, which leads to a very high level of physical and psychological stress (Kales et al., 2003), resulting in an increase in the adrenaline hormone, blood pressure, heart rate and body temperature. The metabolic demands of firefighters, expressed as relative oxygen consumption (Vo_2max in ml•kg−1•min-1), range between 16 and 55 ml•kg−1•min-1 (Phillips et al., 2017; Sothmann et al. al., 1990). A high level of muscular strength and endurance is required for optimal performance (Lindberg, 2014) when performing firefighting and rescue with heavy equipment, and based on previous studies of physical exertion in firefighting, maximum heart rate reaches 84–100%, and oxygen consumption 63–97% of maximum values (Williams-Bell et al., 2009). Moreover, it is accompanied by anaerobic metabolism and a higher concentration of lactic acid in values of 6–13 mmol/L, which temporarily accumulates during high-intensity physical activities (Von Heimburg et al., 2006).

According to the current data (01.01.2023-01.10.2023) Belgrade has had 4076 interventions of which 2727 were fires, 485 technical interventions and 864 other interventions, Vojvodina 5963 of which 4275 were fires, 771 technical interventions and 917 other interventions, Western Serbia 6298 of which 3967 fires, 848 technical interventions and 1483 other interventions and Eastern Serbia 6017 interventions of which 4148 fires, 459 technical interventions and 1410 other interventions.

The aim of this study is to determine the differences in the professional physical preparation of firefighters from different regions of the Republic of Serbia. It is hypothesized that there are significant differences in the professional working physical preparation of firefighters from different regions of the Republic of Serbia, that is, between individual tests: Beep test (BP), Modified Step test (MS), Fireman Polygon test (FP), Fireman Equipment Carry test (FEC) and Casualty Drag Test (CD).

METHODS

Non-experimental research was conducted using field testing using modified tests. The study was carried out in accordance with the postulates of the Declaration of Helsinki (Christie, 2000) and with the approval of the Ethics Committee of the Faculty of Sports and Physical Education, University of Belgrade (ethics committee permit number 484-2). Similarly, validated new tests for the assessment of professional working physical preparation were applied (Samardžić et al., 2023).

Subjects

In this study 101 adult, healthy and physically active subjects, male professional firefighters (age = 26.42 ± 3.60 years, body height = 183.23 ± 5.83 cm, body mass = 83.11 ± 8.36 kg, body mass index - BMI = 24.72 ± 2.28 kg/m^2) were involved.

Procedure

The following tests were used to examine professional work physical preparation:

Bip test

Subjects in sports clothes run between two lines at a distance of 20 m according to the pace dictated by a sound signal (application: BT Lite). At the first sound signal, the subjects started from the high start position and ran 20 m (to the marking line). The running pace is increased by shortening the time interval between the sound signals. The test ended when the subjects late twice to run to the marking line before the emitted beep signal or when they gave up on their own.

Modified Step test

Cardiovascular ability assessment test for firefighters, which required equipment: stopwatch, mobile application "Metronome Pro", bench (bench height 40 cm). The test was performed for 60 seconds in complete personal protective equipment (PPE) with a oxygen bottle. The subject listened to the sound from the mobile phone (through the speaker) and picked up a 4/4 beat/60 BPM (right-left-right-left). Heart rate was measured 15 seconds after the test. After that, the pulse value after the test and the life years were entered into the table for calculating the VO_2max step test (trainermetrics application).

Fireman Polygon Test

This is a test/polygon of dexterity, agility, coordination and power of the whole body, 85 m long. The firefighter crawled on his knees for 10 m, then ran into a 12 kg tractor tire, picked up a 5 kg mallet and punched 10 reps, ran into an 8 kg truck tire, flipped it back and forth 6 reps, and continued to run to the block on top of which a load was placed in the form of a weight of 5 kg, he made movements with his upper extremities (arms) up and down 10 repetitions, left the chackle and overcame the 200 cm high taraba, which was placed as the last obstacle of the training ground. The test was performed in complete PPE without a oxygen bottle.

Equipment Carry Test

Subjects wore full PPE with a oxygen bottle and were tasked with walking a distance of 22 m placed from one cone to another wearing firefighting equipment: first, they took two 52 mm filled hoses and ran with them a length of 22 m to another cone where they left the hoses, and then return to the first cone. Next, they took two coiled 75 mm hoses by the handles and carried them to the second cone where they left the hoses, then returned to the first cone. After that, a suction hose and a submersible pump, carrying them to the second cone, where they left the hose and the pump, and then they returned to the first cone. After that, they would take two "S9" devices and carry them to the second cone where they left the two devices, then return to the first cone. At the end, they took two buckets (20 kg) of ecopure and carried them to the second cone. The stopwatch was stopped when the subjects reached the second cone.

Casualty Drag Test

Subjects with PPE The doll (weighing 75 kg) had to grab hold of the hands below the belt and drag it back 15 m on the ground, make a detour around the obstacle and drag it to the beginning for another 15 m. The length of pulling the doll was 30 m.

The testing was carried out on the sports field of the Belgrade Fire Brigade in complete PPE in the morning hours from 10:00 a.m. to 2:00 p.m. The pause between tests was 10 minutes.

Statistical analysis

Descriptive statistical analysis was performed, central tendency measures were calculated: mean m Confidence Interval (CI 95%), minimum (Min), Maximum (Max); measures of dispersion: standard deviation (SD) and coefficient of variation (cV%). Also, the Kolmogorov-Smirnov test (K-S test) was performed to determine the normal distribution of data, where $p < 0.05$ indicated statistical significance. Multivariant analysis of variance (MANOVA) and t-test for independent samples were performed to analyze differences. Effect size (ES - Cohen d) was calculated according to formula (Sullivan & Feinn, 2012):

$$d = (\text{Mean1} - \text{Mean2}) / SD \qquad (1)$$

Where is: Mean1 – mean value of test variable for one region; Mean2 – mean value of test variable for second region; SD – pooled standard deviation. Effect size (ES - Cohen d) was classificated as follows: < 0.2 (trivial), 0.2 – 0.49 (small), 0.5 – 0.79 (moderate) and > 0.8 (large) (Cohen, 1988). Statistical analysis was performed in IBM SPSS v27 (Armonk, NY: IBM Corp.).

RESULTS

Table 1. Descriptive statistics of the tests results of professional work physical preparation in relation to the regions of the Republic of Serbia

Region	Test	Mean ± SD	95% Confidence Interval		cV%	K-S test
			Lower Bound	Upper Bound		
Belgrade	Beep test (m)	1413.55 ± 365.06	1279.64	1547.45	25.83	0.200
	Modified Step test (ml/kg/min)	42.38 ± 3.63	41.05	43.71	8.56	0.028
	Fireman Polygon (s)	63.39 ± 7.56	60.62	66.17	11.92	0.050
	Fireman Equipment Carry (s)	73.44 ± 7.16	70.81	76.07	9.75	0.191
	Casualty Drag (s)	18.94 ± 3.21	17.77	20.12	16.94	0.200
East Serbia	Beep test (m)	1612.63 ± 511.35	1366.17	1859.09	31.71	0.069
	Modified Step test (ml/kg/min)	42.05 ± 4.27	39.99	44.10	10.15	0.200
	Polygon (s)	66.25 ± 5.03	63.83	68.68	7.60	0.200
	Fireman Equipment Carry (s)	81.04 +10.42	76.02	86.07	12.86	0.200
	Casualty Drag (s)	22.61 ± 5.37	20.02	25.20	23.75	0.200
West	Beep test (m)	1603.03 ± 413.85	1456.29	1749.78	25.82	0.086

Serbia	Modified Step test (ml/kg/min)	44.11 ± 4.00	42.69	45.53	9.08	0.093
	Fireman Polygon (s)	62.90 ± 6.96	60.43	65.37	11.07	0.200
	Fireman Equipment Carry (s)	80.05 ± 12.55	76.49	83.61	12.55	0.200
	Casualty Drag (s)	22.09 ± 25.59	20.09	24.09	25.59	0.200
Vojvodina	Beep test (m)	1644.44 ± 18.36	1494.32	1794.57	18.36	0.200
	Modified Step test (ml/kg/min)	42.90 ± 4.96	40.43	45.37	11.57	0.032
	Fireman Polygon (s)	67.87 ± 12.59	61.61	74.13	18.55	0.088
	Fireman Equipment Carry (s)	90.60 ± 6.92	87.16	94.04	7.64	0.200
	Casualty Drag (s)	26.37 ± 4.21	24.28	28.46	15.96	0.200

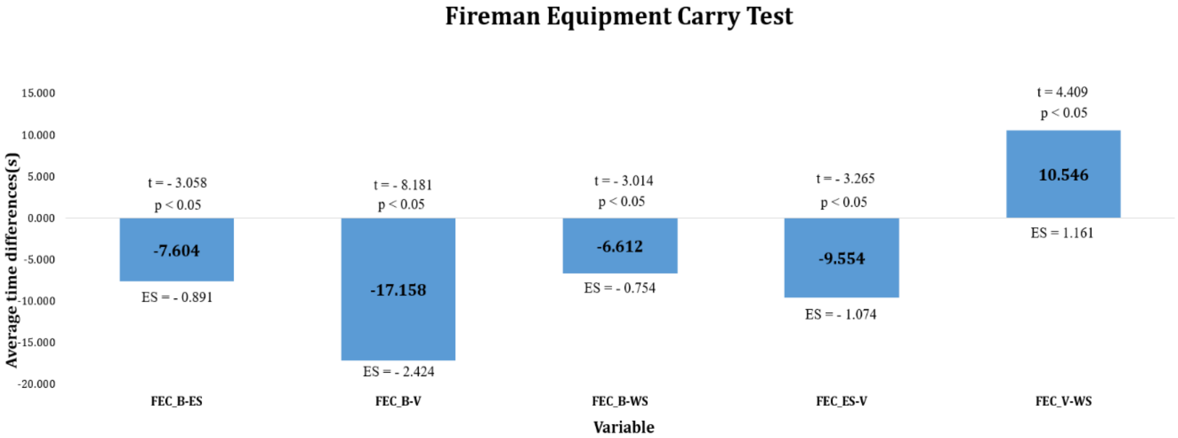
Mean ± SD - average value ± standard deviation, CI 95% - confidence interval, cV% - coefficient of variation, K-S - Kolmogorov-Smirnov test

Table 1 shows the descriptive indicators of the entire battery of tests for the assessment of professional work physical preparation for all 4 regions of the Republic of Serbia. Observing the values of the coefficient of variation (cV% < 30%), it can be argued that all participants are homogeneous group within all tests for all 4 regions. Only the subjects of the beep test for the Eastern Serbia region have approximately threshold values of 31.71%. Violated normality of data distribution ($p < 0.05$) is observed for the Modified Step test for Belgrade and Vojvodina.

Table 2. Results of Multivariant analysis of variance (MANOVA)

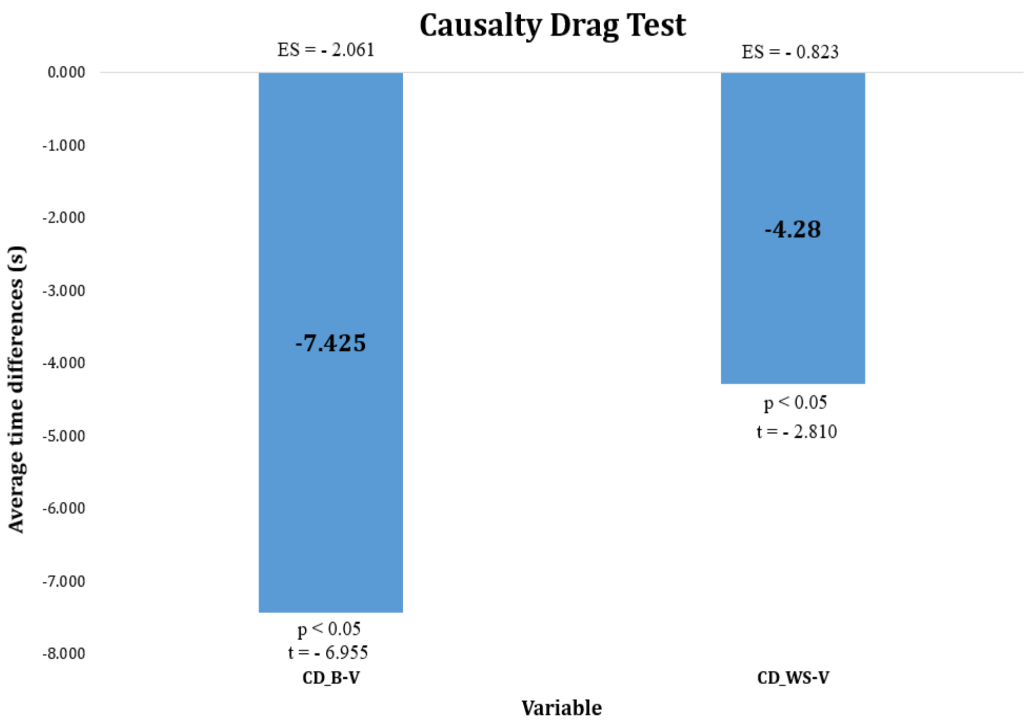
Test	Value	F	Error df	Sig.	Partial Eta Squared
Wilks' Lambda	0.577	3.773	257.133	**0.000**	0.167

In Table 2 Wilks' Lambda test shows significant values (Wilks' Lambda = 0.577, F = 3.773, p = 0.000) which indicates that significant differences ($p < 0.05$) exist on some level in tests battery for assessment of professional work physical preparation of firefighters in some of the regions.



Picture 1. Graphical presentation of results in Fireman Equipment Carry test between regions of the Republic of Serbia

Figure 1 shows that firefighters from the Belgrade region achieve a significantly better/shorter time (mean difference = -7.604; t = -3.058; ES = -0.891; $p < 0.05$) compared to the Eastern Serbia region. Firefighters from the Belgrade region achieve a significantly better/shorter time (mean difference = -17.158; t = -8.181; ES = -2.424; $p < 0.05$) compared to the Vojvodina region and a significantly better/shorter time (mean difference = -6.612; t = -3.014; ES = -0.754; $p < 0.05$) in relation to the region of Western Serbia. Firefighters from Eastern Serbia achieve significantly better/shorter time (mean difference = -9.554; t = -3.265; ES = -1.074; $p < 0.05$) compared to the region of Vojvodina, while firefighters from Vojvodina achieve significantly worse/longer time (mean difference = 10.546; t = 4.409; ES = 1.161; $p < 0.05$) in relation to the region of Western Serbia.



Picture 2. Graphical presentation of results in Causalty Drag test between regions of the Republic of Serbia

Figure 2 shows that firefighters from the Belgrade region achieve a significantly better/shorter time (mean difference = -7.425; t = -6.955; ES = -2.061; $p < 0.05$) compared to the Vojvodina region, while firefighters from Western Serbia also achieve significantly better/shorter time (mean difference = -4.28; t = -2.810; ES = -0.823; $p < 0.05$) compared to the region of Vojvodina.

DISCUSSION

The aim of this study was to determine the differences in the professional physical preparation of firefighters from different regions of the Republic of Serbia. Based on the descriptive values, it can be claimed that the firefighters from the region of Vojvodina are the best physically prepared in terms of cardio-respiratory abilities with a greater running distance (1644.44 m ± 301.88 m) compared to the regions of Eastern Serbia (1612.63 m ± 511.35 m), Western Serbia (1603.03 m ± 413.85 m) and Belgrade (1413.55 m ± 365.06 m) in Bip Test (m). Similarly, Western Serbia is better in the Modified Step test (ml/kg/min) with higher average values achieved (44.11 ml/kg/min ± 4.00 ml/kg/min) compared to other regions, where firefighters achieved lower average values VO_2max values (ml/kg/min). Firefighters from Eastern Serbia have the lowest VO_2max values (42.05 ml/kg/min ± 4.27 ml/kg/min) compared to firefighters from other regions.

In the Fireman Polygon test, the fastest were the firefighters from the region of Western Serbia with average values (62.90 s ± 6.96 s), which is shorter than the time achieved by firefighters from other regions of the Republic of Serbia. The slowest average time (67.87 s ± 12.59 s) was achieved by firefighters from the region of Vojvodina. According to the established values, it can be argued that firefighters from the Western Serbia region are the best physically prepared in terms of dexterity, agility, coordination and power of the whole body, while firefighters from Western Serbia are the least prepared. In the Equipment Carry (s) test, the fastest were the firefighters from the Belgrade region with the achieved average values (73.44 s ± 7.16 s), while the slowest were the firefighters from the Vojvodina region with the achieved average values (90.60 s ± 6.92 s). This indicates that the firefighters from the Belgrade region are the best physically prepared in terms of agility and power, while the firefighters from the Vojvodina region are the least agile and powerful. For the Casualty Drag Test (s), the fastest were firefighters from the Belgrade region with average values achieved (18.94 s ± 3.21 s), while the slowest were firefighters from the Vojvodina region with average values achieved (26.37 s ± 4.21 s). The above indicates that the firefighters from the Belgrade region are the best physically prepared in terms of strength and power, while the firefighters from the Vojvodina region are the least trained for the same abilities.

For Equipment Carry test (s) the biggest significant difference, a large effect size (ES = -2.424; $p < 0.05$) was determined between the regions of Belgrade and Vojvodina. Also, a large effect size (ES = -0.891; $p < 0.05$) was determined between the regions of Belgrade and Eastern Serbia. Then, a moderate effect size (ES = -0.754; $p < 0.05$) exists between the regions of Belgrade and Western Serbia. A large effect size (ES = -1.074; $p < 0.05$) was found for firefighters from the regions of Eastern Serbia and Vojvodina. A large effect size (ES = 1.161; $p < 0.05$) was found between firefighters from the regions of Vojvodina and Western Serbia. For the Casualty Drag Test (s), large effect size (ES = -2.061; $p < 0.05$) were found between firefighters from the Belgrade and Vojvodina regions, as well as a large effect size (ES = -0.823; $p < 0.05$) between firefighters from the West Serbia and and Vojvodina region. The stated differences and established effect sizes point primarily to the different training level for the abilities of strength, power and agility between firefighters from different regions.

CONCLUSION

By insight at the analysis of the differences in professional work physical preparation of firefighters from different regions of the Republic of Serbia, it was determined that significant differences ($p < 0.05$) exist in the Equipment Carry (s) and Casualty Drag (s) tests between regions, while no significant differences ($p > 0.05$) were found for other tests. Based on the results of the differences and determined effect sizes (ES from -0.754 to -2.424; $p < 0.05$) in the Fireman Equipment Carry test (s), it can be concluded that firefighters from the Belgrade region are more agile and more powerful than firefighters from the Eastern Serbia region, Vojvodina and Western Serbia. Firefighters from the region of Vojvodina are less agile and powerful compared to firefighters from the region of Western Serbia. Based on the established differences and effect sizes (ES from -0.823 to -2.061; $p < 0.05$) in the Casualty Drag test, it can be claimed that firefighters from the Belgrade region are stronger and more powerful than firefighters from the Vojvodina region, the same applies to firefighters from the West region of Serbia in relation to firefighters from the region of Vojvodina. It is recommended that the regions that achieved lower / poorer results in the Fireman Equipment Carry and Casualty Drag tests include training procedures through work plans and programs in order to improve professional work physical preparation.

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SPORTS INJURIES IN BASKETBALL: A SYSTEMATIC REVIEW

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ABSTRACT

Injuries are an integral part of sports, both at the professional and recreational levels. The most common injuries in basketball are ankle, finger and knee injuries, but there can also be painful spasms in the back and abdominal muscles. The subject of this research is studies focused on sports injuries in basketball. The aim of this review is to electronically search for and collect relevant literature from 2000 to 2016 in the following databases: PubMed, SCIndex, Google Scholar, sports science journals and relevant literature that could address the research question. The search was conducted using a combination of keywords related to sports injuries. Descriptive methods were applied to analyze the obtained data. A total of 10 studies were included in the systematic review. The analysis of the results showed a difference between males and females in injuries. In females, lower back injuries, knee injuries, upper extremity injuries, and anterior cruciate ligament injuries were more common in percentage terms. In males, meniscus injuries and jumper's knee were more common. Partially viewed, the highest number of injuries was present in the knee joint (38.01% - 29.32%) and the ankle joint (21.03% - 17.28%) with a higher percentage in males, and the most common type of injuries was joint sprains and ligament strains.The results also showed that injuries were most common in positions 2 and 3 (shooting guard and small forward), followed by positions 4 and 5 (centers), and least common in position 1 (point guard). The constitution of the basketball player's musculoskeletal system and the structure of the basketball game largely explain the presence of the highest number of injuries in the lower extremities. The modernization of tools for assessing the physical status and fitness of basketball players contributes to a decrease in the number of injuries from year to year.

Keywords: Sports injuries, basketball, knee, ankle.

INTRODUCTION

Characteristics shared by all sports, including basketball, are: predominance of speed-strength abilities, highly developed and specific techniques (skills), advanced game tactics, domination of more or less complex spatial movements, a large number of non-stereotypical movements and atypical situations and, finally, cooperation among all team members (Karalejić and Jakovljević, 2008). Injuries are an integral part of sports, both professional and recreational. When we look at the number of sports injuries in the 1970s, we notice that this number has multiplied several times today. With the tendency of sports to run faster and jump higher, i.e. to break the previous records, the need for the development of training technology arose. As training technology advanced and placed increasingly greater demands on athletes, the risk of injuries also increased. Younger age groups are also facing greater demands, and they are expected to achieve top results. Evidence of this is that today's juniors achieve results that senior athletes achieved 40 years ago. Basketball is a popular and mass sport, classified in the general division of sports as an "acyclic" sport or a team sport. It is a team sport that involves direct "combat" between two groups of people or two teams. The active playing time is 40 minutes (4 quarters of 10 minutes each). The course of the game involves short, high-intensity (maximal and submaximal) activities alternating continuously with periods of active or passive rest (breaks in the game). It takes place within a specific space and time frame (Karalejić and Jakovljević, 2008). Basketball is a very fast and demanding game with many jumps and frequent rapid changes of direction, exposing the athlete's body to significant physical exertion which can lead to injuries in the case of physical unpreparedness. The most common injuries in basketball are ankle, finger and knee injuries, but painful spasms in the back and abdominal musculature can also occur frequently (C.Rakić, 1979). This research focuses on studies published from 2000 to 2016, with a focus on sports injuries in basketball. The aim of this review was to gather relevant literature on sports injuries in basketball.

METHODS

The electronic search of research papers was conducted in the following databases: PubMed, SCIndex, Google Scholar, journals in the field of sports sciences, as well as relevant literature that could address the research problem. Papers published in SCI-listed journals from 2000 to 2016 were searched. The search was conducted using a combination of keywords related to sports injuries. Descriptive methods were applied to analyze the obtained data. The systematic review of the papers was presented according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher, Liberati, Tetzlaff & Altman, 2009).

Inclusion Criteria:

- Controlled randomized and non-randomized studies were reviewed and included in further analysis, while uncontrolled studies were excluded.
- Papers published in English and Serbian languages were included in the study.
- Study subjects: basketball players.
- Type of intervention: studies related to basketball sports injuries were included.
- Type of the obtained results: the primary obtained result for the systematic review was sports injuries in basketball.
- Exclusion Criteria:

Study type:

- Studies in which subjects engaged in different sports.
- Studies written in languages other than English and Serbian.
- Duplicates

RESULTS

By reviewing databases, 56 potential papers were identified and an additional 10 were identified based on references. After removing duplicates and reviewing titles and abstracts, 50 papers remained. After reviewing the full texts based on the inclusion criteria, 10 papers were included. (Figure 1).

The total number of subjects included in this study was 125,178, with 90,665 male subjects, 30,746 female subjects, and 3,767 subjects of both genders who were active athletes. Three studies included active athletes of both genders (Sallis, R. E., Jones, K., Sunshine, S., Smith, G., Simon, L. 2001; Vanderlei, F.M., Bastos, F.N., Lemes, I.R., Vanderlei, L.C.M., Júnior, J.N., Pastre, C.M. 2013; Owoeye, O.B.A., Akodu, A.K., Oladokun, B.M., Akinbo, S.R.A. 2012). One study included amateur subjects of both genders (Stergioulas, A., Tripolitsioti, A., Kostopoulos, N., Gavriilidis, A., Sotiropoulos, D., Baltopoulos, P. 2007). One study included basketball players of both genders (Zedde, P., Mela, F., Prete, F., Masia, F., Manunta, A.F. 2014). Two studies included professional basketball players of both genders (Riva, D., Bianchi, R., Rocca, F., Mamo, C. 2016; Walters, S. L. 2003). Three studies included basketball players of all levels and ages, both genders (Ito, E., Iwamoto, J., Azuma, K., Matsumoto, H. 2015; Randazzo, C., Nelson, N.G., McKenzie, L.B. 2010; Leppanen, M., Pasanen, K., Kujala, U.M., Parkkari, J. 2015).

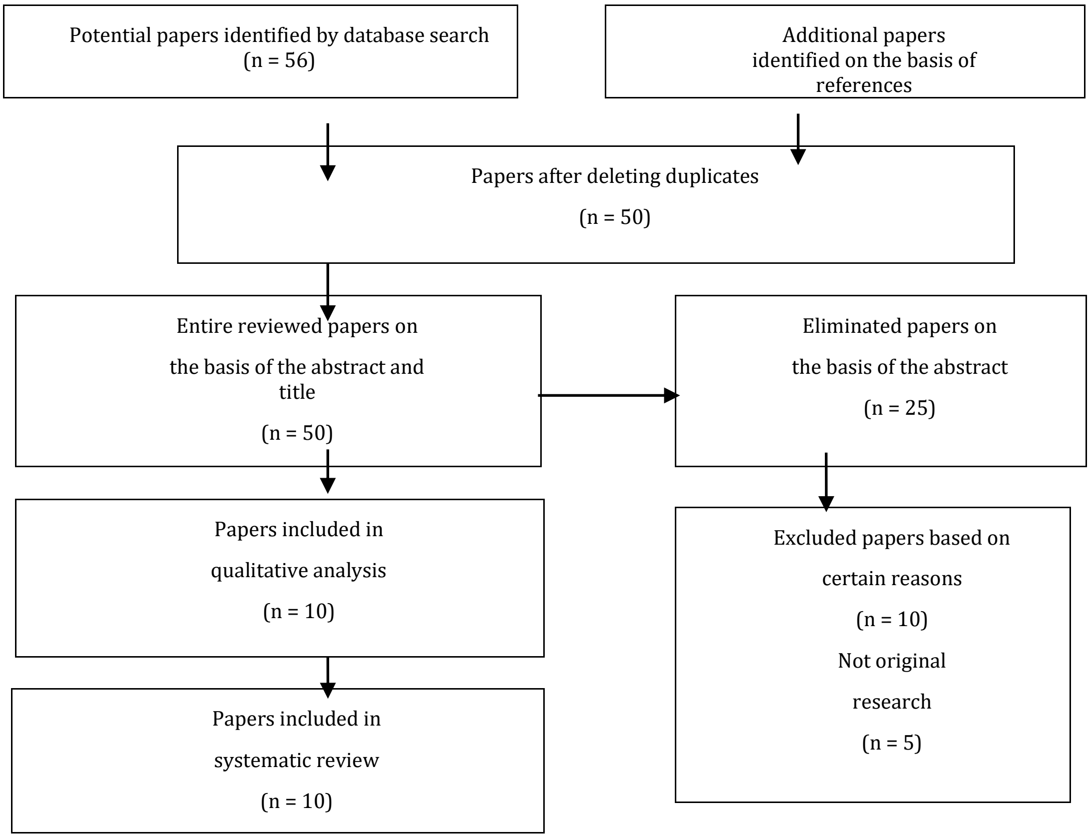

Figure 1. Presentation of the process of collecting adequate papers based on pre-defined criteria.

Table 1. Systematic overview and characteristics of included research.

Author (year)	Number of subjects	Type of injury		Results
		Male	Female	
Stergioulas et al. (2007)	M-153 F-136 amateurs	Ankle 31.8% Knee 13.7% Back 5.5% Fingers 7.3% Wrist 5.5% Shoulders 6.3% Thigh 5.5% Leg 5.4% Head 3.7% Chest 3.6% Pelvis 2.7%	24,5% 15,1% 14% 7% 5,8% 6,6% 5,8% 5% 3,5% 4,7% 2,3%	The most common injuries: sprains M- 41.9% F- 43%
Zedde et al. (2014)	Basketball players	meniscus		Different methods of restoring the meniscus
Riva et al. (2016)	M-55 Professional basketball players	Knee, ankle, back		By improving proprioceptive control, reducing injuries
	n-1219 M-640	M-729 F-800		Student t-test M F

Ito et al. (2015)	F-579 Basketball players of all ranks and ages	Knee, foot, ankle, back, upper limb injuries	Knee 41.7% Foot and ankle 24.8% Back 11.8% Upper extremities 9.7%	50,4% 23,8% 11,4% 5,1%
Sallis et al. (2001)	n- 3767 athletes in a period of 15 years	Wrist, hand, neck, face, foot, wrist, hip, knee, lower leg, shoulder, thigh	M Wrist 38.01% Hand 2.58% Neck 8.49% Face 14.76% Foot 4.06% Wrist 12.18% Hip 6.64% Knee 21.03% Calf 5.17% Shoulder 3.69% Thigh 8.49%	F 29,32% 5,76% 3,66% 7,86% 7,33% 9,95% 5,76% 17,28% 3,14% 5,24% 10,99%
Walters (2003)	F-813 WNBA	Knee, ankle, foot, back, fingers, shoulders, face, neck	A long-term study showed that half of the injuries are knee and ankle injuries	
Randazzo et al. (2010)	M- 89,603 F- 29,080 From 5 to19 years old Basketball players with reported injuries in the period from 1997-2007	Head, upper extremities, lower extremities, torso	Head - 16.4% Upper extremities - 37.2% Lower extremities - 42% Carcass - 4.1%	
Owoeye et al. (2012)	M-72 F-76 From 15 to 18 years old	A total of 32 injuries: M-17 and F-15 Knee M-7; F-6 Ankle joint M-4; F-3	Out of 100 participating basketball players, an average of 22.7% injuries, which is equivalent to 1% injuries per match	
Vanderlei et al. (2013)	M-142 F-62 Adolescents from13 to 16 years old	In relation to player positions per season: Center (72); guard (103); playmaker (29)	Backs, centers and playmakers have the most injuries Age, height, weight and experience are risk factors	
Leppanen Et al. (2015)	M-101 F-106 From 13 to 18 years old	Lower extremities 66%	97 respondents had injuries, which means that 0.47% of basketball players have injuries annually	

DISCUSSION

Injuries by Gender

By reviewing previous studies we have found differences in injuries between males and females (Stergioulas et al. 2007; Ito et al. 2015; Sallisa et al. 2001). The results showed disparities in lower back injuries, with females having a higher prevalence, while males were more susceptible to serious injuries. However, knee and ankle injuries were statistically the most common among both genders (Stergioulas et al. 2007). Percentage-wise, the largest gender differences were observed in knee injuries, with females leading at 50.4% compared to 41.7% in males. Injuries to the ankle and lower back did not show significant gender differences, but upper extremity injuries had a notable difference of 9.7% compared to 5.1% in favor of the male population. Knee injuries were mostly dominated by anterior cruciate ligament (ACL) injuries, with 30.3% in males and 48.7% in females. They were followed by meniscal injuries with 13.2% in males and 9.6% in females, and jumper's knee with 14.8% in males and 7.2% in females (Ito et al. 2015). Partially, among the one hundred examined basketball players of both genders, the highest incidence of injuries was observed in the knee joint (38.01% - 29.32%) and the ankle joint (21.03% - 17.28%), with a higher percentage in males (Sallisa et al. 2001).

Injuries by Location

Based on a retrospective analysis of data from the national electronic injury surveillance system in the United States from 1997 to 2007, it is estimated that 4,128,852 basketball-related injuries were treated in emergency departments. The most common injuries were ligament sprains and joint sprains of the lower extremities, especially the ankle joint, particularly in older children (15-19 years). Younger children (5-10 years) more frequently sustained upper extremity injuries. Randazzo et al. (2010) concluded that an annual average of 375,000 injuries, which is decreasing year by year, is not alarming, but efforts should be made to further reduce the injury rate. Research results show that out of 207 basketball players in one year, 97 injuries were reported, with the majority being lower extremity injuries (66%), and knee injuries (45%) being the most common (Leppanen et al. 2015). The most common cause of injuries was the jump-landing motion, accounting for 28.1% of injuries. The majority of injuries occurred in the offensive phase, and cryotherapy was the most commonly used treatment modality (Owoeye et al. 2012).

Injuries by Player Position

The study has shown the frequency of injuries depending on the player's position. The results revealed that injuries were the most common in positions 2 and 3 (guard and forward), followed by positions 4 and 5 (centers), and least frequent in position 1 (point guard). Additionally, individual and training characteristics may be associated with risk factors for positions 2, 3, 4, and 5, while body weight is a risk factor for players in all positions (Vanerlei et al. 2013).

After two years of working on proprioceptive and postural control of players, the absences from games and training due to knee and ankle injuries were reduced by as much as 70.2%, while in the second they decreased by 72.3% compared to initial measurements. The percentage of absences due to lower back pain decreased by 60.7% after the first two-year cycle and by 87.3% after the second two-year cycle compared to initial measurements. A high level of improvement in perceptual stability of technical skills and movement control contributes to injury prevention efficiency, not only in basketball but also in other sports (Riva et al. 2016). It has been proven that more injuries occur in the latter part of the game (Walters 2003).

CONCLUSION

Based on the analyzed research and their results, it can be concluded that sports injuries are an integral part of every sport, including basketball as a sports game. The analysis of results showed that the most common injuries among basketball players are lower extremity injuries. Percentage-wise, knee and ankle injuries are the most common, with sprains being the most frequent type of injury. The constitution of the musculoskeletal system of basketball players and the structure of the basketball game largely explain the presence of the highest number of injuries in the lower extremities. The relatively tall stature, combined with diverse movements in a confined space at high speed and explosiveness, leads to the load of the two most commonly injured joints. A high risk factor for fractures of lower extremity bone structures is also present. The modernization of instruments for assessing the physical status and fitness of basketball players contributes to a year-on-year decrease in the number of injuries.

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THE INFLUENCE OF PHYSICAL TRAINING ON ATHLETIC PERFORMANCE AND INJURY PREVENTION IN YOUTH SPORTS

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ABSTRACT

This paper examines the substantial influence of physical training on athletic performance and injury prevention in youth sports. Recognizing the increasing popularity of youth sports and the corresponding rise in injury rates, the paper emphasizes the critical need for proper physical training to not only enhance performance but also mitigate injury risks. It begins by analyzing the role of physical training in youth athletic development, emphasizing aspects such as strength, flexibility, endurance, coordination, and balance. It further delves into the specific components of training regimes, including warm-ups, cool-downs, skill development, strength and conditioning programs, and rest periods, that are crucial for optimizing performance and preventing injuries. The paper also highlights the implications of overtraining and specialization at an early age, drawing attention to their potential for causing physical and psychological harm. Furthermore, it explores the positive long-term impacts of effective physical training, including lifelong fitness, reduced risk of chronic diseases, and the development of a healthy relationship with physical activity. The research concludes with recommendations for coaches, parents, and youth athletes on creating balanced, age-appropriate, and safe training programs.

Keywords: Physical Training, Injury Prevention, Youth Sports, Strength and Conditioning, Overtraining.

INTRODUCTION

Importance of Physical Training in Youth Sports

The importance of physical training in youth sports is indisputable. Firstly, it effectively enhances the physical qualities and athletic capabilities of young athletes. Essential attributes such as strong muscular strength, robust cardiorespiratory function, and quick accurate response abilities, which are indispensable in competitive sports, can be bolstered through systematic and targeted physical training[1]. Secondly, appropriate physical training can aid young athletes in the prevention of sports-related injuries. During their developmental stage, the bones, muscles, and ligaments of adolescents are growing and hence are more susceptible to injuries than adults. Scientific physical training not only amplifies the physical prowess of young athletes but also reduces their risk of injuries by improving body coordination, balance, and flexibility[2]. Additionally, physical training has a positive impact on the psychological development of adolescents. Participation in sports activities can boost their self-confidence, enhance teamwork skills, and foster a healthy competitive spirit. These are essential psychological attributes in their developmental journey[3]. Physical training plays a pivotal role in youth sports, not only improving athletic performance but also preventing injuries, and facilitating psychological development. In the practice of youth sports training, we need to continually explore the most suitable training methods for them, aiming to achieve optimal physical and mental development.

Rise in Youth Sports Participation and Injury Rates

In recent years, we've seen a marked rise in the participation of young individuals in sports activities, which is a testament to the increased awareness about the role of physical activities in maintaining a healthy lifestyle. However, this increased involvement has a flip side too[4]. As participation has gone up, so too have the rates of sports-related injuries among young athletes. Young athletes are at a particular risk due to their growing bodies. The bones, ligaments, and muscles of adolescents are still in the developmental stage, which makes them more susceptible to injuries[5]. These injuries, if not treated properly, can lead to long-term health issues, affecting not only their sporting careers but also their overall growth and development. Additionally, the intense competition and high pressure in youth sports have also contributed to the rising injury rates. Many young athletes, driven by the desire to excel, often push themselves beyond their limits, which can lead to overuse injuries. It is not uncommon to find young athletes training intensely without adequate rest and recovery, further increasing their risk of injuries. What makes this situation more worrisome is the fact that a lot of these injuries can be prevented with proper training, guidance, and awareness[6]. Hence, it becomes critical to ensure that as we promote youth sports participation, we also emphasize the importance of safety and injury prevention, and create an environment where young athletes can thrive, enjoy sports, and stay injury-free.

ROLE OF PHYSICAL TRAINING IN YOUTH ATHLETIC PERFORMANCE

Development of Strength

When discussing the development of strength in young athletes, it's crucial to understand that it's a complex process that requires carefully planned and structured physical training. The physical growth of adolescents is marked by an increase in muscle mass and bone density, both of which contribute to increased strength. However, the rate at which these changes occur can vary greatly among individuals, which makes personalized training programs an essential part of strength development. Initially, improvements in strength in young athletes are largely due to neural adaptations, as the body learns to use its existing muscle more efficiently[7]. Over time, as the body matures, there is an increase in muscle mass which directly contributes to enhanced strength. It is also worth mentioning that boys and girls have different strength development trajectories, due to the influence of sex hormones, which further underscores the importance of personalized training programs. Appropriate strength training can optimize these physiological changes, while also minimizing the risk of injuries. Resistance training, for instance, has been shown to be an effective way to increase strength in adolescents. It's crucial, however, that such training is supervised by professionals to ensure correct technique and safety. Moreover, strength training should not be pursued at the expense of other vital aspects of physical training, such as endurance, flexibility, and agility[8]. The goal is to achieve a balanced, all-around development that not only enhances performance but also safeguards against injuries and promotes overall health and well-being.

Enhancement of Flexibility

The enhancement of flexibility plays a significant role in the athletic development of young sports participants. Flexibility is key to performing a wide range of movements smoothly and safely. It also allows for more significant athletic performance and assists in preventing injuries that can arise from tight or unbalanced muscle groups. Developmental stages in youth bring about a host of physical changes, including a natural increase in flexibility. However, it's necessary to supplement this organic growth with a properly designed flexibility training regime, especially as the intensity of the sport activities increases[9]. Each individual may require a unique approach to flexibility training due to differences in their body types, sports, and individual needs. There are several methods available to improve flexibility, such as dynamic stretching, static stretching, and proprioceptive neuromuscular facilitation (PNF). Each method has its own benefits, but it's vital to apply them correctly and in the appropriate context. For instance, dynamic stretching is often used as part of the warm-up routine before sports activity, while static stretching and PNF are more suitable for cooling down post-activity. When incorporated correctly, flexibility training can significantly enhance the athletic performance of young athletes. By allowing for greater range of motion, it can improve techniques in various sports and can also contribute to better posture and alignment, which are fundamental in preventing injuries[10]. However, as with all forms of training, it is essential that flexibility exercises are supervised by trained professionals to ensure safety and effectiveness. Young athletes need to understand that overstretching or incorrect stretching techniques can lead to injuries. Therefore, a balanced approach to flexibility training, paired with strength, endurance, and agility training, is a critical component of a comprehensive training program for young athletes.

Building Endurance

Building endurance is a fundamental aspect of physical training in youth sports. Endurance, the ability to maintain physical and mental effort over prolonged periods, significantly influences athletic performance and durability. In young athletes, the development of endurance is intrinsically linked with maturation. As they grow, physiological changes, such as increases in heart size and blood volume, lead to improvements in the cardiorespiratory system's efficiency, ultimately enhancing endurance. However, to maximize this natural development, it's essential to incorporate structured endurance training. The methods of endurance training often vary based on the specific demands of the sport, but typically involve a mixture of long-duration, low-intensity exercises and shorter, high-intensity interval training (HIIT)[11]. Both of these methods help increase the body's aerobic capacity and strengthen the heart and lungs, thereby improving overall endurance. Importantly, endurance training for young athletes should always be carefully planned and monitored to avoid overtraining and injuries. Striking the right balance is critical – pushing the young athlete to improve, but not to the point of exhaustion or risk of injury. Moreover, building endurance should not overshadow the need for holistic athletic development. While endurance is key, it is equally important to train for strength, flexibility, and agility, as these components contribute to the overall athletic performance and injury prevention. We advocate for a well-rounded approach to physical training in youth sports that emphasizes endurance but also incorporates other essential facets of athletic development. This balanced approach not only aids in enhancing performance but also helps young athletes to enjoy their sports, which can encourage lifelong physical activity and overall well-being.

Improving Coordination

Improving coordination is a crucial component of physical training in youth sports. Coordination, the ability to perform complex movements smoothly and efficiently, is central to athletes' performance in virtually all sports disciplines. Young athletes are still developing their motor skills, and as such, their coordination abilities are continually evolving. The process of motor learning, where the nervous system learns to control muscles and joints to achieve a desired movement, is critical to coordination improvement. To facilitate this, training should include a variety of exercises that challenge the athletes' ability to coordinate their movements. Drills that encourage athletes to use different parts of the body simultaneously, or to quickly switch between different movement patterns, are particularly effective. For example, sport-specific drills that mimic the movements required in a particular sport, or multi-skill drills that engage different motor skills at the same time, can significantly improve coordination. It's also important to consider the role of cognitive development in coordination. The ability to quickly perceive and react to environmental cues is a vital aspect of coordination in many sports. Therefore, training should also involve cognitive tasks, such as decision-making drills or exercises that require quick reactions to changing circumstances. Importantly, as with all aspects of physical training, improving coordination must be done safely. Overloading young athletes with complex tasks before they're ready can lead to poor technique and potentially increase the risk of injuries. Therefore, coordination training should be progressive, gradually increasing in difficulty as the athlete's skills improve. While improving strength, flexibility, and endurance are essential components of athletic development, improving coordination is equally important. A well-rounded physical training program that addresses all these areas will best equip young athletes for optimal performance and injury prevention in their respective sports.

Achieving Balance

Achieving balance, both figuratively and literally, is a pivotal element in physical training within youth sports. Balance refers to the body's ability to maintain its center of gravity over its base of support, which is a fundamental skill in virtually every sport. It not only influences the athlete's ability to execute movements efficiently but also plays a crucial role in injury prevention. As young athletes grow and develop, their body dimensions change rapidly, which can temporarily affect their balance. Therefore, balance training should be an integral part of their physical training regimen. Exercises that challenge stability, like single-leg stands, beam walking, or using balance boards, can help improve both static and dynamic balance skills. However, achieving balance is not merely about improving physical stability. It also refers to maintaining a balanced approach to training. This involves ensuring a well-rounded development of the young athletes, focusing not just on one aspect such as strength, endurance, or flexibility, but on all of them in a balanced manner. A balanced training program also implies avoiding over-specialization in a single sport at a young age, which can lead to overuse injuries and burnout. Young athletes should be encouraged to participate in a variety of sports to develop a broad range of skills and prevent excessive strain on specific muscle groups. Furthermore, balance must be struck between training and rest. Adequate recovery time is essential for preventing injuries, promoting growth, and enhancing performance. Achieving balance, in all its forms, is critical for young athletes. A well-rounded, balanced approach to training not only maximizes performance but also promotes health, well-being, and a sustainable love for sports.

COMPONENTS OF EFFECTIVE PHYSICAL TRAINING REGIMES

Importance of Warm-ups and Cool-downs

The importance of warm-ups and cool-downs in youth sports cannot be overstated. These are crucial elements of any training or athletic performance that can greatly influence an athlete's output and also significantly affect the risk of injuries. Warm-ups serve multiple purposes in preparing the young athlete's body for the upcoming physical strain. They gradually raise the body temperature, increase heart rate, and enhance blood flow to the muscles. These physiological changes help to prepare the muscles for the increased demands of sports activities and reduce the risk of strains and other injuries. Warm-ups also provide a chance to mentally prepare and focus on the upcoming task. Similarly, cool-downs are equally essential. They allow the body to gradually return to its resting state after a vigorous workout or sports performance. Gradually reducing the intensity of physical activity helps prevent blood from pooling in the large muscles and facilitates the removal of metabolic waste products from the muscles. The stretching exercises often included in a cool-down routine can also help to relax the muscles and increase their flexibility, which can further aid in injury prevention. It's important to note that both warm-ups and cool-downs should be tailored to the individual's needs and the demands of the sport. The exercises involved should mimic the movements used in the sport and prepare the athlete's body for those specific demands.Both warm-ups and cool-downs are integral to youth sports, serving as bookends to any intense physical activity. They not only optimize performance but also play a vital role in reducing the risk of injuries, highlighting their importance in any comprehensive training program.

Skill Development

Skill development is a cornerstone of physical training in youth sports. Every sport requires a unique set of skills, and the mastery of these skills often determines an athlete's performance level and success in that sport. Developing these skills not only enhances athletic performance but also significantly reduces the risk of injuries. As young athletes grow and mature, their ability to learn and refine sports skills improves. This learning process involves both cognitive understanding of the skill and physical practice to master the movements. Effective skill development involves a combination of direct instruction, guided practice, and feedback from coaches or trainers. It's crucial to recognize that skill development is not a one-size-fits-all process. Each athlete may have different strengths, weaknesses, and learning styles, all of which should be considered when designing training programs. This personalized approach helps to ensure that each athlete can develop their skills to their maximum potential. Importantly, skill development must be carried out safely. Proper technique should be emphasized from the very beginning to reduce the risk of injuries. This is particularly important in sports where improper technique or movements can lead to serious injuries. Lastly, while skill development is crucial, it should not overshadow the importance of other aspects of physical training. Building strength, endurance, flexibility, and balance are equally important for young athletes. A comprehensive approach that includes all these elements, along with skill development, is the best way to enhance athletic performance and prevent injuries in youth sports.

Strength and Conditioning Programs

In the context of youth sports, strength and conditioning programs are vital for athletic performance and injury prevention. These programs aim to build physical strength, improve muscular endurance, increase speed and agility, enhance mobility and flexibility, and develop balance and coordination. Strength and conditioning programs can have profound impacts on young athletes' performance by improving their power output, speed, and overall physical resilience. These programs usually involve a mixture of resistance training, plyometric exercises, speed and agility drills, and flexibility routines. It's crucial to note that the training methods and intensity should be age-appropriate and sport-specific, taking into account the young athlete's developmental stage and physical abilities. While the performance-enhancing benefits of such programs are important, their role in injury prevention is equally crucial. A well-structured strength and conditioning program can enhance the musculoskeletal system's robustness, enabling it to withstand the stresses of athletic performance. For instance, strengthening the muscles around a joint can help stabilize the joint and reduce the risk of sprains or dislocations. However, it's critical that these programs are overseen by knowledgeable and experienced professionals. Incorrect training techniques or excessive training loads can lead to injuries, defeating the purpose of the program. Trainers need to ensure that the training load is appropriate for the athlete's current level of fitness and that the techniques used are correct to maximize safety and effectiveness. Strength and conditioning programs play a vital role in youth sports. These programs, when correctly implemented, can significantly improve athletic performance and reduce the risk of injuries, making them an essential part of any comprehensive youth sports training regimen.

Need for Adequate Rest and Recovery

The need for adequate rest and recovery is an often overlooked, yet critical element in youth sports training. Rest and recovery periods are when the body adapts to the stress of exercise, replenishes energy stores, and repairs tissues damaged during training or competition. These processes are crucial for the young athletes' growth, development, and overall health, as well as their athletic performance. Overtraining without sufficient recovery time can lead to a state of chronic fatigue, decreased performance, and increased risk of injuries. Therefore, training schedules should include regular rest days and lighter training periods to allow the body to recuperate. The amount and type of rest needed can vary greatly among individuals, and factors such as the intensity and volume of training, the athlete's age and fitness level, and the specific demands of their sport all need to be considered. Sleep is a key component of rest and recovery. It's during sleep that significant recovery and growth processes occur. Poor sleep can impede recovery, negatively affect performance, and even increase injury risk. Therefore, it's vital to educate young athletes and their parents about the importance of good sleep hygiene. Nutrition is another critical aspect of recovery. A balanced diet that provides adequate carbohydrates, protein, fats, and fluids can help replenish energy stores, repair muscle tissue, and rehydrate the body. While training is crucial for enhancing athletic performance, it's equally important to emphasize the need for adequate rest and recovery in youth sports. Achieving this balance is key to sustaining long-term athletic development and preventing injuries in young athletes.

RISKS OF OVERTRAINING AND EARLY SPECIALIZATION

Physical Consequences

When discussing physical training in youth sports, it's essential to address the potential physical consequences that could arise due to improper training practices. These consequences can range from short-term injuries to long-term health impacts that could potentially affect the overall development of young athletes. Short-term physical consequences often come in the form of sports-related injuries. These may include acute injuries, such as fractures or sprains, which occur suddenly during physical activity, or overuse injuries, like tendonitis or stress fractures, which develop over time due to repetitive strain on certain body parts. Both types of injuries can sideline young athletes for significant periods and may hinder their athletic progress. Long-term consequences can also be severe. Improper training during crucial developmental years can lead to issues like chronic joint problems, growth plate injuries, and an increased risk of osteoarthritis later in life. Furthermore, serious injuries during adolescence can lead to a decrease in physical activity levels, contributing to an increased risk of lifestyle-related diseases such as obesity and cardiovascular disease. Psychological consequences, such as burnout or a loss of enjoyment in sports, can also lead to a decline in physical activity, with long-term implications for health and well-being. These potential consequences underscore the importance of appropriate, well-supervised physical training for young athletes. By focusing on proper technique, appropriate load management, and injury prevention strategies, we can help young athletes reap the benefits of sports participation while minimizing the risks. After all, the goal of youth sports should not just be to excel in the short term, but to foster lifelong physical fitness and a love for sports.

Psychological Implications

Alongside the physical aspects of youth sports, it's important to consider the psychological implications associated with training and performance. Sports participation can greatly influence a young person's psychological well-being, with potential impacts ranging from fostering resilience and self-esteem to the risk of burnout and stress. On the positive side, sports can cultivate essential life skills, including teamwork, leadership, discipline, and goal setting. Additionally, overcoming challenges and improving performance can boost self-esteem and confidence. Moreover, the social interactions inherent in team sports can promote social skills and provide a sense of belonging. However, there can also be negative psychological implications if not managed properly. High levels of pressure and expectations, whether self-imposed or from parents and coaches, can lead to significant stress and anxiety. This pressure, combined with a high volume of training and competition, can result in sport burnout, characterized by exhaustion, decreased sports performance, and a reduced sense of accomplishment. Furthermore, young athletes who experience significant or recurrent injuries may face psychological challenges, such as fear of re-injury, frustration, or depression during their recovery periods. These potential psychological implications highlight the importance of a balanced, athlete-centered approach in youth sports. Coaches and parents should aim to foster a positive sports environment that encourages effort, enjoyment, and personal growth, rather than focusing solely on performance outcomes. Additionally, providing psychological support, such as teaching stress management skills and addressing concerns promptly, can help young athletes navigate the psychological challenges they may encounter in their sports journey.

LONG-TERM BENEFITS OF EFFECTIVE PHYSICAL TRAINING

Promotion of Lifelong Fitness

Promoting lifelong fitness is one of the fundamental objectives of youth sports and physical training. The habits and values developed during these formative years often persist into adulthood, making this period an ideal time to instill the importance of physical activity and a healthy lifestyle. Participation in youth sports provides an excellent platform to develop physical skills, learn about teamwork, and experience the joy of movement. It also offers opportunities to understand the connection between physical activity and well-being. Encouraging diverse athletic experiences and fostering enjoyment in sports can help to ensure that young athletes maintain an active lifestyle as they age, regardless of whether they continue in competitive sports. A balanced approach to training, focusing on skill development, injury prevention, and overall enjoyment, can further foster a lifelong commitment to fitness. Overemphasis on competition or specialization in a single sport at a young age can lead to burnout and increased risk of injuries, which may discourage continued participation in sports and physical activity. Additionally, it's crucial to integrate education on nutrition and rest as part of the training program. Understanding the role of balanced diet, adequate hydration, and sufficient sleep in performance and recovery can help establish healthy habits that extend beyond sports. While the immediate goal of youth sports might be to improve athletic performance, the long-term aim should always be to foster a lifelong love of physical activity. By prioritizing fun, skill development, and holistic well-being, we can use youth sports as a vehicle to instill the values of lifelong fitness.

Reduction in Chronic Disease Risk

Participation in youth sports and regular physical activity can significantly contribute to the reduction in chronic disease risk. With rising rates of chronic conditions such as heart disease, diabetes, and obesity in today's society, it's critical that we encourage healthy habits from an early age. Engaging in regular physical activity during youth can help regulate body weight, improve cardiovascular health, enhance insulin sensitivity, and strengthen the musculoskeletal system. These benefits collectively contribute to a reduced risk of chronic diseases later in life. Furthermore, the nutritional habits and lifestyle choices that often accompany participation in sports can further bolster these protective effects. However, it's crucial to note that the risk of chronic disease can also be influenced by overtraining or inadequate recovery in young athletes. These factors can lead to an increased risk of injuries, hormonal imbalances, and negative impacts on growth and development, which can have long-term health consequences. Therefore, while youth sports and physical training have the potential to reduce the risk of chronic disease, it's essential to ensure that these activities are carried out in a balanced and health-promoting manner. The goal should be to cultivate a lifelong love of physical activity and instill a deep understanding of the link between an active lifestyle, balanced nutrition, and chronic disease prevention. In this context, coaches, parents, and healthcare providers play a vital role. By promoting a balanced approach to training, advocating for rest and recovery, and providing education on healthy nutrition, we can help young athletes reap the long-term health benefits of participation in sports.

Development of a Healthy Relationship with Physical Activity

Developing a healthy relationship with physical activity is one of the most beneficial outcomes of engaging in youth sports. This relationship sets the stage for attitudes towards fitness, health, and wellness that can last a lifetime. A positive experience in youth sports can foster a love for physical activity. It offers opportunities to experience the joy of movement, to appreciate the abilities of one's body, and to understand the direct impact of exercise on well-being. This positive association can make physical activity a desirable, enjoyable part of life, rather than a chore or obligation. However, developing this healthy relationship requires a supportive and balanced approach to youth sports and physical training. Overemphasis on competition, winning, or performance can turn sports into a source of stress, potentially leading to burnout or even a dislike of physical activity. Therefore, coaches, parents, and trainers play a pivotal role in creating an environment that emphasizes enjoyment, personal growth, and skill development, over merely winning. In addition, education is a crucial part of this process. Young athletes should be taught about the benefits of regular physical activity, the importance of rest and recovery, and the role of nutrition in performance and health. Understanding these concepts can help them make informed decisions about their own physical activity habits as they grow older. Youth sports provide an invaluable opportunity to cultivate a healthy relationship with physical activity. With the right approach, we can use these experiences to encourage lifelong fitness, improve long-term health outcomes, and foster a positive mindset towards physical activity.

RECOMMENDATIONS FOR SAFE AND BALANCED PHYSICAL TRAINING

Guidelines for Coaches

Coaches play an essential role in youth sports, shaping not only the athletic performance of young athletes but also their attitudes towards physical activity, fitness, and health. As such, it's important to consider some guidelines that can help coaches create an environment that promotes both athletic development and overall well-being. First and foremost, coaches should prioritize safety. This includes ensuring proper technique in all exercises and movements, supervising training sessions to prevent accidents, and advocating for protective gear where necessary. It also involves promoting fair play and respect among athletes, both of which can reduce the risk of injuries. Moreover, coaches should understand the principles of growth and development and how these influence training and performance. As young athletes are still growing, they have specific needs and limitations that must be considered in their training programs. This involves taking a long-term approach to development, focusing on skill acquisition and gradual physical development rather than short-term performance goals. Another critical aspect is promoting a balanced approach to sports participation. This involves discouraging early specialization and encouraging young athletes to experience a variety of sports. This can lead to more rounded physical development, reduce the risk of overuse injuries, and prevent burnout. Rest and recovery should also be emphasized. Coaches need to ensure that training schedules include sufficient rest periods to allow for physical recovery and growth. They should also educate athletes about the importance of sleep and nutrition in recovery and performance. Coaches also play a vital role in fostering a positive psychological environment. They should promote a growth mindset, where effort, learning, and improvement are valued over winning. Mistakes should be seen as opportunities for learning rather than failures. Coaches should also be alert to signs of stress or burnout among their athletes and should be prepared to provide support or refer athletes to mental health professionals if needed. Additionally, coaches should strive to foster a love for physical activity that extends beyond structured sports. Encouraging activities like biking, hiking, or playing active games can help young athletes develop a lifestyle that is active, balanced, and enjoyable. Finally, coaches should maintain open communication with parents, other coaches, and healthcare providers. Sharing information about the athlete's progress, any concerns, and any injuries can help everyone involved support the young athlete effectively. As influential figures in the lives of young athletes, coaches bear significant responsibility. By adhering to these guidelines, they can help young athletes reach their athletic potential, foster a lifelong love for physical activity, and promote overall health and well-being.

Responsibilities of Parents

Parents play a significant role in their children's involvement in youth sports. They provide support, encouragement, and guidance, making them key contributors to their children's athletic development and overall well-being. Therefore, understanding their responsibilities in this regard is of utmost importance. First and foremost, parents should ensure their child's safety during sports participation. This involves providing appropriate protective equipment, ensuring safe transport to and from practices or games, and being aware of the conditions in which their child is practicing and competing. Parents should also educate themselves about the specific demands and risks associated with their child's sport. Understanding the physical demands can help parents monitor their child's training load, spot potential overuse injuries, and ensure their child gets adequate rest and recovery. This can also help them in communicating effectively with coaches and healthcare providers regarding their child's training and performance. One of the most important responsibilities of parents is to foster a positive sports experience for their children. This involves encouraging effort, perseverance, and sportsmanship, rather than focusing solely on winning or performance outcomes. Parents should also emphasize the importance of enjoyment in sports and support their children in trying various sports, which can contribute to more balanced physical development and reduce the risk of burnout. Parents also play a crucial role in facilitating healthy lifestyle habits. They can ensure their child gets adequate sleep, provide nutritious meals to support their child's training and recovery, and model an active lifestyle. Teaching children about the importance of good nutrition and sleep for performance and recovery can help them develop healthy habits that last a lifetime. Additionally, parents should be attuned to their child's mental well-being. Youth sports can be a source of stress for some children, and parents should be prepared to support their children in managing this stress. This may involve having open conversations about their child's feelings towards sports, providing reassurance, or seeking help from mental health professionals if needed. Parents have a significant influence on their children's sports experience. By understanding their responsibilities and acting as positive role models, they can help their children reap the benefits of sports participation, foster a lifelong love for physical activity, and promote their overall health and well-being.

Recommendations for Youth Athletes

As a youth athlete, there are several recommendations to consider for your sports participation to be rewarding, healthy, and safe. These recommendations are aimed at supporting your performance, promoting a healthy lifestyle, and preventing injuries. First, it's crucial to understand the importance of balanced training. Engaging in a variety of sports activities can enhance overall athletic development and reduce the risk of overuse injuries. Try not to specialize too early and enjoy different physical activities, which will contribute to your all-round fitness and skills. Second, pay close attention to your body. Learn to recognize signs of fatigue, stress, or injury. If something doesn't feel right, don't ignore it. Make sure to communicate any discomfort, pain, or concerns with your coach and parents. Third, do not underestimate the power of rest and recovery. It is just as important as training itself. Adequate sleep is crucial for your body's recovery, growth, and cognitive functioning. Try to establish a consistent sleep schedule that provides enough rest for your body. Nutrition is another critical aspect. A well-balanced diet can provide the necessary fuel for your training and aid recovery. Make sure you're consuming enough calories and nutrients to support your physical activity levels. Stay hydrated before, during, and after exercise. Another important recommendation is to prioritize skill development. This includes not only sport-specific skills but also basic motor skills like balance, agility, and coordination. Developing these skills can enhance your performance and reduce the risk of injury. Warm-up and cool-down routines should be an integral part of your training sessions and competitions. Warm-ups prepare your body for the activity ahead, while cool-downs help your body return to a resting state, aiding recovery and reducing the risk of injuries. Lastly, remember that sports should be enjoyable. While it's great to be competitive and strive for improvement, it's also important to have fun. Enjoy the process of learning, training, and competing. Foster positive relationships with your teammates and coaches, and use sports as a way to express yourself and enjoy your youth. By following these recommendations, you can make the most of your sports experience, improving your performance, staying healthy, and developing a lifelong love for physical activity.

CONCLUSION

Recap of Key Findings

Our exploration of physical training in youth sports has underscored several key points. We've affirmed that well-rounded physical training, focusing on strength, flexibility, endurance, coordination, and balance, can enhance athletic performance and mitigate injury risks. We've also highlighted the importance of adequate warm-ups, cool-downs, and skill development. Another crucial finding is that a balanced approach to youth sports, which includes encouraging diverse sports experiences, promoting rest and recovery, and ensuring a focus on enjoyment and personal growth, can foster lifelong fitness and reduce chronic disease risk. Furthermore, we've underlined the significant roles played by coaches, parents, and the young athletes themselves in creating a positive, safe, and effective sports experience.

Importance of Physical Training in Youth Sports

Physical training in youth sports is of paramount importance for multiple reasons. It equips young athletes with the necessary skills, strength, endurance, flexibility, coordination, and balance to perform well and safely in their sports. Besides enhancing athletic performance, structured physical training plays a crucial role in injury prevention. Furthermore, participation in sports from a young age fosters healthy habits, such as regular physical activity and proper nutrition, that can last a lifetime. These habits contribute significantly to the reduction in chronic disease risk and the promotion of lifelong fitness. In essence, physical training in youth sports lays a strong foundation for a healthier and more active life.

Future Research Directions

Looking ahead, there are several directions for future research in the realm of physical training in youth sports. Further studies could delve deeper into the specific elements of training that yield the greatest benefits in terms of performance enhancement and injury prevention. The long-term effects of various training approaches on chronic disease risk and lifelong fitness could also be explored. Additionally, research could investigate the psychological impacts of youth sports participation more extensively, examining ways to foster a healthy mindset towards sports and physical activity. Lastly, the development and assessment of interventions to educate coaches, parents, and athletes about best practices in youth sports training would be valuable. These research directions will continue to enrich our understanding and promote the positive impacts of physical training in youth sports.

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INVESTIGATION OF THE RELATIONSHIP BETWEEN NATURE AND MOOD OF INDIVIDUALS PARTICIPATING IN ECORECREATIVE ACTIVITIES

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ABSTRACT

Eco-recreational activities have gained importance as a free time activity where the physical and mental being interacts with nature. Mood is the emotional state of the individual and it has an impact on perception and interpretation of the world. In this context, the world of meaning created by the individual in his relationship with nature also affects his mood. The aim of the study was to examine the relationships between nature and moods of individuals participating in eco-recreational activities. The study group of the research comprised 314 people aged between 18-45, selected by random sampling method. In addition to the personal information form created by the researcher for data collection, "Relationship with Nature scale" developed by Terry et al. (1999; 2003) and adapted to Turkish by Soylu et al., (2022) and "Being Related to Nature" scale developed by Nisbet, Zelenski and Murphy (2009) to determine the level of adults' relationship with nature was used. The hypotheses created within the scope of the research were tested using t-test for independent samples, ANOVA and Pearson Correlation analysis methods. As a result of the findings, no significance was determined between the participants' relationship with nature and their mood according to the gender variable ($p>0.05$). On the other hand, it was observed that the state of being in touch with nature and the mood levels of individuals participating in eco-recreational activities were positively related ($p <0.05$). It is thought that eco-recreational activities have many positive effects on individuals. Especially in the age of technology and speed, exercise/physical activities performed in touch with nature in order to engage in mental activity on an event or phenomenon, make strategic decisions and relax the body are considered important for the good mood of individuals.

Keywords: Ecorecreation, Activity, Nature and Mood

INTRODUCTION

In today's society, population density has gradually increased in cities and accordingly, the number of high and close buildings has increased. On the other hand, the capitalist system has opened the areas where people can see green and blue for different aims and the fact that people live in harmony with nature in the evolutionary process has been ignored.

It would not be incomplete or wrong to say that the reason underlying the rapidly increasing global problems is that individuals change and transform the ecosystem in line with their own interests. In particular, the destruction of the natural environment has led to a decrease in green areas. Individuals have almost forgotten that nature is good for the soul, in other words, they have almost forgotten their relationality with nature. Individuals living on the axis of the concept of "punctuality" in the business life of the capitalist system have been condemned to a stressful life on the one hand and alienated from nature on the other. In this vortex, he/she has become unwittingly unable to realise how much even a walk in the park takes him/her away from the urban crowd.

Basically, many thinkers in history have conducted studies to understand the relationship between nature and human beings. Many studies have been expressed with different conceptualisations in different disciplines regarding the relationship between the psychology of individuals and the environment. Clinical psychologist Ralph Metzher emphasised the term ecopsychology, which was first used by Robert Greenway in 1963. Furthermore, Theodore Roszak, inspired by Greenway's teachings, coined the term ecopsychology in 1992 in his book The Voice of the Earth. Arguing that ecopsychology is a synthesis of ecology and psychology, Roszak tried to understand humanity's relationship with nature.

Why has this relationship (nature-human), which has its evolutionary roots in the distant past, been forgotten today? It is actually the same species that both asks and answers this question: Human beings. It is the human race that changes, transforms and destroys nature with an infinite desire in line with its own needs. Even so much so that when it is assumed that the human species is not in nature, nature has the ability to renew itself in a short time.

Considering all these; individuals have turned to green behaviour, which is not harmful to the environment and described as "*green*", to reduce the negative effects on nature. In fact, the understanding of green behaviour, in which people consider environmental sensitivities in the use of natural resources, is seen as a result of sustainability (Mont and Plepys, 2008; Ritter et al., 2015).

The concept of ecology is defined as "*the branch of science that examines the matter and energy cycles that ensure the continuation of life of human and other living things and their relationships and interactions in their living and non-living environments"* (Karaküçük ve Akgül, 2016). The concept of ecorecreation is the realisation of all activities, policies and practices of leisure called recreation with the sensitivity of "environmental protection" and "sustainability" (Karaküçük and Akgül, 2016; Kement, 2019). These activities, which are performed using a specific environment, are generally considered as activities in nature. Sportive activities in nature are classified as "nature sports", "outdoor recreation", "adventure sports", "adventure recreation" with different names depending on the risk factors they contain and the supporting elements used (Koçak and Balcı, 2010).

According to this information, in our research; Based on the idea of emphasising the importance of eco-creative activities, which was one of the popular fields of study, it was aimed to investigate the relationship between the state of being related to nature through these activities and the mood of the individual.

METHODS

Research Model and Participants

The research was conducted on the basis of quantitative research model. In the universe consisting of a large number of elements, the survey model, in which a survey is conducted on the whole universe or a sample to be taken from it to make a general judgement about the universe, has been applied (Karasar, 2012). The study group of the research included a total of 314 people aged between 18-45 years ($Mean_{age}$= 28.17±4.92) selected by convenience sampling method.

Data Collection Tools

Nature Relatedness (NR-6) Scale: The scale was created by Nisbet and Zelenski (2013) by taking 6 items from the original 21-item Nature Relatedness Scale. The scale was a 5-point Likert scale ("1" Strongly Agree, "2" Agree, "3" Undecided, "4" Disagree, "5" Strongly Disagree) and was a self-assessment tool.

Brunel Mood Scale: The adolescent and adult form of the Brunel Mood Scale, which examined the athletes' answers to the question "how do you feel right now", was developed by Terry et al. (1999; 2003) and adapted into Turkish by Soylu et al. (2022) and consisted of 24 statements and 6 sub-dimensions (anger, confusion, depression, fatigue, tension and vitality).

Data Collection

The use of the data collection tools used in the study was conducted through the form prepared in the web environment. The study was performed after obtaining the necessary scale usage permissions.

Statistical analysis

The data obtained from the research were analysed using the SPSS 23 statistical package programme. Whether the data met the prerequisites of parametric tests was decided by examining the skewness and kurtosis (normal distribution of data) values, Kolmogorov-Smirnov and Levene (equality of variances) test results (Büyüköztürk et al., 2017). Descriptive statistics, t-test, ANOVA, and Pearson correlation tests were used to analyse the data.

RESULTS

Table 1: T-Test Results Regarding the Total Scores Obtained from the Nature Relatedness Scale According to Gender Variable

Variables	Gender	N	X̄±Sd	t	P
Nature Relatedness Scale Total Score	Female	166	20.48±3.69	-.029	.977
	Male	148	20.50±3.62		

According to the results of the analyses for the total scores of the Nature Relatedness Scale, it was not observed that there was no significant difference ($p>0.05$).

Table 2: ANOVA Analysis Results Regarding the Nature Relatedness Scale Total Score According to the Question of "Who Do You Participate in Ecorecreative Activities with?"

	Variables	N	X	Sd	F	P	Tukey
Who Do You Participate in Ecorecreative Activities with	[a]Alone	120	38.2	3.55	2.47	.046	**a-c**
	[b]Family	116	36.9	4.37			**b-c**
	[c]Friends	78	24.8	2.34			
	Total	**314**					

$p<0.05$

According to the results of the ANOVA analysis, statistical significance was observed between the individuals who participated in the activity alone and the individuals who participated with their friends and between the individuals who participated in the activity with their family and the individuals who participated with their friends ($p<0.05$). On the other hand, no significance was found between individuals who participated alone and individuals who participated with their families ($p>0.05$).

According to the results of the correlation analysis conducted to test the relationship between the total scores of the scale of being in contact with nature and the sub-dimensions of the Brunel Mood Scale; A positive and moderately statistically significant relationship was observed between the nature relatedness scale and anger sub-dimension (r=-0,421; p<0,01), confusion sub-dimension (r=-0,462; p<0,01), depression sub-dimension (r=-0,405; p<0,01), fatigue sub-dimension (r=-0,455; p<0,01), tension sub-dimension (r=-0,506; p<0,01) and finally vitality sub-dimension (r=-0,502; p<0,01).

Table 3: Correlation Table for the Relationship Between the Nature Relatedness Scale Total Scores and Brunel Mood Scale Subscales

Variables		Nature Relatedness Scale Total Scores	Anger	Confusion	Depression	Fatigue	Tension	Vitality
Nature Relatedness Scale Total Scores	**R**	1						
	P							
	N	314						
Anger	**R**	.421**	1					
	P	**.000**						
	N	314	314					
Confusion	**R**	.462**	.878**	1				
	P	**.000**	**.000**					
	N	314	314	314				
Depression	**R**	.405**	.868**	.864**	1			
	P	**.000**	**.000**	**.000**				
	N	314	314	314	314			
Fatigue	**R**	.455**	.866**	.842**	.850**	1		
	P	**.000**	**.000**	**.000**	**.000**			
	N	314	314	314	314	314		
Tension	**R**	.506**	.867**	.842**	.804**	.848**	1	
	P	**.000**	**.000**	**.000**	**.000**	**.000**		
	N	314	314	314	314	314	314	
Vitality	**R**	.502**	.885**	.896**	.869**	.848**	.862**	1
	P	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	
	N	314	314	314	314	314	314	314

*p<0.01***

DISCUSSION

According to the results of this study, a significant relationship was found between nature relatedness and the mood of individuals. In the study conducted by Meraki, (2019), while a good increase was observed in the psychological status of individuals who performed activities in relation to nature, it was found that the general quality of life, spiritual domain, social domain, environmental-cultural domain, which were sub-dimensions of quality of life, were higher in the mean of individuals who practised nature sports. This result was significant for individuals to feel psychologically well in the activities performed in nature.

On the other hand, in a study conducted by Ardahan and Lapa (2011) on trekkers and bicycle users, it was revealed that individuals obtain some benefits by participating in open space activities. These benefits include taking responsibility for oneself and others, feeling happy, socialising, strong, relaxed, learning new things, feeling refreshed and healthy, positively affecting confidence in oneself and others, positively affecting personality and body development, increasing imagination and environmental sensitivity.

CONCLUSION

As a result, eco-creative activities that individuals spare time for themselves in their daily lives allow their lives to be related to nature. Thus, it can be said that it enables positive changes in the mood of individuals. In this context, the relationship of the individual with nature has a positive meaning, in other words; it is known that the calm and peaceful atmosphere of nature is interpreted as an important healing power for human beings. In this context, it is important for individuals to participate in activities where they can spend time in nature to get away from the daily routine and relax.

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ASSESSING STANDING LONG JUMP DISTANCE: ACCURACY OF KINOVEA-BASED VIDEO ANALYSIS

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ABSTRACT

The assessment of the Standing Long Jump provides valuable insights into an individual's lower body explosive strength. Compared to traditional methods of measuring (i.e., measuring tape), Kinovea-based video analysis allows frame-by-frame analysis after testing completion, and its user-friendly interface ensures that no extensive experience is necessary to utilize the tool effectively. This study aimed to assess intra-rater and inter-rater reliability of Kinovea for measuring Standing Long Jump distance, as well as concurrent validity compared to the traditional measuring method (i.e., tape measurement). The study included 10 healthy male football players who completed three repetitions of Standing Long Jump with a rest period of around 1 minute between each trial. Subsequently, Kinovea software (version 0.9.5) was utilized to measure the distance for each jump by 2 raters separately. The results indicated excellent intra-rater reliability (SEM= 0.788-1.176 cm, CV%= 0.34-0.5, ICC= 0.997-0.999, p < 0.05) and no significant differences within the repeated measurements for rater 1 (F= 0.447-2.93, p > 0.05) and rater 2 (F= 2.04-0.585, p > 0.05) across all jump trials. The Two-way RM ANOVA indicated no significant main effects or interactions for raters and measurement sessions, indicating excellent inter-rater reliability and concurrent validity compared to the tape measurements. The findings of this study confirm that Kinovea-based video analysis can be used as a reliable and valid tool for measuring Standing Long Jump distance and implies its broader application in measuring other types of horizontal jumps frequently assessed in sports and rehabilitation.

Keywords: video analysis, standing long jump, lower body strength, explosive strength, sports performance

INTRODUCTION

The assessment of lower body explosive strength is important in optimizing sports performance in any sport, as well as minimizing the risk of lower body injuries, which predominantly occur in high-impact sports such as football (Bisciotti et al., 2016), handball (Olsen et al., 2004) and basketball (Emerson, 1993). The Standing Long Jump (SLJ) is commonly used in the assessment of lower body explosive strength (Castro-Piñero et al., 2010). It involves the subject standing behind the starting line with both feet close together while initiating a powerful push-off to jump forward as far as they are able to. The jump distance is measured from the start line to the spot where the back of the heel made the nearest contact with the floor. This procedure is usually repeated thrice, and all the scores are measured in centimeters (Castro- Piñero et al., 2009).

The traditional method of measuring Standing Long Jump distance in field settings involves using a standard measuring tape (Castro-Piñero et al., 2009). The limitations of this method arise from its inherently subjective and time-consuming nature which often results in extended testing periods. Consequently, this may lead to athletes experiencing frustration or going into a cooldown period while awaiting their turn to execute the test which can potentially influence the final test results (Bourdon et al., 2017). Adversely, high-cost marker-based motion capture cameras which are considered the "golden standard" also face limitations in terms of cost-effectiveness, ease of use and accessibility on the field; therefore, they are not frequently used by sports or health professionals (Aleksic et al., 2023; Pueo et al., 2020).

In terms of practical and cost-effective alternatives, smartphone cameras coupled with video-analysis tools,such as Kinovea, offer a more accessible solution for field applications with minimal interference to the athletes (Pueo, 2016; Pueo et al., 2020; Balsalobre-Fernandez et al., 2014). Kinovea is a free and open-source video analysis tool which allows the frame-by-frame video analysis of distances, angles, coordinates, and other spatio-temporal parameters (Balsalobre-Fernandez, 2014). The advantage of Kinovea is that the videos can be analyzed after the testing is completed and its user-friendly interface ensures that no extensive experience is necessary to effectively utilize the tool (Balsalobre-Fernandez, 2014).

Previous studies have shown that Kinovea-based video analysis can be used as a reliable and valid tool formeasuring flight time and vertical jump height (Balsalobre-Fernandez et al. 2014; Caseiro-Filho, 2023; Pueo et al., 2020) as well as accurately measuring distances up to 5 meters from the object and at angles of 90°–45° (Kim et al., 2022). Another study suggested that Kinovea also provides an acceptable level of accuracy in angular and linear measurements obtained by digitizing the x- and y-axis coordinates (Puig-Divi et al., 2019).

However, to the best of our knowledge, no prior research has investigated the reliability and validity of Kinovea in specifically assessing the distance of the Standing Long Jump. Consequently, the aim of this study was threefold, and that is to assess: 1) intra-rater reliability (two experienced raters), 2) inter-rater reliability (two experienced raters), and 3) concurrent validity by comparing Standing Long Jump distance measurements in Kinovea to traditional measuring method (i.e., tape measurement). We hypothesize that the findings from this study will confirm that Kinovea is a reliable and valid tool for measuring the distance of the Standing Long Jump.

METHODS

Subjects

The study included 10 healthy male football players (Mean ± SD: Age= 23.3±2.9 years; Body height= 182.0±7.0 cm; Body mass= 78.8±9.7 kg). The study was conducted in accordance with The Declaration of Helsinki (2013) and participation was voluntary.

Procedure

All participants were instructed to execute three repetitions of SLJ with a rest period of around one minute between each trial to avoid the influence of fatigue. Prior to the testing execution, a standard form of warm-up was conducted, and participants were provided with standardized guidelines to perform the SLJ (Almuzaini et al., 2008). A designated starting line was marked on the floor along with a 5 m measuring tape securely attached to the floor and in line with the participant. The jump distance was recorded with precision to the nearest 1 cm, measuring from the starting line to the point where the heel nearest to the starting line touched down. In the case that a participant fell backward, the distance to the point where the heel closer to the starting line made contact with the ground was recorded as the final jump distance. Every participant completed a total of three jumps, regardless of whether they fell backward during any of their attempts.

Figure 1 illustrates the set-up for testing execution. The camera was positioned at a height of 70 cm and ata distance of 5 meters from the measuring tape. The distance between the cones was set to 5 meters. Videosfor further video analysis were recorded using an iPhone 13 at 240 frames per second.

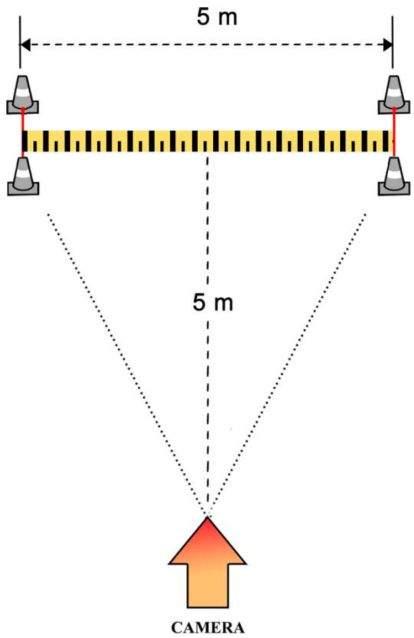

Figure 1. Camera set-up for testing procedure.

Subsequently, Kinovea software (0.9.5.) was used to measure the distance for each jump as shown in Figure

2. Each measurement of the Standing Long Jump was repeated three times in the Kinovea software by tworaters. Prior to obtaining distance measurements, the raters used the 5 m measuring tape in the video as areference distance for calibration.

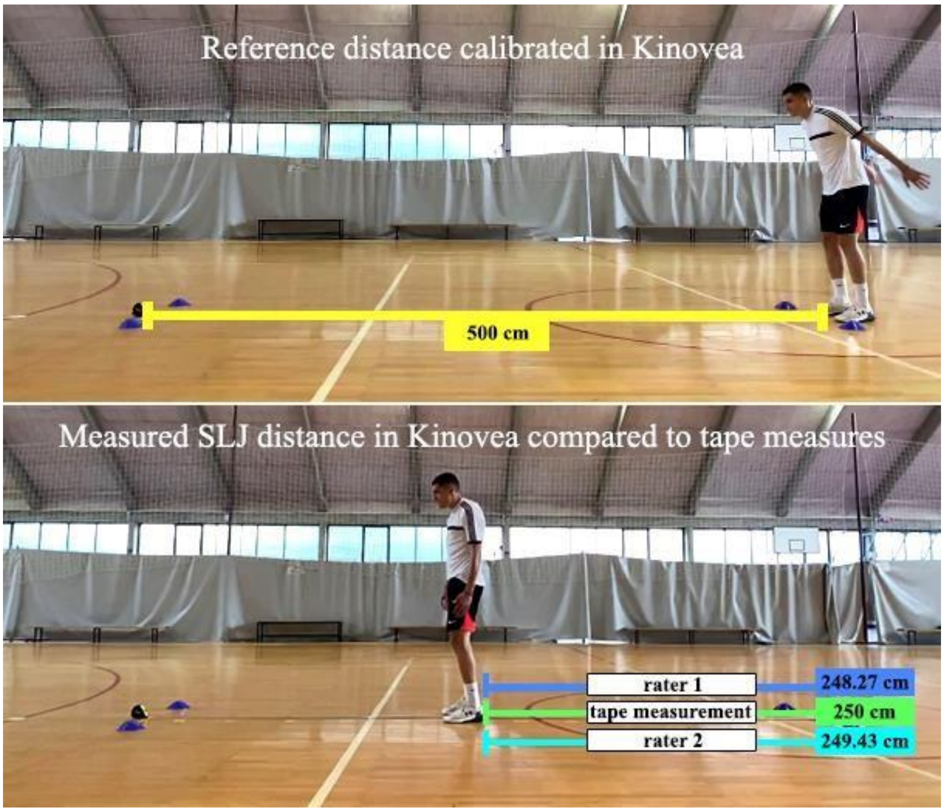

Figure 2. Illustrative comparison of measurements obtained in Kinovea and tape measurement.

Statistical analysis

Descriptive statistics [Mean (M) and Standard deviation (SD)] were computed across all measurement sessions and jump trials to provide a summary of the measurements obtained by a measuring tape and by both raters who used Kinovea.

Intra-rater reliability was assessed using the measures of absolute [Standard Error of Measurement- SEM and Coefficient of Variation- CV (%)] and relative [Intra-Class Correlation Coefficient- ICC)] reliability (Hopkins, 2000), to quantify the degree of consistency in measurements obtained by each rater. Additionally, repeated measures ANOVA (RM ANOVA) was conducted separately for each rater, to assess the differences within the three repeated measurements for each jump trial.

To determine the degree of agreement between the measurements obtained by raters and the measuring tape, a Two-way RM ANOVA (Within-Within Design) was conducted. Additionally, Bland-Altman plots wereemployed to visually inspect the limits of agreement- LoA=95% and systematic bias by plotting the differences between the raters, and between the raters and the measuring tape, compared to the corresponding mean values (Martin Bland and Altman, 1986).

Prior to analyses, the data was inspected to comply with the assumptions of normality (Shapiro-Wilk test), sphericity (Mauchly's test of sphericity) and homogeneity of variance (Levene's test).A significance threshold of $p<0.05$ was established for all statistical analyses. The software used for all analyses was Microsoft Excel (2019), SPSS (version 24), and Jamovi (version 2.3.21.0).

RESULTS

Descriptive statistics are shown in Table 1 and 2 for the measurements acquired using a measuring tape and raters who used Kinovea software, across all jump trials and measurements.

Table 1. **Descriptive statistics for Standing Long Jump distance obtained by measuring tape**

		Jump Trials					
		Trial 1		Trial 2		Trial 3	
Method	**Variable**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Measuringtape	Jump Distance (cm)	230	11	236	16	239	14

Table 2. Descriptive statistics for Standing Long Jump distance obtained by raters who used Kinovea

Measurement Sessions in Kinovea							
		1st Measurement		2nd Measurement		3rd Measurement	
	Jump Trial	**M**	**SD**	**M**	**SD**	**M**	**SD**
Rater 1	Trial 1	230	11	230	10	230	10
	Trial 2	236	16	236	15	237	15
	Trial 3	239	14	239	13	239	13
Rater 2	Trial 1	229	11	230	10	230	10
	Trial 2	236	15	236	15	236	15
	Trial 3	240	14	239	14	239	14

Intra-rater Reliability of the Standing Long Jump Measures

Table 3 displays the results of intra-rater reliability for each jump trial. The absolute and relative reliabilitymeasures indicate excellent reliability (SEM= 0.788-1.176 cm, CV%= 0.34-0.5, ICC= 0.997-0.999, p < 0.05). In addition to that, the results of RM ANOVA revealed no significant differences within the repeated measurements for rater 1 (F= 0.447-2.93, p > 0.05) and rater 2 (F= 2.04-0.585, p > 0.05) across all jump trials.

Table 3. **Absolute and Relative Measures of Reliability and RM ANOVA Results for each rater**

Raters	Jump Trials	ICC (3, 1) SEM	CV%	ICC (95% CI)	RM ANOVA F	*p*
Rater 1	Trial 1	0.891	0.39	0.997 (0.993 ÷ 0.999)	0.269	0.767
	Trial 2	0.806	0.34	0.999 (0.998 ÷ 1.000)	2.93	0.079
	Trial 3	1.109	0.46	0.997 (0.994 ÷ 0.999)	0.447	0.647
Rater 2	Trial 1	0.788	0.34	0.998 (0.995 ÷ 0.999)	0.585	0.568
	Trial 2	1.176	0.50	0.998 (0.993 ÷ 0.999)	0.276	0.762
	Trial 3	1.074	0.45	0.998 (0.994 ÷ 0.999)	2.04	0.159

Inter-rater Reliability and Concurrent Validity of the Standing Long Jump Measures

The results of Two-way RM ANOVA indicated no significant main effects or interactions for Raters (F= 0.047, p= 0.954) and Measurement Sessions (F= 0.301, p= 0.744). Significant main effects were observed only in Jump Trials (F= 6.608, p= 0.007), but not interactions. Additional post hoc analyses with Tukey's HSD correction revealed significant differences between the 1st and 2nd jump trial (t= -2.47, p= 0.082) and 1st and 3rd trial (t= -1.16, p= 0.502), but not the 2nd and 3rd trial (t=-3.45, p= 0.018).

Regardless, there were no significant differences between the measurements obtained by raters and tape measurements throughout all measurement sessions. Moreover, the Bland-Altman analyses, as illustrated in Figure 3, revealed minimal systematic bias (0.12 ± 3.4 cm) and demonstrated that all measurements fallwithin the upper and lower limits of agreement with 95% confidence interval.

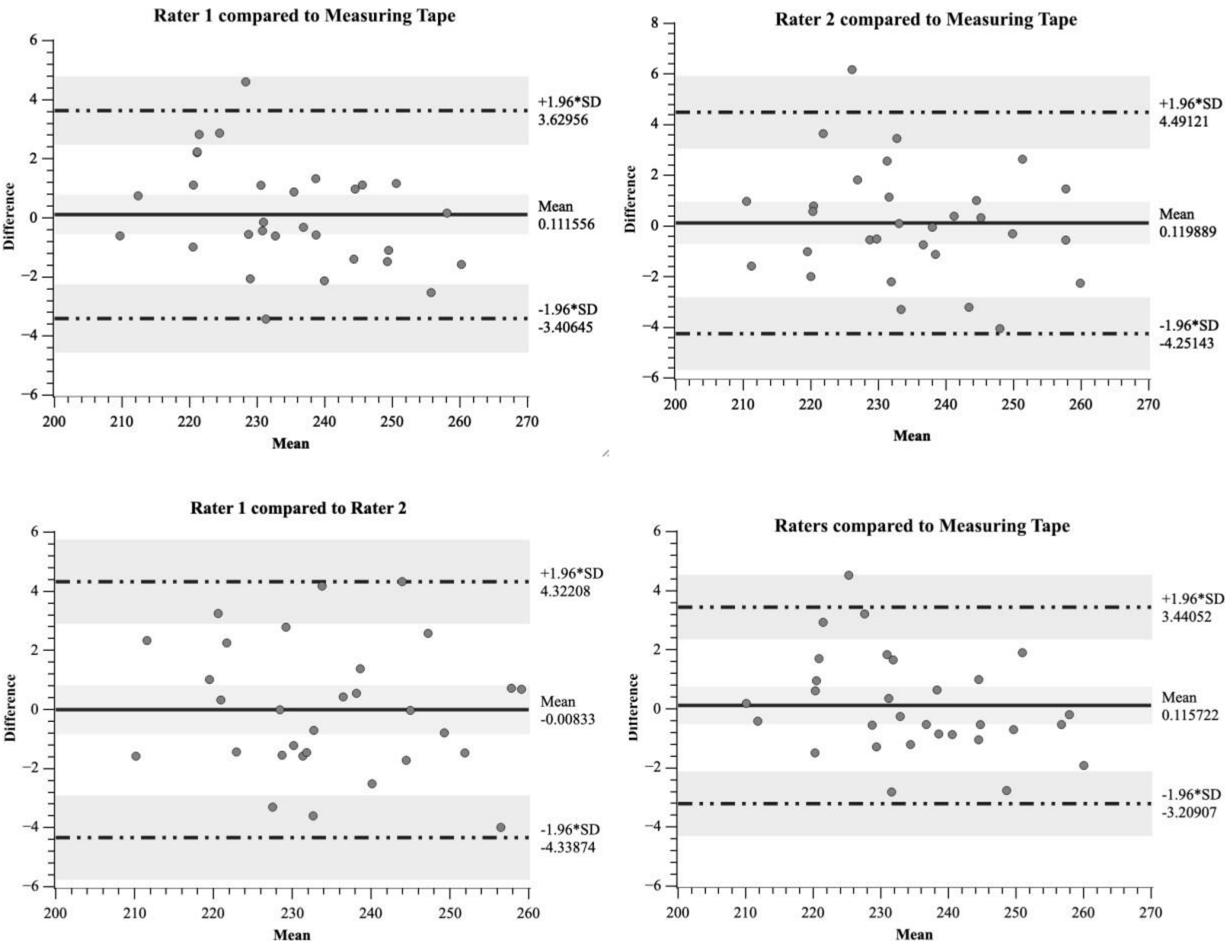

Figure 3. Bland-Altman plots for the limits of agreement between the raters and measuring tape

DISCUSSION

The aim of this study was threefold, and that is to assess: 1) intra-rater reliability (two experienced raters),

inter-rater reliability (two experienced raters), and 3) concurrent validity by comparing Standing Long Jump distance measurements in Kinovea to traditional measuring method (i.e., tape measurement).

We confirmed our hypothesis that Kinovea is a reliable and valid tool for measuring the distance of the Standing Long Jump.

Specifically, in terms of intra-rater reliability, both the absolute (SEM, CV%) and relative (ICC) measures of reliability showed excellent reliability, and no significant differences were found within the repeated measurements for both raters across all jump trials. This indicates excellent consistency of measurementsobtained by raters who used Kinovea-based video analysis to estimate SLJ distance.

Additionally, excellent inter-rater reliability and concurrent validity were also confirmed in the Two-way RM ANOVA analysis by no significant main effects or interactions found within raters or measurement sessions when compared to the traditional method of measuring SLJ distance (i.e., measuring tape). The accuracy of Kinovea-based video analysis in measuring SLJ distance was further confirmed through Bland- Altman plots, demonstrating that all measurements lie within the upper and lower limits of agreement with a 95% confidence interval. This signifies a strong level of agreement between measurements from rater 1 and rater 2, as well as between the average measures obtained by raters and the measuring tape.

These results indicate that Kinovea-based video analysis could be used for accurate estimation of Standing Long Jump distance compared to the measuring tape, especially when an object of a known dimension is placed in line with the subject which facilitates the calibration process in the software (i.e., the 5m measuring tape which was laid out from the start line where the subject was standing). This confirms the results of previous studies which found an acceptable level of accuracy of Kinovea for obtaining linear measurements up to 5 meters from the object (Kim et al., 2022; Puig-Divi et al., 2017; Puig-Divi et al., 2019)

The implications of these findings extend beyond the Standing Long Jump, opening up the possibilities of measuring other types of horizontal jumps such as the Unilateral Standing Long Jump, Triple Hop, and Crossover Triple Hop, which are frequently used in sports and rehabilitation (DiFabio et al., 2018). More specifically, this method could facilitate the assessment of imbalances or asymmetries in the jump distances achieved between the dominant and non-dominant leg, which is an aspect of great importance in monitoring anterior cruciate ligament reconstruction (ACLR) recovery (Mirković, et al., 2022; Xergia et al., 2013); and more so, the Kinovea-based approach could offer the advantage of extracting key frames from the video for a more in-depth analysis of the specific parts of the movement, such as the changes in flexionangle kinematics during the propulsion and landing phases of the jump (Faj et al., 2023).

Another possibility that is opened by these findings is in indirectly measuring other variables that are dependent on distance, such as the running speed. By accurately determining the total running distance and annotating the key timeframes in the video, we could indirectly estimate the total running speed, as well as the speed during specific phases of running (ex. first 5m, last 5m, etc.). However, more research is required to further investigate these potential applications.

Limitations

The present study had some limitations, which should be further addressed: 1) The sample size included 10 participants, which may appear relatively small. However, the G*Power (ver. 3.1.9.7) analysis showed that the required number of subjects for the alpha level of 0.05, power of 0.80, and 3 measurement repetitions was 10-12 subjects. 2) Significant main effects and no interactions found for Jump Trials in the Two-Way RM ANOVA indicate that the results differed in jump trials, therefore potentially implying the presence of systematic bias. Further post hoc analyses showed that the differences were found between the 1st and 2nd and the 1st and 3rd jump trials, but not between the 2nd and 3rd trial. Moreover, the results showed that the subjects had a tendency to improve their jump distance in each trial. This could indicate that more trials were needed to avoid systematic bias and obtain more consistent results regarding Standing Long Jump performance. However, assessing the performance of subjects was not the aim of this study. 3) Technical aspects of the smartphone camera and the Kinovea software also need to be considered. Due to the field distortions of the smartphone camera lens, the 5 m measuring tape used for calibration of distance in Kinovea needs to be placed in line with the subject in order to obtain better accuracy of measurements. Additionally, the results may also be dependent on the camera placement and quality of videos taken by the smartphone camera.

CONCLUSION

In conclusion, the findings of this study confirm that Kinovea-based video analysis can be used as a reliable and valid tool for measuring Standing Long Jump distance, and also implies its broader application in measuring other types of horizontal jumps which are frequently assessed in sports and rehabilitation. Importantly, the study underscores the user-friendly nature of this method which requires no extensive expertise, making it easily applicable in practical settings. While considering certain technical limitations, the overall results of this study affirm the utility of Kinovea as a valuable asset for coaches, athletes, and sports scientists aiming to assess Standing Long Jump performance.

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THE ANALYSIS OF SUCCESSFUL JUMPS FOR THREE DIFFERENT PARKOUR OBSTACLE HEIGHTS AT JUMPING EVENTS

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ABSTRACT

The aim of the study was to determine whether there is a statistically significant difference among successful jumps for three different parkour obstacle heights at jumping events. The defined variables include total penalties, the knock down, refusal, disobedience, elimination, a fall, penalties for single obstacles, and penalties for combination obstacles. In total, 229 (n =229) take-offs were analyzed from during ten selected jumping events which took place in Zagreb (December 18, 2022) and in Osijek (June 30, 2023), in open club competitions. The height of the obstacles ranged from 105 cm to 140 cm, whereby, of the total number of take-offs, 153 (66.8 %) were achieved at heights of 105 cm to 115 cm, 49 (21.4 %) at heights of 120 cm to 125 cm, and 27 (11.8 %) at heights of 130 cm to 140 cm. The descriptive statistics were calculated, and the distribution of the results was analyzed using the Kolmogorov-Smirnov test. The Kruskal–Wallis test was used to calculate the average ranks and to determine any statistically significant differences in successful jumps for three different parkour obstacle heights at jumping events. The Mann–Whitney U test was used to determine any statistically significant difference between heights. The level of significance was set at $p < 0.05$. The results indicated a significant difference for the variables of refusal ($p = 0.024$) and elimination ($p = 0.023$) for three different parkour obstacle heights. The Mann–Whitney U test revealed a statistically significant difference for refusal ($p=0.014$) and elimination ($p=0.012$) between obstacle heights of 105 – 115 cm and heights of 120 – 125 cm. Between the heights of 105 – 115 cm vs 130 – 140 cm and 120 – 125 cm vs 130 – 140 cm, no statistically significant difference was discovered for refusal and elimination. Considering that most faults were committed at lower (105-115cm) compared to higher (120-125cm) obstacles, the authors assume that the results obtained are the outcome of the various rankings of the riders and consequently the quality of the horses that jumped lower obstacles (a lower ranking rider) and higher obstacles (a higher ranking rider). This study could be useful to coaches so that they could adequately plan the training process while taking into consideration the ranking of the rider and the obstacle height.

Keywords: equestrian sport, jumping, obstacle height, performance analysis.

INTRODUCTION

One of the most popular equestrian disciplines is the Olympic discipline of jumping which tests the skill of the rider and the horse in parkours with obstacles of various heights, and both single and combination obstacles which are mutually placed at various positions and distances (Stachurska, Pięta & Nesteruk, 2002). The complex interactive part of the dual “rider-horse” relationship is tasked with successfully overcoming the modern parkour course design adapted to various rankings of riders and horses (Clayton, George, Sinclair & Hobbs, 2021). Success at the competition is determined by how well the individual partner relationship between the rider and horse functions within a dyad (Christensen, et al., 2021).

To achieve success at the competition, the parkour obstacle course needs to be completed without incurring penalties. The rules and regulations of the International Federation for Equestrian Sports (FEI) and the Croatian Equestrian Federation (HKS) define the possible faults committed during jumping, whereby performance or ranking at competition is determined based on the number of incurred penalties so that the more successful contestant is the one with fewer penalties. A certain number of penalties can be incurred by knocking down an obstacle (the knockdown), stopping at an obstacle (refusal), circling a hurdle (disobedience), elimination from the event, and the rider falling (the fall), which can all occur either for single or combination obstacles (FEI Jumping Rules 2022, *27th Edition, effective as of 01 January 2022*, https://www.konjicki savez.hr, accessed October 1, 2023).

An analysis of successful jumps could help clarify how faults are committed and how to prevent them (Williams, 2013). Clayton and Barlow (1989) concluded that obstacle height has a greater impact on the biomechanics of the jump of the horse than the type of obstacle, which is important for understanding of possible outcomes of jumps. Powers and Harrison (2002) studied the impact of the rider on the entire jump phase, pointing out in their conclusion that the dominant role of the rider was to lead the horse to the appropriate takeoff point to perform a successful jump. When it comes to the impact of the type of obstacle on the outcome, by analyzing faults such as refusal and disobedience, it was determined that the staccionata and the oxer are the obstacles most frequently knocked over, that more faults are committed for combined than single obstacles, that the height and spread of an obstacle affect the number of committed faults, that obstacles are knocked over more frequently during a curvilinear approach than a direct approach, and that in the case of circling an obstacle no differences in faults were noted (Stachurska et al., 2002). Marlin and Williams (2020) concluded that the greatest number of faults are committed for vertical and compound obstacles, that faults were more likely to be committed during the second part of the parkour course than the first, and that the approach at a right angle decreases the possibility of committing a fault. The possible number of faults increases with the number of obstacles in the parkour course, the greatest number of committed faults is noted for high Liverpool jumps and the lowest for jumping the triple bar, and fewer faults are committed for single compared to compound obstacles. The type of obstacle, the experience of the horse, and the direction of approach affect the likelihood of successful performance (Ničová & Bartošová, 2022).

The study aimed to determine whether there was a statistically significant difference in successful jumps for three different parkour obstacle heights ranging from 105 cm to 140 cm. The analyzed factors included types of faults committed for various parkour obstacle heights. The defined variables include total penalties, the knockdown, refusal, disobedience, elimination, a fall, penalties for single obstacles, and penalties for combination obstacles.

METHODS

The data were compiled by analyzing 229 take-offs during ten jumping events. Five of the analyzed events were held on December 18, 2022, as part of the open club tournament CSN – A2* event of the EC "Evago" in Zagreb, while the remaining five were held on June 30, 2023, in Osijek organized by the EC "Osijek" as part of the CSN – A2** club event. A total of 229 (n = 229) take-offs for parkour obstacles ranging from 105 cm to 140 cm in height were analyzed, of which 153 (66.8 %) were realized at heights V1= from 105 cm to 115 cm, 49 (21.4 %) at heights V2= from 120 cm to 125 cm, and 27 (11.8 %) at heights V3= from 130 cm to 140 cm. Within the 229 take-offs, 2427 obstacles were included, of which 2125 were single and 302 combination, 2782 jumps over 1397 vertical, and 1385 spread obstacles.

The three different parkour heights V1= from 105 cm to 115 cm, V2= from 120 cm to 125 cm and V3= from 130 cm to 140 cm are the independent variables, while the indicator of performance is defined as an outcome with no incurred penalties or an outcome with incurred penalties. Total penalties (UBG), the knockdown (RP), refusal (SP), disobedience (OP), elimination (IT), a fall (PJ), penalties for single obstacles (GPP), and penalties for combination obstacles (GSP) made up the dependent variables.

The necessary data were compiled from the analyses of the ground jury during the event itself, based on the immediate recordings of outcomes on their evaluation sheets. The correctness of the notations was evaluated on the spot by comparing them to the results of the panel of judges which are projected using a video beam during the performance of each competitor. The data about the elements of the parkour obstacle course were obtained based on course design sketches made by the FEI course designers for each event.

The SPSS 19 statistical program was used to calculate the descriptive statistics, while the distribution of the results was analyzed using the Kolmogorov-Smirnov test. The Kruskal–Wallis test was used to calculate the mean ranks and to detect any statistically significant differences between the successful jumps for three different parkour obstacle heights. The Mann–Whitney U test was used to determine any statistically significant differences between obstacle heights. The level of significance was set at $p < 0.05$.

RESULTS

Table 1. presents the descriptive statistics of the variables.

Table 1. Descriptive statistics

	N	Min	Max.	Sum	Mean	Std.dev
The number of knockdowns	229	0	4	188	0.82	0.87
The number of refusals	229	0	3	52	0.23	0.66
The number of disobediences	229	0	3	23	0.10	0.38
The number of eliminations	229	0	1	19	0.08	0.28
The number of falls	229	0	1	7	0.03	0.17
The number of faults for single obstacles	229	0	5	198	0.86	1.02
The number of faults for compound obstacles	229	0	4	67	0.29	0.64

Legend: N – number of take-offs, Min. – minimal value, Max. – maximal value, Sum. – sum, Mean – means, Std. dev. – standard deviation.

Table 2. Descriptive indicators of the outcome of the entire sample and test of normality of distribution

	N	Outcome	Fre.	(%)	KS test	Sig.	Skew	Kurt
UBG	229	no penalties	79	34.5 %	0.22	0.00	1.03	0.77
		penalties	150	65.5 %				
RP	229	no penalties	102	44.5 %	0.27	0.00	0.76	- 0.15
		penalties	127	55.5 %				
SP	229	no penalties	197	86.0 %	0.50	0.00	3.29	10.55
		penalties	32	14.0 %				
OP	229	no penalties	211	92.1 %	0.53	0.00	4.48	23.01
		penalties	18	7.9 %				
IT	229	no penalties	210	91.7 %	0.53	0.00	3.04	7.33
		penalties	19	8.3 %				
PJ	229	no penalties	222	96.9 %	0.54	0.00	5.49	28.39
		penalties	7	3.1 %				
GPP	229	no penalties	104	45.5 %	0.26	0.00	1.30	1.62
		penalties	125	54.6 %				
GSP	229	no penalties	178	77.7 %	0.45	0.00	2.79	9.23
		penalties	51	22.3 %				

Legend: UBG – total penalties, RP – the knockdown, SP – refusal, OP – disobedience, IT – elimination, PJ – a fall, GPP – faults for individual obstacles, GSP – fault for compound obstacles, N – number of take-offs, Fre. – frequency, % – percentage, KS test – the results of the Kolmogorov – Smirnov test, Sig. – level of significance ($p < 0.05$), Skew. – skewness, Kurt. – kurtosis, St. Er. – standard error.

Table 2. shows the frequency and percentage of the outcomes for the studied variables within the entire sample of 229 take-offs for all three studied parkour obstacle heights. The results indicate that faults were committed during 150 of the take-offs, 127 involved a knockdown, 32 involved refusals, 18 involved disobedience, 19 an elimination, and 7 a fall. For 125 take-offs, faults were committed for individual obstacles, and for 51 take-offs for combination obstacles. The results of the Kolmogorov – Smirnov test (KS test, p =

0.00), used to study the normality of distribution, indicated that the assumption of normality was not confirmed and had to be rejected.

The results of the Mean Rank variables based on height (Table 3.) indicate that V1 had the highest value of mean rank for the variables UBG, SP, OP, IT, PJ, and GPP, while the highest mean rank values were recorded for the variables RP and GSS were determined for parkour height V2.

Table 3. Mean Rank variables based on height

		Obstacle height		
		V1 = 105 to 115 cm (n = 153, 66.8 %)	V2 = 120 to 125 cm (n = 49, 21.4 %)	V3 = 130 to 140 cm (n = 27, 11.8 %)
UBG	Mean Rank	119.71	106.52	103.72
RP	Mean Rank	114.20	118.77	112.69
SP	Mean Rank	120.02	103.45	107.50
OP	Mean Rank	118.00	110.59	106.00
IT	Mean Rank	118.97	105.50	109.74
PJ	Mean Rank	115.99	111.50	115.74
GPP	Mean Rank	120.30	104.00	104.93
GSP	Mean Rank	113.77	119.02	114.69

Legend: UBG – total penalties, RP – the knockdown, SP – refusal, OP – disobedience, IT – elimination, PJ – a fall, GPP – faults for individual obstacles, GSP – fault for compound obstacles, n – number of take-offs, Mean Rank – mean rank value, V1 – height from 105 to 115 cm, V2 – height from 120 to 125 cm, V3 – height from 130 to 140 cm.

The results of the Kruskal - Wallis test (Table 4.) determined a statistically significant difference for SP for three different parkour heights V1, V2, and V3, c^2 (df =2, n = 229) = 7.49, p = 0.024 and for IT c^2 (df =2, n = 229) = 7.57, p = 0.023, whereby V1 indicated a higher value for mean rank.

Table 4. The Kruskal - Wallis test, Grouping Variable: height of the obstacle

	UBG	RP	SP	OP	IT	PJ	GPP	GSP
Chi-Square	2.57	0.24	7.49	4.73	7.57	1.96	3.41	0.45
df	2	2	2	2	2	2	2	2
Asymp. Sig.	0.276	0.885	**0.024**	0.094	**0.023**	0.375	0.182	0.800

Legend: df – degree of freedom, Asymp. Sig. – level of significance (p < 0.05), Legend: UBG – total penalties, RP – the knockdown, SP – refusal, OP – disobedience, IT – elimination, PJ – a fall, GPP – faults for individual obstacles, GSP – fault for compound obstacles.

In Table 5., the results of the Mann – Whitney U test for the variable SP indicate a statistically significant difference between heights V1 and V2 (U = 3205.50; z = -2.47; p = 0.014; n = 202), and for the variable IT between heights V1 and V2 (U = 3307.50; z = -2.51; p = 0.012; n = 202). Between V1 and V3 as well as between V2 and V3 no statistically significant difference was noted for SP and IT. In the case of both SP and IT, the values of the mean rank were greater for V1 compared to V2.

Table 5. The Mann – Whitney U test

	SP				IT			
	V1 - V2 (n = 202)		V1 - V3 (n = 180)	V2 - V3 (n = 76)	V1 - V2 (n = 202)		V1 - V3 (n = 180)	V2 - V3 (n = 76)
Mann – Whitney U	3205.50		1840.00	638.50	3307.50		1899.00	637.00
Z	-2.47		-1.39	-0.64	-2.51		-1.25	-1.35
Asymp. Sig. (2-tailed)	**0.014**		0.16	0.52	**0.012**		0.21	0.18
	V1	V2			V1	V2		
Mean Rank	105.05	90.42			104.38	92.50		

Legend: z – the value of the approximation, Asymp. Sig. (2-tailed) – level of significance ($p < 0.05$), Mean Rank – mean rank value, SP – refusal, IT – elimination, n – number of take-offs, V1 – height from 105 to 115 cm, V2 – height from 120 to 125 cm, V3 – height from 130 to 140 cm.

DISCUSSION

The rider and horse should be able to adapt to various conditions of the parkour obstacle course and thereby gain experience. The requirements of a parkour course should be adjusted for each ranking, whereby the strategies ensuring the well-being of the horse must not be overlooked (McLean & McGreevy, 2010). The outcome of jump success depends on external factors, the parkour course design, the competencies of the rider and horse, as well as the synchronicity of their dyadic relationship (Stachurska et al., 2002). Even though it is impossible to isolate the impact of other factors, in this study we predominantly analyzed the impact of obstacle height on the outcome of the studied variables.

The results of the UBG analysis (Table 2.) of the total take-offs indicated that 65.5 % included a fault. No statistically significant difference was noted for the three heights, with the addition that an insignificantly larger number of faults was committed for height V1 compared to height V2 and V3 (Table 3).

The analysis of 229 take-offs for three heights (V1, V2, V3) within ten events at open club competitions, indicated that the knockdown was the most frequently occurring fault (188) (Table 1.). Therefore, of the overall sum of take-offs (229), 55% included a knockdown, while 44.5 % had a fault-free outcome (Table 2.). The greatest percentage of take-offs was realized at the lowest height (66.8 %), meant for the lowest ranking riders and horses, while heights V2 and V3 required greater riding skills and more training for the horse. What could also impact the success of a jump is the response of the horse to the rider's guidance, so the knockdown could be impacted by insufficient experience and effectiveness of a lower-ranking rider. The position of the horse during takeoff primarily depends on the skill of the rider (Powers & Harrison, 2004).

The Kruskal - Wallis test (Table 4.) did not determine a statistically significant difference for the knockdown from three different heights, which suggests that height did not have a statistically significant impact on the number of knocked-down obstacles. The findings of this study are not congruent with those of the study of Stachurska et al. (2002) who, by analyzing faults committed during the completion of a parkour course with heights ranging from 1m to 1.4 m, determined that the number of faults increased with an increase in the obstacle height. The results of this study suggest that the combined factors of lack of experience and the frequent participation of competitors and horses in the lowest-ranking category led to the knockdown being the most frequently committed fault.

The results of the Kruskal - Wallis test (Table 4.) indicated a statistically significant difference for refusal ($p = 0.024$) and elimination ($p = 0.023$). A further statistical analysis using the Mann – Whitney U test (Table 5.) determined a statistically significant difference in refusal ($p = 0.014$) and elimination ($p = 0.012$) between heights V1 and V2. The mean rank value (Table 5.) indicates higher values for height V1. No statistically significant difference was noted between heights V1 and V3, V2 and V3 (Table 5.). Irrespective of the fact that horses are willing to participate in movement, following their etiological behavior they are naturally not motivated to jump obstacles, and when the opportunity arises they prefer to avoid any kind of effort related to jumping (Górecka-Bruzda, et al., 2013). Jumping a variety of hurdles of different colors and positions causes stress (Williams, 2013). Height V1 (105 – 115 cm) was meant for lower-ranking riders and horses with less competitive experience, while height V2 (120 – 125 cm) was meant for higher-ranking riders and horses with more experience. A statistically significant difference was discovered for refusal and elimination between height V1 and V2, whereby most faults were committed for height V1. This could be analyzed in light of all the combined influences of external stimuli, the reactive nature of the horse due to the experienced stress, and the more difficult handling of the horse by less skilled riders (Hothersall & Casey, 2012). Halting at an obstacle as a reactive form of behavior and insufficient support from the rider during the jump itself could lead to deeper resistance to jumping an obstacle (Bartolomé, et al., 2013). The repeated occurrence of refusal or halting, according to the Rules of competition in show jumping published by the HKS, eliminates competitors from the match. The findings of this study are not congruent with the findings of Stachurska et al. (2002) who point out that greater obstacle height often results in greater refusal to jump. That less skilled riders can, due to competitive stress, affect the jump outcome was also claimed by Bridgeman (2009) who in his study points out that the psychological unease of the rider is significantly linked to the reactive negative behavior of the horse at competition, with a relevant impact on the outcome. Refusal to jump an obstacle is indicated when a horse circles around it, or during a run-out. Halting at an obstacle and circling it can be considered variations of the same fault (Stachurska et al., 2002). The results of our study determined that of the total take-offs, 7.9 % included circling an obstacle. Few instances of disobedience is a finding congruent with the one of Stachurska et al. (2002), who cite that it rarely occurs at events, but that the frequency of occurrence increases with an increase in obstacle height. A difference was noted for disobedience for heights V1, V2, and V3 but without statistical significance, albeit disobedience did occur only slightly more for height V1. For the total number of take-offs, there is a greater frequency of the knockdown compared to refusal, disobedience, or elimination (Table 1.), which might suggest the readiness of the rider and the horse to jump an obstacle, whereby height did not act as a deterrent.

The kinematics of the gallop and jump indicate the considerable amount of work needed and the importance of maintaining balance under conditions of a change in dynamic balance during the approach phase of the jump and the jump itself. It is well-known that less experienced riders have a weaker balance than more experienced ones (Williams, 2013). Due to the unpredictable nature of a horse, potentially great speeds, unexpected behavior, and the ability to change direction rapidly with the effect of surprise, the risk of the rider falling increases (Onsen et al., 2022). The fact that 3.1 % of the take-offs ended in the rider falling could suggest the readiness of the rider and horse to jump an obstacle and the preparedness of the rider to successfully perform at the selected heights. No statistically significant differences were noted for falls at various heights.

In 54.6 % of the take-offs, a fault was committed for single obstacles (Table 2.). Height had no impact on the significant difference between faults committed for single obstacles, even though there was a somewhat higher number of faults committed at height V1 compared to heights V2 and V3 (Table 3.), which might indicate the insufficient riding routine during the approach phase in the case of less experienced riders (Hothersall & Casey, 2012). In the case of combination obstacles, no significant difference was noted in the faults committed at various heights. A somewhat greater number of faults was noted for height V2 (Table 3.), which might be explained away by the greater demands posed by compound obstacles in higher-category parkour courses. A lower percentage of take-offs with a fault for compound obstacles (22.3 %) compared to the percentage of take-offs with a fault for single obstacles (54.6 %) might indicate the readiness and determination of the rider and horse to successfully jump a combination obstacle, considering that coaches do emphasize training the most difficult elements. The difficulty related to jumping a combination obstacles could motivate the horse to put in more effort and concentrate more, considering the situation they find themselves in, which might justify the findings of this study (Stachurska et al., 2002). Some studies point out that more faults are committed for combination than single obstacles (Stachurska et al., 2002; Ničová & Bartošová, 2022).

CONCLUSION

Among the analyzed variables, in the case of the knock down the number of faults is the greatest, but without statistical significance concerning different heights. A significant difference was detected for refusal and elimination between heights V1 and V2, whereby more faults were committed for lower parkour obstacles (105 – 115 cm) compared to higher ones (120 – 125). It is assumed that the difference is the result of the different rankings of the riders and consequently the quality of the horses jumping the lower obstacles (lower ranking riders) and the higher obstacles (higher ranking riders). The field of performance analysis in equestrian sport provides a good foundation that could be used by riders, coaches, and parkour obstacle course designers. This study could be useful to coaches so that they could adequately plan the training process while taking into consideration the ranking of the rider and the obstacle height.

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Poster Session

GENDER DIFFERENCES IN THE SELF-EFFICACY OF PHYSICAL EDUCATION TEACHERS ACCORDING TO INCLUSION IN TEACHING - THE EXAMPLE OF MONTENEGRO

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ABSTRACT

The aim of this research is to establish differences in the level of self-efficacy between physical education teachers of primary schools of both genders in Montenegro according to inclusion in teaching. The sample of respondents consisted of 173 physical education teachers of primary schools in Montenegro, 128 (~74%) male and 45 (~26%) female. The assessment of self-efficacy was carried out through the "Situational-specific Self-Efficacy and Physical Educators Scale" questionnaire, which was developed and validated by Block, Hutzler, Barak & Klavina (2013). The Serbian language version was validated and used in the research of Jovanović, Kudláček, Block & Đorđević (2014). The questionnaire begins with general instructions, an explanation of the theory of self-efficacy and examples for using the rating table when giving answers. The research consists of four parts. The parameters of descriptive statistics were calculated: mean value, standard deviation, minimum and maximum score. The Mann-Whitney U test was used to determine statistically significant differences in the self-efficacy of Montenegrin physical education teachers in relation to gender. No difference was found between physical education teachers of Montenegro, male and female, in the level of self-efficacy towards inclusion in physical education classes. The significance of this research lies in the fact that this is one of the first scientific information on the state of the self-efficacy level of physical education teachers according to the inclusion in Montenegro.

Keywords: self-eficincy, PE teachers, inclusion, gender differences.

INTRODUCTION

From the school year 2004/2005 20 elementary schools in Montenegro started to introduce new curricula and programs with inclusion as a new curricular concept. Over time, that reform process included all schools, but also preschool institutions. Gymnasiums started reforming during the 2006/2007 school year, as well as vocational schools (Kašćelan, 2010). The inclusion of students with disabilities in "regular" schools continues to be a challenge for teachers, especially due to the insecurity generated by inseparable professional education and the lack of systemic support in practice.

One of the important factors for the successful implementation of inclusion in physical education classes is the psychological and emotional readiness of teachers to work with children with disabilities. For these reasons, the assessment of their self-efficacy and safety is important for the successful organization of teaching (Block et al., 2010).

Self-efficacy is one of the personal characteristics of teachers that is associated with the quality of teaching and numerous positive educational outcomes (Klassen & Tze, 2014). Teacher self-efficacy is an assessment of the abilities needed to achieve the desired results in student engagement and learning. This also applies to working with students with disabilities and low motivation (Tschannen-Moran & Woolfolk Hoy, 2001). It is necessary to develop specific competences needed for work in inclusive education during the education of physical education students, as well as to create a teaching climate that supports curiosity and creativity as important determinants, traits, openness to new experiences (Orlić et al., 2016).

Based on a comprehensive review by Israeli authors Hutzler et al. (2019), from a practical point of view, participants in the educational process should be aware of several factors that influence self-efficacy during the inclusion of children with disabilities in physical education: (a) the extent and type of experience of teachers with people with disabilities at school, in the family or in community; (b) professional and academic education for inclusion; (c) individual factors, including gender; (d) school environment factors, such as process rather than performance orientation; (e) type and degree of disability.

There is no available scientific information on examining the self-efficacy of teachers/professors of physical education in elementary school in Montenegro according to inclusive teaching. Likewise, gender differences (as an individual factor) in the manifestation of self-efficacy among physical education teachers towards inclusive teaching would be of importance for the pedagogical practice of Montenegro. For these reasons, the aim of this research is to establish differences in the level of self-efficacy between physical education teachers of primary schools of both genders in Montenegro according to inclusion in teaching.

METHODS

Subjects

The population of respondents are physical education teachers in elementary schools in Montenegro. The sample of respondents consisted of 173 physical education teachers of primary schools in Montenegro, 128 (~74%) male and 45 (~26%) female.

Procedure

The assessment of self-efficacy was carried out through the "Situational-specific Self-Efficacy and Physical Educators Scale" questionnaire, which was developed and validated by Block, Hutzler, Barak & Klavina (2013). The Serbian language version was validated and used in the research of Jovanović, Kudláček, Block & Đorđević (2014). The questionnaire begins with general instructions, an explanation of the theory of self-efficacy and examples for using the rating table when giving answers. The research consists of four parts. The first part consists of a description of questions related to the adaptation of students with intellectual disabilities attending physical education classes (11 questions); the second part on students with physical disabilities (12 questions); the third part on students with visual impairment (10 questions); while the fourth part refers to general personal data of physical education teachers. The marks given for each question range from 1 (no confidence) to 5 (complete confidence).

The consent of the Ministry of Education of Montenegro (number 1040201-603/20-5351/4 dated October 27, 2020) was obtained for the implementation of this research. The research was conducted during November and December 2020 on the territory of Montenegro.

Statistical analysis

The parameters of descriptive statistics were calculated: mean value, standard deviation, minimum and maximum score. The Mann-Whitney U test was used to determine statistically significant differences in the self-efficacy of Montenegrin physical education teachers in relation to gender. The data were processed in the statistical program SPSS.

RESULTS

Due to the rationalization of space, the results of the descriptive statistics of the self-efficacy of physical education teachers of Montenegro of both genders (128 men and 45 women) according to the inclusion of students with intellectual, physical and sensory (visual impairment) disabilities will not be shown on tables.

Table 1 shows the results of the Mann-Whitney U test of differences in relation to gender in assessing the self-efficacy of Montenegrin physical education teachers in working with students with intellectual disabilities. The results of the Mann-Whitney U test of differences show that there is no difference in the level of self-efficacy between male and female physical education teachers of Montenegro in working with students with intellectual disabilities.

Table 1. *Results of the Mann-Whitney U test of differences in relation to gender in assessing the self-efficacy of physical education teachers in Montenegro in working with students with intellectual disabilities.*

	INTa	INTb	INTc	INTd	INTe	INTf	INTg	INTh	INTi	INTj	INTk
Mann-Whitney U	2645.50	2856.00	2563.00	2868.50	2862.50	2574.00	2773.00	2756.00	2704.50	2501.50	2730.00
Wilcoxon W	10901.50	3891.00	10819.00	3903.50	11118.50	10830.00	11029.00	11012.00	3739.50	3536.50	3765.00
Z	-0.881	-0.09	-1.20	-0.04	-0.07	-1.13	-0.10	-0.46	-0.65	-1.41	-0.56
Asymp. Sig.	0.378	0.93	0.23	0.97	0.98	0.26	0.70	0.65	0.52	0.16	0.57

Table 2 shows the results of the Mann-Whitney U test of differences in relation to gender in assessing the self-efficacy of Montenegrin physical education teachers in working with students with physical disabilities. The results of the Mann-Whitney U test of differences show that there is no difference in the level of self-efficacy between male and female physical education teachers of Montenegro in working with students with physical disabilities.

Tabela 2. *Mann-Whitney U test of differences in relation to gender in the assessment of self-efficacy of physical education teachers in Montenegro on the inclusion of students with physical disabilities in teaching.*

	FIZa	FIZb	FIZc	FIZd	FIZe	FIZf	FIZg	FIZh	FIZi	FIZj	FIZk	FIZl
Mann-Whitney U	2721.0	2543.5	2738.0	2689.5	2745.0	2828.5	2685.0	2650.0	2818.5	2815.0	2834.0	2703.0
Wilcoxon W	10977.0	10799.5	10994.0	10945.5	11001.0	3863.5	10941.0	10906.0	11074.5	3850.0	11090.0	10959.0
Z	-0.58	-1.23	-0.53	-0.72	-0.50	-0.19	-0.71	-0.85	-0.23	-0.24	-0.17	-0.66
Asymp. Sig.	0.56	0.22	0.60	0.47	0.62	0.85	0.48	0.40	0.82	0.81	0.87	0.51

Table 3 shows the results of the Mann-Whitney U test of the differences between Montenegrin physical education teachers of both genders in assessing self-efficacy according to the inclusion of visually impaired students in physical education classes. The results of the Mann-Whitney U difference test show that there is no difference in the level of self-efficacy between male and female physical education teachers of Montenegro in working with visually impaired students.

Tabela 3. *Results of the Mann-Whitney U test of the difference between genders in the evaluation of the self-efficacy of physical education teachers of Montenegro in working with students with visual impairment.*

	VIDa	VIDb	VIDc	VIDd	VIDe	VIDf	VIDg	VIDh	VIDi	VIDj
Mann-Whitney U	2679.0	2735.0	2750.0	2838.5	2592.5	2829.0	2816.0	2784.0	2836.5	2727.5
Wilcoxon W	3714.0	3770.0	3785.0	3873.5	10848.5	3864.0	3851.0	3819.0	11092.5	10983.5
Z	-0.73	-0.53	-0.48	-0.15	-1.06	-0.19	-0.24	-0.35	-0.16	-0.56
Asymp. Sig.	0,47	0,50	0,64	0,88	0,29	0,85	0,81	0,73	0,87	0,58

DISCUSSION

When it comes to gender differences, ie. comparing the self-efficacy of male and female physical education teachers according to the inclusion of students with disabilities in the teaching process, one can initially notice an imbalance in the balance of their number. Namely, the research included a total of 128 male (74%) and 45 female (26%) genders, which is the imbalance that occurs in the initial training when enrolling in academic studies in the region (Radojević & Petrović, 2006), so it is obviously transmitted and on employment.

The results of this research found no difference in the level of self-efficacy between male and female physical education teachers in Montenegro regarding the inclusion of students with disabilities (intellectual and physical disabilities, as well as visual impairment) in teaching. In general, this agrees with previous research that showed that in the initial training, during the training for physical education teachers, there are no gender differences in the segment of self-efficacy towards the inclusion of students with disabilities in teaching (Hodge, & Jansma, 2000; Hutzler, Zach, & Gafni , 2005).

Likewise, physical education teachers from the region (Serbia), looking at both genders, have an equally highly expressed attitude towards inclusion in physical education classes (Protić-Gava et. al., 2018). Nevertheless, there are studies that favor the self-efficacy of physical education teachers of the male gender in relation to the female gender (Alhumaid, 2021), but the study limits the inclusion of students with autistic spectrum disorders. This also coincides with the study by Gregool et al. (2018), female physical education teachers with less experience have a negative attitude towards the inclusion of students with intellectual disabilities.

On the other hand, there are recent studies from the environment that show higher self-efficacy in female physical education students compared to male colleagues (Jovanović, Kudláček, Block & Djordjević, 2014). This may mean that a gender difference in self-efficacy may appear during the initial training, which is canceled during the career, at least when it comes to Montenegro.

More recent targeted pilot research from the region (Serbia) conducted on physical education teachers reports similar results to this research (Mirčić, 2020). On the other hand, the Irish experience shows that female physical education teachers show statistically significantly more positive attitudes when it comes to working with children with "specific problems" in learning and moderate disabilities (Meegan & MacPhail, 2006).

Comprehensive systematic review research on this topic suggests that there are different results, which show that there is a pronounced self-efficacy of both male and female physical education teachers (Tarantino et. al., 2022).

CONCLUSION

This research included a total of 173 respondents, 128 male and 45 female, with the aim of examining the difference in self-efficacy of male and female physical education teachers regarding inclusion in teaching. No difference was found between physical education teachers of Montenegro, male and female, in the level of self-efficacy towards inclusion in physical education classes.

The significance of this research lies in the fact that this is one of the first scientific information on the state of the self-efficacy level of physical education teachers in primary school (and in general physical education pedagogues from preschool to university level education) according to the inclusion in physical education classes of students with disabilities in Montenegro. This research is significant for the pedagogical practice of Montenegro, because information was obtained on the self-efficacy of physical education teachers towards inclusive teaching in relation to their gender.

The opinion of the author of this research is that in all study programs of basic and master's academic studies in the field of pedagogy, at least one compulsory subject that deals with the issue of teaching children and adolescents with disabilities should be co-opted. Initial training is one of the essential points of full inclusion in education and society as a whole. Likewise, it is necessary to systematically act affirmatively on the creation of informal forms of continuous education in this area, as well as active attendance of them by all physical education pedagogues in the territory of Montenegro.

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RELATIONSHIP BETWEEN FUNCTIONAL FITNESS AND THE SEVERITY OF COVID-19 SYMPTOMS

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ABSTRACT

The COVID-19 pandemic has profoundly impacted global health, affecting millions of individuals worldwide. The pandemic has posed significant challenges to public health and profoundly influenced the fitness and overall health of individuals worldwide. One of the key areas of interest in this context is the intricate relationship between clinical symptoms and physical fitness in the post-COVID-19 condition. Therefore, the aim of this paper was to explore the relationship between functional fitness and the severity of COVID-19 symptoms. This research is a part of the project "Post-COV Swim" financed by the Erasmus sport small-scale partnership. The project's primary focus is on water-based exercises for individuals recovering from COVID-19 and aims to assess their impact on various aspects of participants' well-being (mental, physical, physiological). The study included the 46 participants who had been infected with COVID-19. Participants were tested for fitness components (6 min walk, 2 min walk, sit and reach, handgrip strength and the 30-second chair stand) and the severity of Covid symptoms (mild, moderate and severe/life-threatening). There was a significant relationship between left handgrip strength and severity of symptoms ($r = -0.521$, $p < 0.01$) and between handgrip strength max and severity of symptoms ($r = -0.438$, $p < 0.01$). It can be concluded that the poor muscle strength was associated with greater severity of symptoms in patients with post-COVID-19 condition.

Keywords: post-COVID-19, handgrip, strength, pandemic

INTRODUCTION

The COVID-19 pandemic has had a profound impact on global health, affecting millions of individuals worldwide. The pandemic has not only posed significant challenges to public health but has also profoundly influenced the fitness and overall health of individuals worldwide. Beyond its immediate respiratory symptoms, COVID-19 has been shown to have far-reaching effects on physical and mental well-being, impacting everything from exercise routines and cardiovascular health to mental resilience and overall quality of life. The COVID-19 pandemic places a significant strain on healthcare systems globally. Despite extensive research endeavours and advanced medical care, around 15% of individuals recovering from COVID-19 experience lasting physiological and psychological symptoms, such as breathlessness, tiredness, and dizziness, which endure for several months after infection (Gebhard et al, 2021). Understanding the multifaceted ways in which COVID-19 can affect fitness and health is crucial for healthcare professionals, researchers, and individuals striving to maintain their well-being in the midst of this ongoing global crisis.

Assessing the physical capacity of COVID-19 patients in the immediate and short-term has proven to be difficult (Belli et al, 2020). There is variability in the number of patients who can complete the tasks in commonly used physical capacity assessment tests (Curci et al, 2020). Recent systematic review discovered a decline in activities of daily living (ADL) beyond the specific test or scale employed. This indicates a significant deterioration in ADL performance and, as a result, a loss of independence in COVID-19 patients once they have passed the acute infection phase. Knowing the patient's functional ability status before contracting COVID-19 is crucial for predicting the disease's severity and mortality.

Several recent studies have contributed significantly to our understanding of relationship between the clinical symptoms and physical fitness in post-COVID-19 condition. One such study, conducted by Wright, Astill, and Sivan (2022), delved into the association between physical activity and Long COVID. Their cross-sectional study offered valuable insights into how physical activity levels might influence the persistence and severity of post-COVID-19 symptoms. Additionally, Tuzun et al. (2020) conducted an assessment of musculoskeletal pain, fatigue, and grip strength in hospitalized COVID-19 patients, shedding light on the physical challenges faced by individuals during the acute phase of the disease. Jimeno-Almazán et al. (2022) took a population-based approach, examining the relationship between the severity of persistent symptoms, physical fitness, and cardiopulmonary function in post-COVID-19 individuals. Their findings added valuable nuances to our understanding of how the severity of Long COVID symptoms may be intertwined with one's physical fitness and cardiopulmonary health. Furthermore, Schwendinger et al. (2023) conducted a comprehensive narrative review exploring the impact of COVID-19 on cardiorespiratory fitness. This review emphasized the concerning issue of low cardiorespiratory fitness in post-COVID-19 individuals, underscoring the importance of understanding and addressing these fitness-related concerns.

As we delve deeper into these research findings, it becomes increasingly clear that the relationship between clinical symptoms and fitness in post-COVID-19 conditions is a complex and multifaceted one. This burgeoning field of study not only holds the potential to improve our management of COVID but also offers crucial insights into the broader interplay between infectious diseases and physical well-being. In this context, this introductory overview sets the stage for a comprehensive exploration of the evolving landscape surrounding COVID and its intricate connections to physical fitness and health.

While the respiratory and systemic symptoms of COVID-19 have received significant attention, its consequences on functional abilities in affected individuals have emerged as areas of concern and interest. Understanding the relationship between the clinical symptoms and physical fitness in post-COVID-19 condition is crucial for assessing the long-term health implications of the disease and for informing rehabilitation and wellness strategies. Therefore, the aim of this paper was to explore the relationship between functional fitness and the severity of COVID-19 symptoms.

METHODS

This research is a part of the project financed by the Erasmus sport small-scale partnership, titled “Exercises in water for people after the COVID-19 infection”, abbreviated as Post-COV Swim, with the project code 101050089. The project’s primary focus is on water-based exercises for individuals recovering from COVID-19 and aims to assess their impact on various aspects of participants’ well-being (mental, physical, physiological). All participants were duly informed about the study’s aims and protocols and signed informed consent before participating. The protocol of the study was approved by the ethical committee of the University of Niš, Faculty of Sport and Physical Education, Serbia, and they conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Subjects

The complete project involved a total number of 65 participants. However, for this paper, we specifically analysed 46 participants with COVID-19, who were part of the initial testing (N= 46; Age = 54.79 ± 14.90 yr.; Height = 167.06 ± 12.15 cm; Weight = 78.70 ± 15.07 kg; BMI = 27.96 ± 4.55).

Procedure

This study included fitness components (6 min walk, 2 min walk, sit and reach, handgrip strength and the 30-second chair stand) and the severity of COVID-19 symptoms.

The 6-minute walk test or 2-minute walk was used to assess cardiovascular fitness (aerobic capacity and endurance). This test is commonly used for evaluating patients with cardiac and pulmonary problems. The test involves measuring the distance covered (in meters) during the 6-minute walk, with participants walking from one cone to another placed 30 meters apart (Enright, 2003). The result of this test is achieved distance in meters.

The Sit and Reach test were used to measure flexibility (extensibility of the hamstrings and lower back). The score is the most distant point (cm) reached with the fingertips.

The handgrip test was used to measure muscle strength using a hand dynamometer (measure in N). Patients were instructed to sit upright with straight elbows and take three attempts, alternate maximal strength tests with the hand dynamometer on both hands for 3 s per try (for further analysis we used the best attempt). Participants were asked to start the test assessment with their dominant hand (right-handed or left-handed). Maximal handgrip was defined as the highest result from both hands.

The 30-second chair stand test was performed using a standard chair. Participants were required to sit and stand up as many times as possible within the 30-second duration. The result of this test is the number of repetitions achieved.

The severity of COVID-19 symptoms was given in three groups: (1) mild (symptoms disappeared without specific medications); (2) moderate (medications used, no severe pneumonia, no extra oxygen needed); and (3) severe/life-threatening (hospitalisation).

The assessment process followed a specific sequence. Participants were initially evaluated for anthropometrics. Following this, they underwent a 10-minute warmup, which involved light mobility exercises. Subsequently, they performed Sit and Reach test then the 6-minute walk or 2-minute walk test. After a 15-minute rest period, participants completed the handgrip and the 30-second chair stand, with a 5-minute break.

Statistical analysis

Statistical data processing was carried out using the statistical package SPSS version 24.0. Basic statistical indicators were calculated for each applied variable. In order to check the normality of the distribution of the results, the Kolmogorov-Smirnov test was used, as well as the coefficient of variation. Pearson correlation was used to determine the relationships between the fitness components (6 min walk, 2 min walk, sit and reach, handgrip strength and the 30-second chair stand) and the severity of COVID-19 symptoms. Value of $p < 0.05$ was considered statistically significant.

RESULTS

Table 1. Basic descriptive parameters in participants with COVID19

	N	Mean	SD	Min	Max
Age (years)	46	54.79	14.90	26.70	83.50
Height (cm)	46	167.06	12.15	151.0	196.0
Body Mass (kg)	46	78.70	15.07	50.2	114.0
BMI (kg/m2)	46	27.96	4.55	21.3	36.9
Body fat %	46	31.63	7.18	18.5	47.4

Table 1. shows the height, body mass, BMI, and body fat percentage in post-COVID-19 participants. The average value of BMI for post covid participants was 27.96±4.55 kg/m2. Table 2. shows the correlation between functional fitness and severity of symptoms in participants with COVID-19. There was a significant relationship between handgrip strength L and severity of symptoms ($r = -0.521$, $p < 0.01$; Table 2) and between handgrip strength max and severity of symptoms ($r = -0.438$, $p < 0.01$; Table 2). However, there was no significant correlation between the handgrip strength R and severity of

symptoms (r = -0.322, p = 0.101). No correlations were found between other variables of functional fitness and severity of symptoms (p>0.05).

Table 2. Pearson correlation coefficient between functional fitness and severity of symptoms

	N	Mean	SD	Pearson correlation	
				r	p
6 min walk (m)	26	547.25	97.16	-0.235	0.305
2 min walk (m)	20	97.87	20.30	-0.248	0.414
Sit and Reach (cm)	46	15.00	9.57	0.293	0.104
Handgrip strength R (N)	46	30.54	11.94	-0.322	0.101
Handgrip strength L (N)	46	29.65	9.98	-0,521**	**0.002**
Handgrip strength max (N)	46	32.58	11.59	-0,438*	**0.011**
30-second chair stand (reps)	46	14.98	4.32	-0.229	0.192

Legend: **. Correlation is significant at the 0.01 level; *. Correlation is significant at the 0.05 level.

DISCUSSION

The present study examined the relationships between functional fitness and severity of symptoms in post-COVID-19 participants. The main findings of this study were an association between handgrip strength and severity of post-COVID-19 symptoms. Specifically, worst handgrip strength was associated with more-severe symptoms (handgrip strength negatively correlates with clinical symptoms, respectively).

It is well documented that grip strength can be a simple but powerful predictor of morbidity and mortality (Sayer, & Kirkwood, 2015). More important, grip strength plays a pivotal role in the assessment and recovery of COVID-19 patients, holding significant clinical importance in the post-infection phase. As a simple yet reliable indicator of overall muscular strength and physical function, grip strength offers valuable insights into an individual's physical fitness and functional capacity. COVID-19 can result in varying degrees of muscle weakness and fatigue, with many patients experiencing prolonged symptoms such as fatigue and musculoskeletal pain (Klok et al, 2020). Evaluating grip strength can serve as a tangible measure of these physical impairments, aiding healthcare professionals in gauging the severity of post-COVID-19 musculoskeletal issues and monitoring the progress of rehabilitation. Moreover, diminished grip strength can have a direct impact on an individual's ability to perform everyday tasks, highlighting the crucial role it plays in assessing the functional independence and overall quality of life of COVID-19 survivors. This was confirmed in the current study where the handgrip strength was negatively correlated with clinical symptoms. To explore this and similar relationships, researchers have undertaken a range of studies and investigations. Studies such as those by Tuzun et al. (2020), Schwendinger et al. (2023), and Jimeno-Almazán et al. (2022) have provided valuable insights into various aspects of this relationship, including musculoskeletal pain, cardiorespiratory fitness, and the severity of persistent symptoms. Jimeno-Almazán et al. (2022) have found that Poor muscle strength was associated with greater severity of persistent symptoms in patients with post-COVID-19 condition. Furthermore, Tuzun et al. (2020) found muscle weakness in Covid patients. Additionally, studies showed that patients with mild forms of acute illness and post-COVID-19 condition presented evident physical restrictions on maximal (Vonbank et al, 2021) and submaximal (Vonbank et al, 2021; Pleguezuelos et al, 2021) exercise capacity.

This study has some limitations. As it is a smaller project with limited size, the results could not be directly applicable to all population. Moreover, it cannot be generalized to all COVID-19 patients, irrespective of the age, disease severity or need for hospitalization. The heterogeneity in patient selection and factors such as virus variants, vaccines could add to the variability in reported prevalence estimates. Additionally, small number of participants that was tested with right hand could contribute to the non-existence of correlations with Covid symptoms.

CONCLUSION

The current study found poor muscle strength was associated with greater severity of symptoms in patients with post-COVID-19 condition. Therefore, the assessment and enhancement of grip strength emerge as integral components in the comprehensive care and recovery strategies for post-COVID-19 patients. Moreover, improving the strength of patients through an exercise intervention could be an effective strategy to better manage the post-COVID-19 condition.

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FUNCTIONAL FITNESS AND QUALITY OF LIFE IN PEOPLE WITH COVID-19

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ABSTRACT

The COVID-19 pandemic put millions of individuals worldwide into difficulties due to the disease as well as the huge economic and social impacts. While the respiratory and systemic symptoms of COVID-19 have received significant attention, its consequences on functional fitness and quality of life in affected individuals have emerged as areas of concern and interest. Understanding how COVID-19 affects the relationship between these abilities in those who have contracted the virus is important for assessing the long-term health implications of the pandemic. Specifically, understanding the vital role of functional fitness in enhancing the quality of life for people with COVID-19 becomes increasingly crucial. Therefore, the aim of this study was to analyze the functional fitness of post-COVID-19 patients and its relationship with quality of life. This research is a part of the project "Post-COV Swim" financed by the Erasmus sport small-scale partnership. The project's primary focus is on water-based exercises for individuals recovering from COVID-19 and aims to assess their impact on various aspects of participants' well-being (mental, physical, physiological). The study included the 46 participants who had been infected with COVID-19. Participants were tested for fitness components (6 min walk, 2 min walk, sit and reach, handgrip strength and the 30-second chair stand) and quality of life (The EQ-5D-5L tool). We found significant negative correlation between 6 min walk and mobility ($r = -0.561$, $p < 0.01$; Table 2) and between 6 min walk and self care ($r = -0.575$, $p < 0.01$). In addition, we found significant negative correlation between handgrip strength and quality of life ($p<0.05$). In conclusion, there is a negative correlation between functional fitness and quality of life in post-COVID-19 patients.

Keywords: 6 min walk, 30-second chair stand, mobility, self-care, post-COVID-19

INTRODUCTION

The global COVID-19 pandemic has brought about an unprecedented challenge to healthcare systems and has transformed the lives of millions of individuals worldwide. Individuals infected with the virus have endured a spectrum of symptoms, ranging from mild to severe, with some experiencing prolonged effects that extend far beyond the initial illness. The pandemic has not only posed significant challenges to public health but has also profoundly influenced the fitness and overall health of individuals worldwide. Beyond its immediate respiratory symptoms, COVID-19 has been shown to have far-reaching effects on physical and mental well-being, impacting everything from exercise routines and cardiovascular health to mental resilience and overall quality of life. Understanding the multifaceted ways in which COVID-19 can affect fitness and health is crucial for healthcare professionals, researchers, and individuals striving to maintain their well-being in the midst of this ongoing global crisis.

Functional fitness, characterized by exercises and movements that enhance daily functioning, has long been recognized as an essential component of well-being (Marques et al. 2014). However, its significance has come to the forefront in the context of COVID-19. This virus has illuminated the importance of maintaining physical and functional resilience in the face of illness, as it can have a profound impact on an individual's ability to cope with the virus and recover effectively. Amidst the ongoing challenges posed by COVID-19, a growing body of research and clinical experience suggests that functional fitness plays a pivotal role in the recovery and overall quality of life for those who have been affected.

Most recent systematic review demonstrated that COVID-19 survivors had reduced levels of physical function, activities of daily living, and health-related quality of life (de Oliveira Almeida et al, 2023). Greater handgrip strength correlated with reduced severity of COVID-19, suggesting that individuals with severe COVID-19 might have experienced more substantial muscle degradation, while enhanced muscle strength could have served as a protective factor against the disease (Sevilla, & Sánchez-Pinto, 2022). There are also some controversial results regarding COVID-19, physical fitness and HQoL relationship. One research showed while physical fitness decreases (Basterfield, et al., 2022), there is also decrease in HQoL levels, during pre- and post-pandemic social distancing (Pinho, Caria, Aras Júnior, & Pitanga, 2020). One study only presented the evaluation of fitness, that decreased at post-Covid period (Dayton et al, 2021; Morrison, Meh, Sember, Starc, & Jurak, 2021). Furthermore, there are also some studies without conclusion due to several factors acting as mediators for associations between cardiorespiratory fitness, and quality of life (Juraket al, 2021).

While the respiratory and systemic symptoms of COVID-19 have received significant attention, its consequences on functional fitness and quality of life in affected individuals have emerged as areas of concern and interest. Understanding how COVID-19 affects the relationship between these abilities in those who have contracted the virus is important for assessing the long-term health implications of the pandemic. Specifically, understanding the vital role of functional fitness in enhancing the quality of life for people with COVID-19 becomes increasingly crucial. Therefore, the aim of this study was to analyse the functional fitness of post-COVID-19 patients and its relationship with quality of life. This investigation seeks to provide insights, and inspiration for both healthcare professionals and individuals alike, empowering them to embrace functional fitness as a powerful tool in the fight against COVID-19 and the pursuit of a healthier, more resilient future.

METHODS

This research is a part of the project financed by the Erasmus sport small-scale partnership, titled "Exercises in water for people after the COVID-19 infection", abbreviated as Post-COV Swim, with the project code 101050089. The project's primary focus is on water-based exercises for individuals recovering from COVID-19 and aims to assess their impact on various aspects of participants' well-being (mental, physical, physiological). All participants were duly informed about the study's aims and protocols and signed informed consent before participating. The protocol of the study was approved by the ethical committee of the University of Niš, Faculty of Sport and Physical Education, Serbia, and they conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Subjects

The complete project involved a total number of 65 participants. However, for this paper, we specifically analyzed 46 participants with COVID-19, who were part of the initial testing (N= 46; Age = 54.79 ± 14.90 yr; Height = 167.06 ± 12.15 cm; Weight = 78.70 ± 15.07 kg; BMI = 27.96 ± 4.55).

Procedure

This study included Functional fitness components (6 min walk, 2 min walk, sit and reach, handgrip strength and the 30-second chair stand) and the Quality of life (The EQ-5D-5L tool).

The 6-minute walk test or 2-minute walk was used to assess cardiovascular fitness (aerobic capacity and endurance). This test is commonly used for evaluating patients with cardiac and pulmonary problems. The test involves measuring the distance covered (in meters) during the 6-minute walk, with participants walking from one cone to another placed 30 meters apart (Enright, 2003). The result of this test is achieved distance in meters.

The Sit and Reach test were used to measure flexibility (extensibility of the hamstrings and lower back). The score is the most distant point (cm) reached with the fingertips.

The Handgrip test was used to measure muscle strength using a hand dynamometer (measure in N). Patients were instructed to sit upright with straight elbows and take three attempts, alternate maximal strength tests with the hand dynamometer on both hands for 3 s per try (for further analysis we used the best attempt). Participants were asked to start the test assessment with their dominant hand (right-handed or left-handed). Maximal handgrip was defined as the highest result from both hands.

The 30-second chair stand test was performed using a standard chair. Participants were required to sit and stand up as many times as possible within the 30-second duration. The result of this test is the number of repetitions achieved.

To assess general health and overall quality of life (The EQ-5D-5L tool), the study employed the EQ-5D-5L questionnaire in Croatian language. It consists of five dimensions (subscales): mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each subscale is rated on a scale from 1 to 5, with 1 denoting the highest level of health or the least amount of discomfort and 5 presenting the highest level of discomfort (Feng, Kohlmann, Janssen, & Buchholz, 2021).

The assessment process followed a specific sequence. Participants were initially evaluated for anthropometrics. Following this, they underwent a 10-minute warmup, which involved light mobility exercises. Subsequently, they performed Sit and Reach test then the 6-minute walk or 2-minute walk test. After a 15-minute rest period, participants completed the handgrip and the 30-second chair stand, with a 5-minute break.

Statistical analysis

Statistical data processing was carried out using the statistical package SPSS version 24.0. Basic statistical indicators were calculated for each applied variable. Analysis of the results was carried out to assess the distribution of the results and to determine the central and dispersion parameters, in order to determine whether the distribution of the results was normal or not. For this purpose, basic descriptive data were calculated. In order to check the normality of the distribution of the results, the Kolmogorov-Smirnov test was used, as well as the coefficient of variation. In order to analyse the relationship between functional fitness and quality of life, Pearson's correlation test and Spearman's correlation test were performed for the parametric and nonparametric variables, respectively. The magnitudes of correlation between variables were qualitatively interpreted using the following criteria: trivial ($r \leq 0.1$), small ($r=0.1$–0.3), moderate ($r=0.3$–0.5), large ($r=0.5$–0.7), and very large ($r=0.7$–0.9). Value of $p < 0.05$ was considered statistically significant.

RESULTS

Table 1 shows the basic descriptive parameters, functional fitness and quality of life in post-COVID-19 participants. The average value of body mass was 78.70±15.07 kg. The average value of BMI for postcovid participants was 27.96±4.55kg/m2.

Table 1. Basic descriptive parameters in participants with COVID19

	N	Mean	SD
Height (cm)	46	167.06	12.15
Body Mass (kg)	46	78.70	15.07
BMI (kg/m2)	46	27.96	4.55
Body fat %	46	31.63	7.18
6 min walk	26	547.25	97.16
2 min walk	20	97.87	20.30
Sit and reach	46	15.00	9.57
Handgrip strength R	46	30.54	11.94

Handgrip strength L	46	29.65	9.98
Handgrip strength max	46	32.58	11.59
30-second chair stand	46	14.98	4.32
Mobility	46	1.54	0.86
Self-care	46	1.19	0.53
Usual activities	46	1.37	0.70
Pain/discomfort	46	2.02	1.52
Anxiety/depression	46	1.58	0.75

Table 2 shows the correlation between functional fitness and quality of life in participants with COVID19. There was a significant negative correlation between 6 min walk and mobility ($r = -0.561$, $p < 0.01$; Table 2) and between 6 min walk and self-care ($r = -0.575$, $p < 0.01$; Table 2). In addition, there is a significant negative correlation between handgrip strength R and quality of life (mobility: r = -,473, $p < 0.01$; self-care: r = -,441, $p < 0.01$; usual activities: r = -,528, $p < 0.01$; pain/discomfort: r = -,343, $p < 0.01$) as well as between handgrip strength L and quality of life (mobility: r = -,462, $p < 0.01$; self-care: r = -,354, $p < 0.01$; usual activities: r = -,362, $p < 0.01$; pain/discomfort: r = -,286, $p < 0.05$). In addition, we also found negative correlation between handgrip strength max and quality of life (mobility: r = -,421, $p < 0.01$; self-care: r = -,307, $p < 0.01$; usual activities: r = -,408, $p < 0.01$; pain/discomfort: r = -,357, $p < 0.01$). No correlations were found between 2 min walk, sit ups and quality of life ($p>0.05$).

Table 2. Pearson correlation coefficient between functional fitness and quality of life

	Pearson coefficient	mobility	self-care	usual activities	pain/discomfort	anxiety/depression
6 min walk	r	-,561**	-,575**	-0.303	-0.322	0.121
	p	0.001	0.001	0.092	0.078	0.523
2 min walk	r	-0.407	-0.429	-0.303	-0.293	-0.155
	p	0.075	0.059	0.194	0.223	0.527
Sit and reach	r	0.04	0.063	0.119	,314*	-0.173
	p	0.785	0.663	0.41	0.03	0.245
Handgrip strength R	r	-,473**	-,441**	-,528**	-,343*	0.062
	p	0.002	0.004	0.001	0.033	0.713
Handgrip strength L	r	-,462**	-,354*	-,362**	-,286*	0.028
	p	0.001	0.011	0.009	0.047	0.851
Handgrip strength max	r	-,421**	-,307*	-,408**	-,357*	0.025
	p	0.002	0.028	0.003	0.012	0.865
30-second chair stand	r	-,405**	-,568**	-,276*	-0.056	-0.159
	p	0.003	0	0.047	0.699	0.276

Legend: **. Correlation is significant at the 0.01 level; *. Correlation is significant at the 0.05 level.

DISCUSSION

Functional fitness and quality of life in post-COVID-19 patients are often profoundly impacted. Many individuals who have recovered from the virus continue to experience a range of lingering symptoms, such as fatigue, shortness of breath, and muscle weakness, which can significantly impair their ability to perform daily activities. These challenges can result in a reduced quality of life, affecting both their physical and emotional well-being. Rehabilitation and support tailored to the specific needs of post-COVID patients are essential in helping them regain their physical function and improve their overall quality of life. Therefore, the aim of this study was to analyse the functional fitness of post-COVID-19 patients and its relationship with quality of life. The main findings of the current study were significant but negative associations between functional fitness and quality of life in post-COVID-19 patients.

Regarding aerobic capacity, distance covered during 6MWT, was lower than the standard values. Therefore, it can be stated that aerobic capacity and endurance were generally impaired. Other studies have also reported a decrease in aerobic performance in patients with long COVID-19 (Hazarika et al, 2021; Morin et al, 2021). Additionally, some studies reported that a great number of post- COVID-19 patients showed decline in results for 6-minute walk test as late as 5 and 6 months after release from hospital (Wahlgren et al. 2022; Sirayder et al, 2022). Therefore, the reduced ability to engage in physical activities due to lingering symptoms can lead to a decreased sense of well-being, impacting various aspects of daily life. This could be the main reason for negative correlations obtained in the current study between the aerobic capacity and quality of life. Addressing this correlation highlights the importance of rehabilitation and interventions aimed at improving aerobic capacity in post-COVID patients to enhance their overall quality of life and recovery. In similar study (Qorolli et al, 2023) that aimed to show the patients' functional status and quality of life, as well as to investigate their inter-relatedness there were no significant correlation between 6-minute walk test and quality of life (EQ-5D-5L). One more study (Sevilla, & Sánchez-Pinto, 2022) found the 6-minute walk test score showed a negative moderate correlation with quality of life, however only with the physical component ($r=-0.36$; $p<0.001$).

A negative correlation has been identified between grip strength and the quality of life in post-COVID-19 patients. This means that as grip strength diminishes, there is a tendency for a decrease in overall quality of life among these individuals. Weakening grip strength can have far-reaching consequences, affecting one's ability to perform everyday tasks, participate in physical activities, and maintain independence. The decline in hand grip strength due to Covid19 but also due to the age-related loss of skeletal muscle mass and function may adversely reflect on quality of life among adults, especially among older adults. This implies that maintaining strong hand grip can improve the quality of life and increase the likelihood of successful aging as individuals advance in years. Our results are in line with similar study that aimed to analyze the muscle strength of post-COVID-19 patients and its relationship with health-related quality of life. The authors found muscle strength was negatively correlated with dyspnea and health-related quality of life, and moderate-large negative correlations were found between dyspnea and health-related quality of life. On the contrary, one study showed positive correlation between grip strength significantly and EQ-5D-5L ($r = 0.545$, $p < 0.001$).

CONCLUSION

We found negative correlations between functional fitness and quality of life in post-COVID-19 patients. Given the compromised functional status and reduced quality of life observed in our study among post-COVID-19 patients, we propose that all individuals who have been discharged from the hospital after a COVID-19 episode should undergo assessments for physical function, aerobic capacity, and quality of life as much early as possible following their hospital stay. Our observation underscores the importance of rehabilitation programs and interventions focused on improving grip strength and aerobic capacity in post-COVID patients to enhance their quality of life during the recovery process.

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PLAYING LEVEL AND POSITION DIFFERENCES IN BODY CHARACTERISTICS AND PHYSICAL FITNESS PERFORMANCE AMONG ELITE AND SUB-ELITE FEMALE HANDBALL PLAYERS

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ABSTRACT

The primary aim was to compare the physical and performance characteristics of elite and sub-elite female handball players. The secondary aim was to compare physical characteristics and motor abilities between playing positions. Team handball is a high-intensity, body-contact sport that requires both aerobic and anaerobic fitness. Thirty-two female handball players (18 elite, first Serbian league and 14 sub-elite, third Serbian league), were recruited and tested during a week in season training period. The testing was conducted in two days, on the first day handball players of the first league were tested, and on the second day handball players of the third league were tested. First, the anthropological measurements of the participants were taken, followed by a 20-minute warm-up consisting of running and shaping exercises as well as games on a reduced field in order to bring the participant's body to an adequate level of preparedness for the test. The following variables were measured in both groups: countermovement jump, countermovement jump with arm swing, squat jump, speed 10, 20 and 30 m, agility T-test, handball throwing and hand grip with dominant hand. Results indicated that there was a statistically significant differences in both t-test (speed 10, 20 and 30m, agility t-test, countermovement jump, countermovement jump with arm swing, the speed of throwing the ball with and without goalkeeper) and ANOVA (body height and body mass). This implies that specific motor abilities and skills, such as speed, agility, explosive power, and throwing ability, differ significantly among players. These findings confirm and expand on previous data about the presence of anthropometric differences within playing positions in handball. Understanding these differences can inform training programs, player selection, and position-specific coaching strategies to enhance overall team performance and player development.

Keywords: motor abilities, team sport, professional handball players, playing position

INTRODUCTION

Team handball is a high-intensity, body-contact sport that requires both aerobic and anaerobic fitness (Hermassi et al., 2019). To perform at a high level, a variety of skills and fitness components (throwing accuracy, running speed, jumping ability) are required, and the sport is distinguished by intermittent periods of high-speed and explosive activities interspersed with less intense activities (Buchheit et al., 2009). Although handball is predominantly an aerobic sport, anaerobic activities such as throwing, jumping, sprinting, changing directions, duels, and contacts are used in both counter-attacks, attack build-up stages, and defense play to score or avoid goals (Michalsik, 2017). Handball is an irregular sport, requiring players to sprint, jump, rotate, change velocity, block, and push and throw the ball, as well as start and stop fast. Performance depends on the player's ability to accelerate and to generate repeated explosive muscle contractions (Hermassi et al.,2015). A few studies have studied the anthropometric and physical features of handball players at various levels and positions. Anthropometric characteristics, as well as physical abilities, have been recognized to be important in determining the success of handball sport (Karcher & Buchheit, 2014). Fieseler et al. (2017), the aim of this study was to examine at the anthropometric characteristics and throwing and sprinting abilities of professional handball players divided by playing position and level of competition. They found statistically significant differences between first German handball league players than third German handball league players in anthropometric characteristics, first German handball league players was higher. The first German league players showed a significantly higher throwing velocity in all type of throws and significantly better sprint performance than third German handball league players. One study (Schwesig et al., 2016) showed that the anthropometric data revealed a significantly lower body height for wings and pivots than for goalkeepers, Wings, pivots and goalkeepers were significantly shorter than backs, but had a similar body mass index, scores on the Yo-Yo Intermittent Recovery Test was greater for the wings than for backs and pivots. Sibila et al. (2009), according to the findings, the wings often have physical body characteristics that are different from those of the other player categories. In comparison to participants in the other groups, their body height, body mass, and subcutaneous fat mass are all statistically significantly lower. Goalkeepers have low values for transversal measurements and a comparatively high body mass value. There is limited information available on the physical performance and anthropometric characteristics of modern professional handball players but it’s important to know differences of body build and physical performance between playing positions underline of a careful assignment of such positions and the development of professional handball players for specific position. The primary aim was to compare the physical and performance characteristics of elite and sub-elite female handball players. The secondary aim was to compare physical characteristics and motor abilities between playing positions.

METHODS

Subjects

Thirty-two female handball players (18 elite, first Serbian league and 14 sub-elite, third Serbian league), were recruited and tested during a week in season training period. According to Lorenz et al. (2013) definition of elite athletes, who played at a higher level than peers within a sport (i.e.national vs. regional), the handball teams were categorized as elite and sub-elite. All participants were informed about the purpose as well as experimental risks and benefits of the research.

Procedure

The testing was conducted in two days, on the first day handball players of the first league were tested, and on the second day handball players of the third league were tested. First, the anthropological measurements of the participants were taken, followed by a 20-minute warm-up consisting of running and shaping exercises as well as games on a reduced field in order to bring the participant’s body to an adequate level of preparedness for the test.

Anthropometric characteristics

Martin's anthropometer GPM 101 (GPM GmbH Switzerland) was used to assess body height with an accuracy of 0.1 cm. The subjects stood in an upright position, barefoot on a firm surface, with their feet together, the measurer made sure that the anthropometer was in a vertical position along the back of the body, and then lowered the sliding compass of the anthropometer to the top of the subject's head, the reading is made on the upper opening along the line that is the read indicator.

Body mass was collected using an Omron BF511 bioelectrical impedance (Omron Healthcare Co, Kyoto, Japan) with an accuracy of 0.1 kg. It is measured by the meter entering information about the subject about age, gender, height. The subjects were barefoot on the instrument with underwear on and hands in front, at shoulder height, holding a piece of bioelectrical impedance.

10m sprint, 20m sprint and 30m sprint

The 10 m sprint is a well-known test considered suitable to discriminate the ability of players to accelerate at a short distance (Tomáš et al., 2014). The protocol consisted of three maximal sprint attempts separated by a recovery period of 2 min. Each attempt was performed with a standing position free departure. The assessment of speed was carried out by maximal sprinting at 10m, 20m and 30m, with an increase in speed as high as possible through the first two gate and reaching the maximum speed when the participant passes through the third gate. Each participant repeated the test three times, while the fastest time was taken into further statistical analysis. Photocells (Witty, System, Microgate, Bolzano, Italy) were used. Photocells were placed at a distance of 10 m, 20 m and 30 m from the starting line. The photocells were positioned at the participantt's hip level to minimize the effect of swinging the arm when passing through the gate. The measurer's task was to give a signal to the subject, after the signal the subject starts from a high start position, and has the task of running the given section as fast as possible. The validity and reliability of speed measurement using photocells were proven by Zabaloy et al. (2021).

Countermovement jump and countermovement jump with arm swing

With their hands free to move, the participants began in the tall standing posture with their feet hip-width to shoulder-width apart. quickly descending to a knee flexion of around 90°, then swiftly ascending to the highest point on the vertical plane in one seamless motion. Including a swing of the arms in their most organic, independent way, then leaping vertically with maximum effort and landing in an athletic posture on the ground. After every leap, the participant repositioned to the beginning position, and the process was carried out three times. The leap was declared invalid and repeated if the participant showed excessive knee bending at any time while in the air. Three trials were used for each test, with a one-minute break in between each trial. Similar to the CMJa, individuals began in the tall standing posture and maintained their hands on their hips during the leap when doing CMJ without arm swing. The leap was declared invalid and redone if the competitor ever took their hands off their hips or showed significant knee bending while in the air. Within a single testing session, there was a 15-minute break in between two tests. The vertical leap height was measured using Optojump (Optojump, Microgate, Bolzano, Italy), whose validity and reliability have been verified (Glatthorn et al., 2011).

Squat jump

Subjects were required to assume a static squat position with 90° of knee flexion, and afterward, they performed a purely concentric action with the instruction of jumping as high as possible. The knee angle was monitored and adjusted before each jump by a skilled investigator using a manual goniometer. Subjects generally needed 3–5 seconds to meet the 90° knee angle, and they were instructed to keep this fixed position for another 2 seconds before initiation of the concentric phase (Markovic et al., 2004).

T- test

The modified agility T-test (Sassi et al., 2009) measured speed with directional changes (forward sprinting, left and right shuffling, and backward running); the subjects stepped off behind starting line with both feet.They ran up to cone 1 and placed their right hands on its base; they moved toward to the cone 2 while facing forward and without crossing their feet; they reached the base of the cone with their left hand; they moved toward to the cone 3 while facing right; they placed their left hand on its base.

Handball throwing

A three-step running throw and a jump throw were used to measure the throwing velocity unique to handball. Prior to the test, a 15-minute warmup that comprised running, lateral movement, dynamic stretching, and jumping was conducted. Participants tested by throwing a standard handball (weigh 480 g, circumference 58 cm) at the goal, which was placed 9 meters from each individual. To a maximum of three sets of three consecutive throws, each person proceeded until they had recorded three throws. Between sets, there was a 1 to 2 minute break, and there was a 10-15 second break between each throw.

The throw with the greatest average velocity was selected for analysis. Throwing time was recorded using low coast Pocket radar (Hernández-Belmonte & Sánchez-Pay., 2021).

Handgrip with dominant hand

Maximum hand grip strength of the dominant hand (HGDH) - The test is performed in a standing position. The subject with the outstretched dominant hand makes a maximum fist grip, which is measured with a hand dynamometer. The measurement is repeated three times with a break between repetitions of at least 60s, and the highest value will be used to determine the maximum power. The validity and reliability of this test was confirmed in the study (Gerodimos., 2012).

Statistical analysis

Descriptive statistics were calculated and presented, mean, standard deviation (SD) was ascertained for all variables. One-way ANOVA test were used to determine differences between groups. Student's t-test of independent sample was used to determine the differences between leagues. The statistical level of significance was set at the level of 0.05, while the statistical processing of the data was done using a statistical package (IBM SPSS, version 20).

RESULTS

Table 1: Descriptive statistics in relation to the league

League

		Frequency	Percent
Valid	I league	18	56.3
	II league	14	43.7
	Total	32	100.0

Table 1 shows the descriptive statistics of the players in relation to the league in which they play. 18 players (56.3%) play in the first league, while 14 (43.7) play in the second league.

Table 2: Descriptive statistics in relation to the position

Position

		Frequency	Percent
Valid	goalkeeper	4	12.5
	pivot	5	15.6
	wing	8	25.0
	back	15	46.9
	Total	32	100.0

Table 2 shows the results of the descriptive statistics of the players in relation to the position they play. Out of the total number of players (32), there were 4 goalkeepers, 5 pivots, 8 wings and 15 backs.

In Table 3 shows the statistical significance in relation to the league of the players, there was no statistical significance in the anthropometric tests for the assessment of height and body mass (Sig-.119; Sig-.264). The results showed that in the speed tests there was statistical significance in the variables S10m (Sig-.000), S20m (Sig-.000) and in the variable S30m (Sig-.002). In the T-test for the assessment of agility, a statistical significance of Sig-.000 was reached. In the variables for evaluating the explosive power of the lower extremities, there was a statistically significant difference in the CMJ (Sig-.021) and CMJa (Sig-.036) tests, while there was no statistical significance in the SJ test (Sig-.170). The results of the strength test Handgrip with dominant hand did not show statistical significance Sig-.508, while in the tests the speed of throwing the ball with and without goalkeeper it reached statistical significance (Sig-.001; Sig-.017).

Table 3 : Differences in motor abilities

League	Height	Body Mass	S10m	S20m	S30m	Ttest	CMJ	CMJa	SJ	HGDH	STBWG	STBG
I league	173.63 ±4.71	69.73 ±10.85	1.89± .12	3.33± .18	4.74± .23	10.69 ±.70	27.40± 3.57	32.46 ±4.96	25.07± 4.13	333.83± 65.22	78.55± 6.82	79.66± 6.94
II league	171.07 ±4.17	65.35± 10.71	2.14 ±.10	3.70 ±.20	5.18 ±.47	12.03 ±.89	23.92 4.52	28.70 ±4.58	22.86 ±4.73	318.42± 63.68	72.42 ±6.79	71.21 ±6.06
T test	.119	.264	**.000**	**.000**	**.002**	**.000**	**.021**	**.036**	.170	.508	**.017**	**.001**
goalkeeper	175.00±4 .76	71.82±16 .81	2.03±.2 0	3.63±. 36	5.21±. 56	11.45± 1.04	25.95± 5.70	31.47±6 .75	23.43± 5.88	355.50±3 5.53	72.50±4 .43	71.50±4 .50
back	174.16±3 .95	69.59±9. 68	1.99±.1 5	3.47±. 24	4.86±. 41	11.24±. 83	26.70± 3.82	31.22±3 .71	24.60± 3.59	338.80±7 0.82	78.20±5 .53	78.80±5 .69
wing	168.06±3 .93	58.02±5. 11	1.96±.1 8	3.41±. 28	4.88±. 41	11.33± 1.33	25.35± 3.35	31.31±4 .61	23.45± 4.49	276.12±2 9.58	73.12±6 .51	72.25±7 .12
pivot	172.70±3 .03	74.96±6. 44	2.05±.1 7	3.55±. 22	5.03±. 29	11.13± 1.32	24.20± 6.55	28.30±8 .48	24.22± 6.79	350.80±6 6.86	76.00±1 3.37	77.00±1 2.98
ANOVA	**.008**	**.014**	.838	.565	.483	.973	.719	.712	.937	.061	.341	.151

S10-speed at 10 meter, S20-speed at 20 meters, S30-speed at 30 meters;Ttest- agility test; CMJ- ,countermovement jump; CMJa- countermovement jump with arm swing ; SJ- squat jump; HGDH-handgrip with dominant hand; STBWG-the speed of throwing the ball without goalkeeper; STBG-the speed of throwing the ball with goalkeeper; Sig-statistical significance; MEAN-mean value; SD-standard deviation; T test - Independent Samples Test.

Table 3 shows the results of the ANOVA test. Using the Anova test, we determined the differences between positions. ANOVA test shows the statistical significance in variables height (sig = .008) and body mass (sig = .014). While there was no statistical significance in the variables speed 10m, 20m, and 30m agility T test and CMJ, CMJ-a, SJ, HGDH, STBWG and STBG.

DISCUSSION

The presented results provide valuable insights into the physical and performance characteristics of handball players, specifically with respect to their league level and playing positions. Table 1 reveals that the majority of players (56.3%) compete in the first league, while the remaining players (43.7%) participate in the second league. This distribution may have implications for the level of competition and the physical demands placed on the players (Hermassi, Laudner & Schwesig, 2019). In this paper (Hermassi, Laudner & Schwesig, 2019), second division players showed a lower level of performance in throwing, sprinting, and jumping than first division players.Table 2 demonstrates the distribution of players by position, with 4 goalkeepers, 5 pivots, 8 wings, and 15 backs. Although certain characteristic, such as body mass, may be advantageous in some positions, it may turn into a disadvantage in another position. It can be assumed that pivots need a robust body composition because it offers more stability and the ability to play against the defense pressure through contacts, pushes, and collisions (Krüger, Pilat, Ückert, Frech & Mooren, 2014). The varying demands and roles associated with these positions can impact the physical attributes required for optimal performance (Fieseler et al., 2017). This study provides a detailed analysis of the movement patterns in relation to physiological profiles in the elite professional handball athletes. These findings provide information for talent assessment and evaluation and should assist in position development and optimization training regimes. These findings may also be useful in the prevention, evaluation and treatment of injuries usually held by handball players. In this work, third parties showed a higher level of performance as far as pitching and sprinting from major leaguers, which emphasizes the challenge and difficulty of valid performance and diagnostic program. Performance capacities clearly differ in different playing positions. Table 3 presents the results of anthropometric tests. It is noteworthy that there were no statistically significant differences in height and weight between players of different league. This suggests that players across positions exhibit relatively similar anthropometric characteristics, which is consistent with previous research in handball. According to previous studies, although every team player has different anthropometric values, there is no difference in upper extremity performance tests due to the same trainings and similar shooting and passing activities in all position players (Rousanoglou et al., 2014). The results indicate statistical significance in speed tests (S10m, S20m,S30m) and agility (T-test). These findings imply that certain positions may require greater speed and agility, which is in line with the specific demands of different positions in handball (Šibila & Pori, 2009). While there was no significant difference in squat jump (SJ), the countermovement jump (CMJ) and countermovement jump with arm swing (CMJa) tests did show statistical significance. This suggests that players in certain positions may need greater lower limb explosive power, potentially for activities such as jumping or fast changes in direction (Aloui et al., 2019). The handgrip strength test did not yield statistical significance, indicating that players across positions have similar grip strength. However, the speed of throwing the ball with and without a goalkeeper showed statistical significance, implying that players in different positions may have varying throwing abilities, which could be a crucial factor in scoring and defending (Hermassi, Wollny,Schwesig, Shephard & Chelly,2017). Table 3 summarizes the results of the sample T-test, which compares the obtained values to standardized values. It shows significant differences in 8 out of 12 variables. This implies that specific physical attributes and skills, such as speed, agility, jumping, and throwing ability, differ significantly among players. These differences can be attributed to position-specific requirements and training (Milanese, Piscitelli, Lampis & Zancanaro, 2011). Analysis suggests that players on the wing and in goalkeeper positions differed most from one another. These findings confirm and expand on previous data about the presence of anthropometric differences within playing positions in handball.

CONCLUSION

In conclusion, the study's findings provide valuable insights into the physical characteristics and performance attributes of handball players based on their league level and playing positions. Understanding these differences can inform training programs, player selection, and position-specific coaching strategies to enhance overall team performance and player development.

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DIFFERENCES IN MOTOR ABILITIES OF GYMNASTS IN RELATION TO CHRONOLOGICAL MATURITY

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ABSTRACT

The aim of this research was to determine the differences in motor abilities of gymnasts in relation to chronological maturity. The sample of participants were consisted of 15 gymnasts, aged 7 to 13 years, active members of the Gymnastics club "Niš". The participants were divided into groups based on their age, where the 1st group was consisted of 6 competitors (7-8 years old), the 2nd group was consisted of 5 competitors (9-10 years old) and the 3rd group was consisted of 4 competitors (11-13 years old). The sample of variables were consisted of variables to assess explosive leg strength (countermovement jump (CMJ), countemovement jump with arm swing (CMJa) and long jump (LJ)), flexibility (stick shoulder turn (ST), forward split (FS) and sit and reach (SR)), and balance (flamingo balance test (FT), Y test (YT) and Bass test (BT)). Basic descriptive parameters, the Kolmogorov-Smirnov Z and ANOVA were taken into account for statistical data processing. The results of the study have showed significant differences between the 1st (7-8 years) and 3rd (11-13 years) group and the 2nd (9-10 years) and 3rd (11-13 years) group in all variables of explosive leg strength (CMJ, CMJa, LJ), and significant differences between the 1st and 2nd groups in the CMJa and LJ. In balance variables, the results have showed significant differences between the 2nd and 3rd group (YT and BT), but also significant differences between the 1st and 3rd group (YT). The obtained differences are mostly in favor of older gymnasts, which can be largely attributed to the length of training experience. Whether maturation has an effect on the manifested differences should be further investigated.

Keywords: : explosive strength, range of motion, balance, men's gymnastics, maturation.

INTRODUCTION

Considering that most sports are based on one or a few activities, gymnastics requires the performance of several complex activities at the same time (Sands et al., 2004). Gymnastics training starts very early, already at the age of three or four. Girls are included in the gymnastics school competition system from the age of six, and boys start performing in the first selection at the age of seven. The intensity of exercise and commitment to training is already at the youngest age higher than in most youth sports (Carrick et al., 2007). Achieving top results requires training twice a day, six days a week, so the average number of hours per week is from 27 to 33 hours (Kums, 2008).

As a basic sport, gymnastics affects the development of motor skills: strength, coordination, flexibility and balance (Arruda & Farinatti, 2007; Carrick, Oggero, Pagnacco, Brock & Arikan, 2007). In terms of coordination, gymnastic elements are classified as the most complex movements. Also, testing and periodically monitoring the abilities of young athletes is important for defining training programs adapted to the demands of sport and age. In this way, a harmonious and optimal development of fundamental motor skills is achieved in accordance with the athlete's physical development (Ricotti, 2011). Chronological maturity, which is calculated by taking a single point in time from the date of birth, has long been used in sport to create age groups, identify talented athletes, and set upper and lower limits for exercise performance (Baxter-Jones et al., 2005; Rowland, 2005).)

Based on the author's knowledge, relatively few researches have dealt with this topic. Petković (2007) conducts research with the aim of determining the difference in motor skills and the success of the implementation of the curriculum of artistic gymnastics (reel forward and backward) depending on the participants age. It was found that there is a significant correlation between motor tests and specific motor tasks in both subsamples (5th grade of elementary school and 4th grade of high school). Jakovljević & Ljubojević (2012) have tried to explain the difference in the results achieved by the participants in the expression of coordination in relation to gender, physical activity and the age. The male participants showed better results on the tests for assessing the coordination of the lower extremities, which is quite understandable considering the structure of movement tasks that boys most often perform through the content of popular sports. Female participants showed statistically better results in the ability to reorganize a dynamic stereotype, that is, to move in an unusual way. This is quite expected if it is known that girls of younger school age mostly play games in which activities dominated by the aesthetics of movement are represented, and which are manifested, among other things, through the skills of mastering and orientation in space. The results also show that there are no statistically significant differences in the expression of the ability to coordinate the upper limbs and the coordination of the whole body.

In this specific sport, there is a very small number of researches concerning the differences in the motor abilities of gymnasts in relation to chronological maturity, therefore there is a need for more recent researches. Based on the aforementioned facts, the goal of this research is to determine the differences in the motor abilities of gymnasts in relation to chronological maturity.

METHODS

Subjects

The sample of participants consisted of 15 male gymnasts, active members of the gymnastics club "Nis" from Niš, aged 7 to 13 years. The participants were divided into selections, based on their age, so that the 1st selection consisted of 6 competitors (7-8 years old), the 2nd selection consisted of 5 competitors (9-10 years old) and the 3rd selection consisted of 4 competitors (11-13 years old).

Measurements

To evaluate the explosive strength of the legs, the following variables were taken into account: Countermovement jump (CMJ), Countermovement jump with arm swing (CMJa) and Long jump (LJ).

To assess flexibility, the following variables were taken into account: Stick shoulder turn (ST), Forward split (FS) and Sit and Reach (SR).

To assess the balance, the following variables were taken into account: Flamingo test (FT); Y test (YT) and Bass test (BT).

Statistical analysis

For all the data obtained by testing, the following were calculated: Basic central and distribution parameters: minimum value (Min), maximum value (Max), arithmetic mean (Mean), standard deviation (SD), symmetry of the result distribution curve - Skjunis (Skew), flattening of the result distribution curve – Kurtosis (Kurt). The normality of the distribution of variables was tested with the Kolmogorov-Smirnov test (KS-z and KS-p). ANOVA was used to determine differences between groups. The data obtained by the previously described procedure were processed with the SPSS 19 statistics program.

RESULTS

Table 1. Results of descriptive statistics and normality of distribution – full sample

In total All three groups	N	R	Min	Max	Mean	SD	Skew	Kurt	K-S test	
									K-S Z	KS-p
CMJ	15	17,9	14,1	32,0	22,02	5,10	0,72	0,17	,521	,949
CMJa	15	19,3	18,7	38,0	27,67	5,72	0,42	-0,76	,857	,454
LJ	15	103	127	230	173,33	32,06	0,57	-0,66	,548	,925
ST	15	45	10	55	29,67	12,17	0,53	0,28	,764	,604
FS	15	23	0	23	9,40	8,78	0,17	-1,78	,893	,402
SR	15	18	12	30	17,80	4,43	1,41	3,22	,652	,790
FT	15	7	0	7	1,33	2,06	1,92	3,29	1,411	,037
YT	15	18,10	85,05	103,15	97,26	5,19	-0,90	0,43	,648	,795
BT	15	9,00	1,00	10,00	4,37	3,61	0,90	-1,08	1,152	,140

Legend: N – number of respondents; R – Range; Min - Minimum score; Max - Maximum result; Mean - Mean value; SD - Standard Deviation; Skew – distribution asymmetry; Kurt – roundness of distribution; KS-z - Kolmogorov Smirnov's Z test; KS-p – significance of KS-z; CMJ – Countermovement jump; CMJa – Countermovement jump with arm swing; LJ – Long jump; ST - Stick shoulder turn; FS - Forward split; SR - Sit and Reach; FT – Flamingo Test; YT – Y Test; BT – Bass Test.

Table 2. Results of descriptive statistics and normality of distribution - Age 7-8 years

I group	N	R	Min	Max	Mean	SD	Skew	Kurt	K-S test	
									K-S Z	**KS-p**
CMJ	6	8,3	14,1	22,4	18,33	2,86	-0,01	0,19	,49	,97
CMJa	6	7,2	18,7	25,9	22,75	2,61	-0,46	-0,32	,33	1,00
LJ	6	36	127	163	146,33	13,50	-0,06	-0,88	,44	,99
ST	6	35	20	55	33,33	12,11	1,22	2,11	,68	,74
FS	6	23	0	23	10,83	9,75	0,02	-2,40	,58	,89
SR	6	7	12	19	14,83	2,48	0,87	0,74	,37	1,00
FT	6	7	0	7	2,17	2,79	1,32	0,77	,81	,53
YT	6	9,45	92,85	102,30	97,03	3,67	0,27	-1,43	,45	,99
BT	6	1,00	1,50	2,50	2,00	0,32	0,00	2,50	,82	,52

Legend: N – number of respondents; R – Range; Min - Minimum score; Max - Maximum result; Mean - Mean value; SD - Standard Deviation; Skew – distribution asymmetry; Kurt – roundness of distribution; KS-z - Kolmogorov Smirnov's Z test; KS-p – significance of KS-z; CMJ – Countermovement jump; CMJa – Countermovement jump with arm swing; LJ – Long jump; ST - Stick shoulder turn; FS - Forward split; SR - Sit and Reach; FT – Flamingo Test; YT – Y Test; BT – Bass Test.

Table 3. Results of descriptive statistics and normality of distribution - Age 9-10 years

II group	N	R	Min	Max	Mean	SD	Skew	Kurt	K-S test	
									K-S Z	**KS-p**
CMJ	5	6,3	17,9	24,2	21,34	2,47	-0,32	-0,61	0,39	1,00
CMJa	5	6,4	25,4	31,8	27,60	2,87	0,98	-1,16	0,77	0,59
LJ	5	43	152	195	172,60	15,68	0,27	0,96	0,41	1,00
ST	5	40	10	50	28,00	16,05	0,30	-1,02	0,43	0,99
FS	5	16	0	16	7,20	7,16	0,05	-2,32	0,54	0,93
SR	5	5	16	21	19,00	2,35	-0,58	-2,63	0,59	0,87
FT	5	4	0	4	1,00	1,73	1,92	3,67	0,71	0,69
YT	5	16,55	85,05	101,60	93,74	6,20	-0,27	0,19	0,33	1,00
BT	5	8,50	1,00	9,50	3,90	3,60	1,21	0,28	0,67	0,75

Legend: N – number of respondents; R – Range; Min - Minimum score; Max - Maximum result; Mean - Mean value; SD - Standard Deviation; Skew – distribution asymmetry; Kurt – roundness of distribution; KS-z - Kolmogorov Smirnov's Z test; KS-p – significance of KS-z; CMJ – Countermovement jump; CMJa – Countermovement jump with arm swing; LJ – Long jump; ST - Stick shoulder turn; FS - Forward split; SR - Sit and Reach; FT – Flamingo Test; YT – Y Test; BT – Bass Test.

Table 4. Results of descriptive statistics and normality of distribution - Age 11-13 years

III group	N	R	Min	Max	Mean	SD	Skew	Kurt	K-S test	
									K-S Z	**KS-p**
CMJ	4	8,7	23,3	32,0	28,40	4,17	-,54	-2,92	,56	,92
CMJa	4	6,6	31,4	38,0	35,13	2,78	-,84	1,21	,46	,98
LJ	4	45	185	230	214,75	20,45	-1,66	2,76	,63	,83
ST	4	15	20	35	26,25	7,50	,37	-3,90	,60	,87
FS	4	20	0	20	10,00	10,98	,00	-5,92	,59	,88
SR	4	15	15	30	20,75	6,50	1,41	2,32	,59	,87
FT	4	1	0	1	,50	,58	,00	-6,00	,61	,85
YT	4	2,10	101,05	103,15	102,03	,92	,36	-1,63	,39	1,00
BT	4	6,00	4,00	10,00	8,50	3,00	-2,00	4,00	,88	,42

Legend: N – number of respondents; R – Range; Min - Minimum score; Max - Maximum result; Mean - Mean value; SD - Standard Deviation; Skew – distribution asymmetry; Kurt – roundness of distribution; KS-z - Kolmogorov Smirnov's Z test; KS-p – significance of KS-z; CMJ – Countermovement jump; CMJa – Countermovement jump with arm swing; LJ – Long jump; ST - Stick shoulder turn; FS - Forward split; SR - Sit and Reach; FT – Flamingo Test; YT – Y Test; BT – Bass Test.

Tables 1 to 4 show the basic descriptive parameters (Range, Minimum score, Maximum score, mean value and standard deviation). Also, the values of Skewnees, Kurtosis and Kolmogorov-Smirnov Z test and it's significance for all variables are shown. By looking at these values, it can be concluded that all variables do not deviate statistically significantly from the normal distribution, and parametric statistics procedures can be applied.

Table 5. – ANOVA

Varijable	df	F	Sig.
CMJ	2	12,60	,00
CMJa	2	24,48	,00
LJ	2	21,41	,00
ST	2	,44	,66
FS	2	,22	,81
SR	2	3,17	,08
FT	2	,87	,44
YT	2	4,11	,04
BT	2	7,81	,01

Legend: df – degree of freedom; F - F test; Sig. - the significance of the F test; CMJ – Countermovement jump; CMJa – Countermovement jump with arm swing; LJ – Long jump; ST - Stick shoulder turn; FS - Forward split; SR - Sit and Reach; FT – Flamingo Test; YT – Y Test; BT – Bass Test.

Table 5 shows the values of the F test and it;s significance. By looking at the significance of the F test, it can be concluded that there is a statistically significant difference between the mean values of the three observed groups in the explosive power variables - CMJ, CMJa, LJ and balance variables - (YT, BT). Table 6 provides a more precise insight into the recorded differences.

Table 6. - ANOVA - individual differences between arithmetic means with statistical significance

Multiple Comparisons				
Tukey HSD				
Dependent Variable			Mean Difference	Sig.
CMJ	7-8 years	9-10 years	-3,01	0,29
		11-13 years	-10,07	0,00**
	9-10 years	7-8 years	3,01	0,29
		11-13 years	-7,06	0,01**
CMJa	7-8 years	9-10 years	-4,85	0,03*
		11-13 years	-12,38	0,00**
	9-10 years	7-8 years	4,85	0,03
		11-13 years	-7,53	0,00**
LJ	7-8 years	9-10 years	-26,27	0,05*
		11-13 years	-68,42	0,00**
	9-10 years	7-8 years	26,27	0,05
		11-13 years	-42,15	0,01**
YT	7-8 years	9-10 years	3,29	0,44
		11-13 years	-5,00	0,21
	9-10 years	7-8 years	-3,29	0,44
		11-13 years	-8,29	0,04*
BT	7-8 years	9-10 years	-1,90	0,46
		11-13 years	-6,50	0,01**
	9-10 years	7-8 years	1,90	0,46
		11-13 years	-4,60	0,05*

Legend: CMJ – Countermovement jump; CMJa – Countermovement jump with arm swing; LJ – Long jump; YT – Y Test; BT – Bass Test.;Mean Difference - Differences between arithmetic means, Sig. -

Statistical significance of differences of arithmetic means; * - statistical significance at the 0.05 level; ** - statistical significance at the 0.01 level

Table 6 shows only the variables in which significant differences between arithmetic means were found. As already mentioned, the differences were noted in motor skills, explosive power and balance.

In terms of explosive power, significant differences in arithmetic means are present between the First and Third group and the Second and Third group (at the significance level of 0.01) in the variable Countermovement jump (CMJ). Also for the same abilities, but for the variables Countermovement jump with arm swing (CMJa) and Long jump (LJ), significant differences of the arithmetic means were determined between all three groups, with this significance only between the First and Second group at the 0.05 level.

In balance, significant differences in the arithmetic means were registered for two variables, the Ypsilon test (YT) and the Bass test (BT). Significant differences between the first and third group were found in the Bass test (at a significance level of 0.01), and between the second and third group in both mentioned tests (at a significance level of 0.05).

DISCUSSION

The aim of this research was to determine the differences in motor abilities of gymnasts in relation to chronological maturity. The main findings were significant differences in explosive strength and balance variables. The mentioned statement most often occurs between the first (age 7-8 years) and the third (age 11-13 years).

Recorded differences in explosive power are exclusively in favor of older groups and the differences in this ability can be attributed to the examinee's maturation but also to the length of the training period. The appearance of significant differences is largely related to the graduation levels of the analyzed sample. With age, the level of explosive power in children also increases, partly due to maturation. Doing artistic gymnastics only improves the quality of this ability, which is confirmed by the research of Malina et al. 2013). The best period for developing explosive strength in boys is from 13 to 15 years old (Bompa, 2006) and the boys of the 3rd selection are closest to that period. It is generally known that leg explosive strength exercises are a specialized high-intensity training method aimed at increasing explosive strength specific to each sport (Adams et al 1992), including artistic gymnastics. The influence of the aforementioned largely depends on the training experience and the length of time of application of methods for the development of explosive strength. The results of the research confirmed that training experience has a significant impact on the emergence of differences between groups. Namely, gymnasts of the 3rd selection have training experience of 5 years or more, gymnasts of the 2nd selection 3 years or more, while gymnasts of the first selection have been involved in the training process for less than two years. In the end, the competition program itself on all apparatuses, even on ones where the explosive power of the lower extremities is most evident (floor and vault), slowly becomes more difficult with training experience and age. This means that older gymnasts train more complex and explosively demanding jumps and acrobatic elements. This also requires increased work on the development of this ability in older gymnasts, so this should also be cited as the reason for the differences in the explosive strength tests.

Recorded significant differences in balance are in favor of better results in older participants, and as in the previous case, it can be concluded that the differences are more due to a longer training period and less to the participants maturation. Gymnastics training is partly aimed at developing the gymnast's specific balance. Training of static balance elements such as scales, handstands (on the one hand as well) and dynamic balance elements, such as exercise on a pommel horse and parallel bars, on the other hand, are an integral part of the training process and certainly influence the improvement of balance.

It is interesting that there are no significant differences between the arithmetic means in the part of flexibility. This can be attributed to the design of the flexibility assessment tests and their metric characteristics, particularly in sit and reach and stick shoulder turn. These two tests are highly dependent on the anthropometric parameters of the subjects. Specifically, the length of the legs, arms and trunk of the sit and reach and the shoulder width of the stick shoulder turn.

CONCLUSION

Based on the subject, aim and results of the research, it can be concluded:

Significant differences of arithmetic means in explosive power in relation to chronological maturity were determined. The differences are in favor of the older ones, which can largely be attributed to graduation and the length of training experience of the gymnasts.

Significant differences of the arithmetic means were determined in two of the three variables used to assess the level of balance. The obtained differences are mostly in favor of older gymnasts, which can be largely attributed to the length of training experience. Whether maturation has an effect on the manifested differences should be further investigated.

Although gymnastics training improves the level of flexibility, the recorded significance of the arithmetic means in flexibility variables did not confirm this. Namely, there are no statistically significant differences between the groups. This can be partly explained by the dependence of applied flexibility tests on anthropometric parameters. The aforementioned should be additionally confirmed by applying tests for checking flexibility that are not dependent on anthropometric parameters - by applying goniometric tests that record the angle of movement achieved.

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COMPARATIVE ANALYSIS OF ANTHROPOMETRIC CHARACTERISTICS AND POSTURAL STATUS BETWEEN PRESCHOOL CHILDREN FROM URBAN AND RURAL AREAS IN THE MUNICIPALITY OF ČAČAK

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ABSTRACT

The aim of the study was to determine urban-rural differences in anthropometric characteristics, prevalence of obesity, and postural status among preschool children aged 6-7. A total of 922 preschool children aged 6-7 from the municipality of Čačak participated in this cross-sectional study (452 boys and 470 girls). The sample was divided by settlement type into urban and rural inhabitants. Anthropometric characteristics were assessed using a battery of three variables: body height (BH), body weight (BW), and body mass index (BMI). BMI was categorized based on the World Health Organization's (WHO) cut-offs. Postural status was evaluated by a physiatrist, and postural parameters such as foot status, scoliosis, and shoulder droop were determined using the method. It was found that preschool children from rural areas have significantly higher body mass index (BMI) values compared to children from urban areas. Furthermore, it was concluded that every fourth preschool-age child is overweight or obese. There was also an association between weight status and residential status. As for the analysis of postural status, a high percentage of foot deformities and shoulder droop were observed, while the prevalence of scoliosis was considerably lower, with approximately one in four children having scoliosis. However, due to the limited anthropometric variables and subjective assessment of postural status, these results should be taken with caution. Nevertheless, this study has made a significant contribution to the assessment of the anthropometric and postural status of children in the municipality of Čačak and can be considered a pivotal initiative, as it is the first study of its kind conducted in this part of Serbia. Thus, this research can serve as a starting point for future practical and research endeavors.

Keywords: morphological characteristics, BMI status, prevalence of obesity, postural deformities, children

INTRODUCTION

Children play a significant role in society, and monitoring their development is essential for assessing health trends and strategies (Sofi & Senthilvelan, 2021). The preschool period, spanning from ages 3 to 7, is considered a critical phase in the holistic development of an individual (Bala, 2002). During this period, children experience rapid growth, although not evenly distributed. Annual height growth is approximately 6-8 cm, with a weight increase of about 2 kg per year (Milanović & Stamatović, 2009).

General motor skills, particularly coordination, may be relatively weak during this age, but basic movements become automated, and motor control improves by the end of this period (Herodek, Živković, & Aleksić-Veljković, 2019).

Today's children spend half of their waking hours in a sedentary position (Colley et al., 2013), which, combined with a lack of physical activity and unhealthy eating habits, contributes to obesity (Planinšec & Matejek, 2004; Mendonça & Anjos, 2004). Obesity is linked to serious health problems such as type 2 diabetes, asthma, hypertension, early atherosclerosis, psychosocial issues, and more (Dikanović & Vignjević, 2009). Olshansky et al. (2005) caution that younger generations may live less healthy lives and have shorter life spans due to these factors. Obesity is prevalent among children and is currently one of the most common public health problems (Kisić-Tepavčević et al., 2008; Kumar & Kaufman, 2018). Recent studies have reported a noticeable upward trend in the prevalence of overweight and obesity over the past two decades (Wang & Lobstein, 2006; Ogden et al., 2016; Rodriguez-Martinez et al., 2020). The World Health Organization (WHO) highlights a significant increase in the proportion of obese children worldwide, from 4% in 1975 to over 18% in 2016 (World Health Organization, 2021).

In addition to its impact on obesity, a lack of physical activity can also lead to muscle hypotrophy and reduced muscle tone. Muscle weakness and imbalances can result in poor posture during movement or rest, leading to the development of postural deformities that may affect the spine, legs, and feet (Živković, 2009; Simov, Minić, & Stojanović, 2011). It's crucial to consider that a child's skeletal system develops rapidly, with the spinal column beginning to form its natural curves as early as the fourth year of life when bones are still relatively soft and susceptible to deformities (Milanović & Stamatović, 2009). Therefore, identifying postural problems in the preschool age is essential for promoting proper body posture in early childhood, not only aiding in proper growth and development but also positively impacting overall health and quality of life for children (Protić - Gava & Krneta, 2010).

Recent research indicates that the prevalence of postural deformities in the spinal column is steadily increasing (Radaković et al., 2017; Vukićević, Čokorilo, Lukić, Miličković & Bjelica, 2018; Vukićević, Pajić, Čokorilo, Lukić, Miličković, et al., 2018). Notably, foot deformities are observed in as much as 60% of children (Romanov, Stupar, Međedović, & Brkin, 2014), while deviations from proper spinal posture in the frontal and sagittal planes affect around 70% of participants, with boys more frequently displaying scoliotic posture. Postural issues are prevalent among children from both urban and rural backgrounds, with certain deformities being more common in urban groups and others in rural ones (Romanov et al., 2014).

Based on residential status, areas have been categorized as urban or rural, with urban areas having higher population density and more infrastructure compared to surrounding regions, while rural areas have lower population density and more agricultural land (Tishukaj et al., 2017). Previous research has shown that health aspects, BMI, obesity prevalence, and postural deformities can vary depending on residential and socioeconomic status (Aberle, Blekić, Ivaniš, & Pavlović, 2009; Romanov et al., 2014; Djordjic, Radisavljevic, Milanovic, Bozic, Grbic, et al., 2016; Katanic et al., 2023). Understanding these associations can provide valuable insights into addressing health disparities among children living in different urban and rural environments.

The analysis of anthropometric characteristics and postural status serves as indicators of the general and specific health status of a particular population in a specific area. When discussing general and specific health status, this primarily refers to nutritional status, the prevalence of deformities, levels of motor, functional, cognitive, and other abilities and characteristics. To address contemporary civilization diseases (diabetes, cardiovascular diseases, hypokinesia, etc.), these analyses should begin from the earliest days. Based on previous research, there have been observed differences in anthropometric characteristics and postural status between children from urban and rural areas. However, no studies have specifically examined the anthropometric and postural status of preschool children in the municipality of Čačak. Therefore, the aim of this study was to assess disparities in urban-rural anthropometric characteristics, nutritional status, and postural status among 6 and 7-year-old preschool children in the Čačak municipality. This research will contribute to diagnosing the anthropometric and postural status of children in the Čačak municipality, as it represents the first study of its kind in this part of Serbia and can serve as a starting point for future practical and research endeavors.

METHODS

Subjects

The sample consisted of preschool children aged 6-7 from the municipality of Čačak. A total of 922 children participated in this cross-sectional study (452 boys and 470 girls). The sample was divided by type of settlement. The criteria for categorizing settlement types were administrative classification and population size. Rural settlements included villages and small towns with 10,000 or fewer inhabitants, while urban settlements had more than 10,000 inhabitants (Monstat, 2011). The municipality of Čačak is located in the central part of central Serbia in the Moravica District and encompasses 58 settlements. According to preliminary results from the 2022 census, the municipality of Čačak has a population of 106,453 residents. Of the 58 settlements in this study, in addition to the city of Čačak, the urban area includes Atenica and Ljubić, while all other settlements are classified as rural areas because, by the definition of rural areas, the population density is less than 150 inhabitants/km^2 or less than 10,000. Characteristics of the sample population are provided in Table 1. Students participated voluntarily with parental consent in the research process, and this study was conducted in accordance with the principles of the Helsinki Declaration.

Procedure

The standard international biological procedure was used to determine morphological characteristics (Eston & Reilly, 2013). Anthropometric characteristics were assessed using a battery of three variables: body height (BH), body weight (BW), and body mass index (BMI). BMI was calculated based on the standard formula: BMI = BM (kg)/BH (m)^2 (BM—body mass, BH—body height). BMI was categorized based on the World Health Organisation's (WHO) cut-offs to underweight, normal weight, overweight and obese individuals (Onis et al., 2007). The body mass index has a high correlation with the amount of body fat and for these reasons is used as an indicator of nutritional levels in children (Costill, Kenney, & Wilmore). The postural status was assessed by a specialist in physical medicine using a visual method, and the following postural parameters were evaluated: foot status, scoliosis, and shoulder droop syndrome.

Statistical analysis

Basic parameters of descriptive statistics were calculated: arithmetic mean, standard deviation, minimum, maximum, range and percentages. To determine differences in anthropometric characteristics between Urban and Rural groups a t-test for small independent samples was used. The association between nutritional status and residential status, as well as postural status with residential status, was assessed using a non-parametric technique - the chi-square test. For all statistical analyses, significance was accepted at $p<0.05$. Data processing was performed using the statistical program SPSS 26 (Statistical Package for Social Sciences, v26.0, SPSS Inc., Chicago, IL, USA).

RESULTS

Based on descriptive statistics, it was determined that preschool children from urban areas had an average body height of 124.55±5.48 cm, body weight of 24.83±4.49 kg, and BMI of 15.86±2.00, while children from rural areas had an average body height of 123.88±5.48 cm, body weight of 25.38±5.61 kg, and BMI of 16.37±2.66.

Table 1. Descriptive Statistics of Anthropometric Parameters by Residential Status of Preschool Children

		N	Mean	SD	Min	Max	Range
Urban	Age	612	6.65	0.28	6.00	7.42	1.42
	Body Height	612	124.55	5.48	104.50	144.00	39.50
	Body Mass	612	24.83	4.49	15.50	51.50	36.00
	BMI	612	15.86	2.00	11.10	26.57	15.47
Rural	Age	310	6.63	0.28	6.08	7.33	1.25
	Body Height	310	123.88	5.48	110.50	138.00	27.50
	Body Mass	310	25.38	5.61	15.50	48.00	32.50
	BMI	310	16.37	2.66	11.52	28.80	17.28

Total	Age	922	6.65	0.28	6.00	7.42	1.42
	Body Height	922	124.32	5.48	104.50	144.00	39.50
	Body Mass	922	25.01	4.90	15.50	51.50	36.00
	BMI	922	16.03	2.26	11.10	28.80	17.70

Legend: N-Number of participants, SD- Standard deviation; Min-Minimum; Max-Maximum

Based on an independent samples t-test (table 2), it was determined that preschool children from rural areas had significantly higher BMI values than children from urban areas (p=0.003), while there was no significant difference in the parameters of body height and body weight between the groups.

Table 2. Differences in Anthropometric Characteristics among Groups of Children Based on Residential Status.

	Urban	Rural	t	p
Body Height	124.55±5.48	123.88±5.48	1.774	0.076
Body Mass	24.83±4.49	25.38±5.61	-1.500	0.134
BMI	15.86±2.00	16.37±2.66	-2.961	**0.003***

Legend: t - Coefficient of the t-test; p - Coefficient of significance.

In the table 3, the distribution of nutritional status by residential status was noticeable. Among urban children, there were 3.6% undernourished, 73.9% normal weight, 16.0% overweight, and 6.5% obese. Similarly, among rural children, the distribution was 3.2% undernourished, 72.3% normal weight, 11.3% overweight, and 13.2% obese. Based on the χ2 test, there was an association between nutritional and residential status (p=0.003, φ=0.122).

Table 3. The Association between Nutritional Status and Residential Status

	Undernutrition	Normal weight	Overweight	Obese	Total
Urban	22 3.6%	452 73.9%	98 16.0%	40 6.5%	612 100%
Rural	10 3.2%	224 72.3%	35 11.3%	41 13.2%	310 100%
Total	32 3.2%	676 72.3%	133 11.4%	81 13.2%	922 100%
	χ2(3, n-922)=13.816, p=**0.003**, φ=0.122				

Legend: χ2 - Coefficient of the χ2-test; p - Coefficient of significance, φ - measure of association.

Table 4 has shown that a significant number of children in both urban (76.1%) and rural (73.9%) areas had certain foot deformities at this age. Based on the chi-square test, it was determined that there is no association between foot status and residential status.

Table 4. The Association between Foot Status and Residential Status

	No deformity	Has deformity	Total
Urban	146 23.9%	466 76.1%	612 100%
Rural	81 26.1%	229 73.9%	310 100%
Total	227 24.6%	695 75.4%	922 100%
	χ2(1, n-922)=0.457, p=0.499, φ=-0.025		

Legend: χ2 - Coefficient of the χ2-test; p - Coefficient of significance, φ - measure of association.

Table 5. The Association between Scoliosis and Residential Status

	No deformity	Has deformity	Total
Urban	465 76.0%	147 24.0%	612 100%
Rural	235 75.8%	75 24.2%	310 100%
Total	700 75.9%	222 24.1%	922 100%
	χ2(1, n-922)=0.000, p=1.000, φ=0.002		

Legend: χ2 - Coefficient of the χ2-test; p - Coefficient of significance, φ - measure of association.

Table 5 displayed scoliosis, with 24.0% of urban children and nearly the same percentage in rural children (24.2%) having scoliosis. Also, based on the chi-square test, it was determined that there is no association between scoliosis and residential status.

In this table (Table 6), it is noticeable that 57.5% of urban children and 64.2% of rural children had a dropped shoulder deformity. Also, based on the chi-square test, it was determined that there is no association between dropped shoulder and residential status.

Table 6. The Association between Dropped Shoulder and Residential Status

	No deformity	Has deformity	Total
Urban	260 42.5%	352 57.5%	612 100%
Rural	111 35.8%	199 64.2%	310 100%
Total	371 40.2%	551 59.8%	922 100%
	$\chi 2(1, n\text{-}922)=3.543$, $p=0.060$, $\varphi=0.064$		

Legend: $\chi 2$ - Coefficient of the $\chi 2$-test; p - Coefficient of significance, φ - measure of association.

DISCUSSION

The aim of this study was to investigate disparities in anthropometric measurements, nutritional well-being, and postural health among 6 and 7-year-old preschool children in the Čačak municipality. Additionally, we aimed to diagnose the anthropometric and postural status of children in this region, marking the inaugural study of its kind in this part of Serbia, and potentially serving as a foundational point for forthcoming practical and research initiatives. Significantly higher BMI values were observed in preschool children from rural areas compared to their urban counterparts ($p=0.003$). However, there were no significant variations in body height and weight parameters between these two groups. In urban areas 16.0% of children were overweight, and 6.5% were obese, while in rural areas 11.3% were overweight, and 13.2% were obese. A statistical analysis ($\chi 2$ test) demonstrated an association between nutritional status and residential location ($p=0.003$, $\varphi=0.122$). Unlike our research, similar research conducted in Poland, which compared Body Mass Index (BMI) between adolescents living in urban and those living in rural areas of southwestern Poland found no significant differences in nutritional status of subjects in regard to place of living (Czajka et al., 2013). While some findings suggest that children from rural areas have lower BMI values compared to children from urban environments (Chillon, Ortega, Ferrando, & Casajus, 2011).

Between 2015 and 2017, the fourth round of the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI) was carried out across 36 countries in children between 6 and 8 years. This study evaluates the weight status of these children and compares the prevalence of childhood overweight, obesity, and thinness across Northern, Eastern, and Southern Europe, as well as Central Asia. The findings revealed significant geographic variations in height, weight, and body mass index (BMI). On average, children in Northern Europe were the tallest, those in Southern Europe were the heaviest, while children in Central Asia were the lightest and shortest. Overall, 28.7% of boys and 26.5% of girls were categorized as overweight (including obesity), with 2.5% of boys and 1.9% of girls classified as thin according to WHO criteria. Obesity prevalence ranged from 1.8% of boys and 1.1% of girls in Tajikistan to 21.5% of boys and 19.2% of girls in Cyprus, with a tendency for higher rates among boys. Levels of thinness, stunting, and underweight were relatively low, except in Eastern Europe (for thinness) and Central Asia. Authors concluded that despite ongoing efforts to combat it, this study underscores that unhealthy weight status remains a significant concern within the WHO European Region (Spinelli et al., 2021). Another study on childhood obesity has shown that the data varies in different countries. For instance, in Germany, an obesity rate of 8.7% was reported, in Finland 13%, in the Czech Republic 16%, in Greece 33%, and in Italy, an astonishing 36% (Cali & Caprio, 2008).

A notable percentage of both urban (76.1%) and rural (73.9%) children exhibited certain foot deformities at this age. However, a chi-square test indicated that there was no significant association between foot conditions and residential status. Scoliosis was present in 24.0% of urban children and nearly the same percentage in rural children (24.2%), with no significant association between scoliosis and residential status as determined by a chi-square test. It is worth noting that 57.5% of urban children and 64.2% of rural children displayed dropped shoulder deformities, with a similar absence of association between dropped shoulder conditions and residential status based on a chi-square test.

When it comes to foot deformities, similar results were obtained in the study by Mihajlović and colleagues (2010), where foot deformities were recorded in 71.5% of girls of the same age in the Novi Sad area, and a slightly lower percentage of foot deformities (60% of the participants) was found in the study by Romanov, Stupar, Međedović, & Brkin (2014) in the same area. As for scoliosis, authors Simov, Minić, & Stojanović (2011) reported that a significantly lower percentage of children had scoliosis (11.34%) compared to our values. In contrast to these data, a much higher percentage of scoliosis (44.8%) was found in 7-year-old children (Vukićević et al., 2018). The same authors state that there is no difference in the prevalence of deformities between children from urban and rural areas (Vukićević et al., 2018). However, since these are mostly subjective assessments of postural status, these results should be taken with caution.

Socioeconomic factors have a significant impact and manifest themselves through various social structures in urban and rural environments, leading to different lifestyles and ways of spending time, both in school and during leisure (Li, Kearney, Keane, Harrington, & Fitzgerald, 2017; Olson, March, Brownlow, Biddle, & Ireland, 2019). The variations among children in different settings can be attributed to disparities in their lifestyles, dietary habits, and the nutritional content of their food. The presence of sanitary condition posters, awareness dramas, and educational programs within schools contributed significantly to students' comprehensive understanding of healthy practices (Scaglioni et al., 2018). In contrast, the absence of such initiatives and the inadequate implementation of an up-to-date curriculum in rural schools resulted in a lack of knowledge regarding healthy habits among students residing in rural areas. The findings in this area emphasize the importance of providing a balanced diet for all individuals, especially growing children. Consequently, future research should consider factors such as food intake, educational backgrounds, and economic statuses among children in rural and urban areas.

Numerous studies have shown that obese children exhibit lower levels of physical activity (Elmesmari et al., 2018), poorer motor skills (Barnett et al., 2016; Banjevic et al., 2022), and a higher prevalence of postural disorders (Shapouri et al., 2019) compared to children of normal weight. This is why the World Health Organization (WHO) has adopted the Global Strategy on Diet, Physical Activity, and Health to support the health and proper physical and motor development (WHO, 2021). The first step in this direction should be monitoring weight and postural status during the preschool years, as it is essential for preventing obesity, reducing health risks, and addressing and correcting postural deformities (Noorwali, Aljaadi, & Al-Otaibi, 2023). Furthermore, it is important for each country to conduct national research and implement strategies following WHO guidelines to adequately address the global issue of childhood obesity, as these parameters play a crucial role in assessing the quality of life and future health status (Pokos, Lauš, & Badrov, 2014).

The strength of this study lies in the assessment of anthropometric, weight, and postural status in a large sample (n=922) of preschool-aged children, and its significance is even greater as it represents the first study to assess these parameters in the mentioned area.

On the other hand, the main limitations of this study are related to the limited number of anthropometric variables and the subjective assessment of postural status, despite being conducted by a specialist in physical medicine. Therefore, future research should consider incorporating a larger set of anthropometric parameters, and ideally, body composition parameters, to provide a more comprehensive picture of children's body composition. Additionally, it is advisable to examine postural status using objective and contemporary measuring instruments.

CONCLUSION

In this study, it was determined that preschool children from rural areas have significantly higher body mass index (BMI) values compared to children from urban areas. Additionally, it was concluded that every fourth preschool-aged child is either overweight or obese. There was also an association between weight status and residential status. As for the analysis of postural status, a high percentage of foot deformities and shoulder droop were observed, while the prevalence of scoliosis was considerably lower, with approximately one in four children having scoliosis. However, due to the limited number of anthropometric variables and the subjective assessment of postural status, these results should be interpreted with caution.

This study has made a significant contribution to the assessment of the anthropometric and postural status of children in the municipality of Čačak and can be considered a pivotal initiative, as it is the first study of its kind conducted in this part of Serbia. This research can serve as a starting point for future practical and research endeavors. Specifically, the practical aspect would involve taking further steps in the prevention and treatment of obesity and postural deformities in preschool children. It would aid physical education instructors and physiotherapists in creating appropriate physical exercise programs aimed at reducing obesity and improving the postural status of children. On the other hand, continuing research is essential to gain a more comprehensive understanding of the physical development of children through a thorough analysis of anthropometric and postural parameters.

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EXAMINATION OF FACTORS AFFECTING THE DRIVE FOR MUSCULARITY IN INDIVIDUALS EXERCISING IN THE GYM

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ABSTRACT

Today, the body of human percieve as a “mirror of human existence” and thus a means of presenting oneself to the outside world. It is known that in patriarchal and heterosexist cultures, women are expected to have a "slim and sexy body image," while men are expected to have a "strong and muscular physique." To achieve this ideal body structure and have a positive image in their minds, individuals may engage in sports activities such as fitness, and bodybuilding. Given the physical and psychological consequences of the drive for muscularity, it is thought critical to identify the urge factors that contribute to it. With this framework, the aim of the research was to examine the relationship between the drive for muscularity and factors such as exercise, meal frequency, monthly income, and type of accommodation. This research was designed using the survey model, which is one of the quantitative research methods. The research sample consisted of 465 participants. Participants were determined by the criteria sampling method. In this study, the data collection tool, the original name "Drive for Muscularity Scale", adapted into Turkish and named "Kaslı Olma Dürtüsü Ölçeği" was used. Data were analyzed with the IBM Statistics (SPSS version 26.0, Armonk, NY). The result of this study show that the drive for muscularity was affected by variables including exercise frequency, meal frequency, monthly income and type of accommodation. Considering the existing literature, the relationship between the motivation drive for muscularity and type of accommodation and monthly income has not been adequately studied. In this regard, it is advised that future studies look at the aforementioned variables.

Keywords: Muscularity, Exercise frequency, Meal frequency, Monthly income, Type of accommodation

INTRODUCTION

Today, the body of human percieve as a “mirror of human existence” and thus a means of presenting oneself to the outside world (Okumuş, 2009). It is known that in patriarchal and heterosexist cultures, women are expected to have a "slim and sexy body image," while men are expected to have a "strong and muscular physique." In Western societies in particular, the ideal male body is defined as muscular and lean (Hausenblas and Fallon, 2002). A V-shaped muscular male body is portrayed as the ideal male body image in modern society, but it is also accepted as an indicator of many positive traits such as happiness, success, and charm (McCabe and Ricciardelli, 2005; Tiggemann, 2011). To achieve this ideal body structure and have a positive image in their minds, individuals may engage in sports activities

(Hausenblas and Fallon, 2002) such as fitness, and bodybuilding. Bodybuilding is preferred by males who have a desire to be muscular (Mosley 2009; StockVis, 2006).

As a matter of fact, the exponential increase in the number of men doing bodybuilding sports in the world in recent years (Mosley, 2009; Stokvis, 2006) is an important indicator of how important the drive for muscularity is for men (Selvi and Bozo, 2019). In addition, a study by Cho and Lee (2013) showed that defining the muscular male body as the ideal male body revealed the relationship between the perception of the ideal male body and the drive for muscularity. In addition, a study by Pope et al. (2000) highlighted those males rated their ideal body shape as being approximately 13 kilograms more muscular than their own body.

The aspiration to have the desired physical appearance can also lead to more exercise (Bruno et al., 2014). As the drive for muscularity influences the exercise behaviour and dietary factors of many athletes, particularly among bodybuilders (Yarar et al., 2022), it is important to determine the relationship between exercise and diet frequency. Furthermore, Ojala et al. (2012) reported that body image is a multidimensional structure of the development and change of attitudes under biological, psychological, social and cultural influences (Ojala et al., 2012). In this context, it is thought that factors such as income and education level and the environment in which the person lives may be related to the urges of male individuals to be muscular.

Although the drive for muscularity may appear to be an indicator of an active and healthy lifestyle, it has been shown to have negative effects on both mental and physical health (Selvi and Bozo, 2019). In this sense, behaviours that could put physical health at risk, such as the use of anabolic steroids to further increase muscle development and applying an intense training program, are associated with the drive for muscularity (Robert et al., 2009). At the same time, it has been emphasized that the drive for muscularity can have negative effects on psychological health such as depression, difficulties in emotional regulation and low self-esteem (Sepulveda et al., 2016; McCreary and Sasse, 2000; Van-Amsterdam et al., 2010). Given the physical and psychological consequences of the drive for muscularity, it is thought critically to identify the urge factors that contribute to it. With this framework, the aim of the research was to examine the relationship between the drive for muscularity and factors such as exercise, meal frequency, monthly income, and type of accommodation.

METHODS

This cross-sectional study was designed using the survey model from the quantitative research method defined by Karasar (2006). Before the study, the participants signed a voluntary consent form stating that they voluntarily participated in the study after they were informed about it.

Participants

The research sample consisted of 465 participants. Participants were determined by the criteria sampling method. In this context, the male participants who trained at fitness centers were included in this research according to inclusion criteria, while the ones who didn't train at fitness centers were not. The demographic characteristics of the Participants are shown in Table 1.

Table 1. Demographic characteristics of participants

Variables	Category	Frequency	Percentage %
Marital Status	Married	55	11,8
	Single	398	85,6
	Widower	12	2,6
Age	18-25	284	61,1
	26-34	155	33,3
	35-40	26	5,6
Education Level	Associate degree	137	29,5
	Bachelor	257	55,3
	Postgraduate	71	15,3
Weekly exercise frequency	1-2 day	167	35,9
	3-4 day	213	45,8
	+5 day	85	18,3
Type of accommodation	Living alone	52	11,2
	Living with friends	63	13,5

	Living with family	203	43,7
	Living in dormitory	92	19,8
	Living with spouse	55	11,8
Income rate	<5500 TL	201	43,2
	5501-10000 TL	156	33,5
	>10001 TL	108	23,2
Meal frequency	1 time a day	-	-
	2 times a day	122	26,2
	3 times a day	219	47,1
	4 times a day	124	26,7
	≥ 5 times day	-	-

Legend: TL – Turkish liras

Data Collection Tools

In this study, the "Drive for Muscularity Scale," developed under its original name by McCreary and Sasse (2000), was adapted into Turkish by Selvi and Bozo (2019) and named the "Kaslı Olma Dürtüsü Ölçeği" (KODÖ) was used as the data collection tool. The scale is a six-point Likert scale and consists of three sub-dimensions. These subdimensions were determined as attitudes toward being muscular (KOT), exercise behaviours toward being muscular (KOAD), and use of food and supplements toward being muscular (KOYTK). Attitudes toward being muscular (KOT), training attitudes toward being muscular (KOAD), and dietary manipulation for being muscular (KOYTK) were identified as these sub-dimensions. The results of the confirmatory factor analysis show that this scale, which consists of three subdimensions, is acceptable for the male sample in Türkiye ($\chi2(84) = 246.2$, $p <.001$, $\chi2$ / sd = 2.93, CFI = .93, NFI = .90, GFI = .90, RMSEA = .08.

Statistical analysis

Data were analysed with the IBM Statistics (SPSS version 26.0, Armonk, NY). After testing the normal distribution of the data with Kolmogorov-Smirnov and homogeneity with Levene's tests, it was determined that the data were not normally distributed, so the Mann-Whitney U test was applied for pairwise comparisons and the Kruskal-Wallis H test was used for comparisons of more than two groups. Tamhane's T2, one of the post-hoc tests, was used to determine the difference that existed between variables. The accepted statistical significance level was $p < 0.05$.

RESULTS

Table 2. The Kruskal-Wallis H test results between the frequency of exercising per week and the sub-dimensions of KODÖ

Sub Dimensions	Exercise Frequency	n	MR	χ^2	p	Differences
KOT	1) 1-2 times	167	204,96	14,380	,001*	1 < 2 1 < 3
	2) 3-4 times	213	240,17			
	3) ≥5 times	85	270,11			
KOAD	1) 1-2 times	167	170,46	58,374	,000*	1 < 2 1 < 3
	2) 3-4 times	213	261,80			
	3) ≥5 times	85	283,71			
KOYTK	1) 1-2 times	167	197,06	19,481	,000*	1 < 2 1 < 3
	2) 3-4 times	213	248,87			
	3) ≥5 times	85	263,86			

*p<.05; MR – mean rank

According to Table 2, when examining the mean rank of participants from KODÖ, it is found that individuals who exercise 3-4 days per week and more than ≥5 days in the KOT, KOAD, and KOYTK subdimensions have a higher drive for muscularity than individuals who exercise 1-2 days. Also, it was found that there is no statistical difference between individuals who exercise 3-4 days per week and more than ≥5 days.

Table 3. The Kruskal-Wallis H test results between type of accommodation of the Participants and the KODÖ sub-dimensions

Sub-dimensions	Type of accommodation	n	MR	χ^2	p	Differences
KOT	1) Living Single	52	242,35	4,032	,402	
	2) Living with friend	63	219,61			
	3) Living with family	203	243,29			
	4) Living in dormitory	92	213,41			
	5) Living with spouse	55	234,30			
KOAD	1) Living Single	52	257,34	17,184	,002*	4 < 1 4 < 2 4 < 3
	2) Living with friend	63	253,15			
	3) Living with family	203	244,18			
	4) Living in dormitory	92	183,47			
	5) living with spouse	55	228,48			
KOYTK	1) Living Single	52	237,36	9,307	,054	
	2) Living with friend	63	264,86			
	3) Living with family	203	239,93			
	4) Living in dormitory	92	211,49			
	5) living with spouse	55	202,81			

*p<.05; MR – mean rank

Table 3 shows that those living in a dormitory have a lower drive for muscularity in the KODÖ subdimension than those living alone, with friends, or with their parents; it was found that there is no statistical difference between those living alone, with a friend, with their parents or with their spouse.

Table 4. Results of the Kruskal-Wallis H test between participants' income level and the KODÖ subdimensions

Sub Dimension	Income rate (TL)	n	MR	χ^2	p	Differences
KOT	1) <5500	201	234,37	4,755	,093	
	2) 5501-10000	156	217,02			
	3) ≥10001	108	253,53			
KOAD	1) <5500	201	209,80	13,544	,001*	1 < 3
	2) 5501-10000	156	238,92			
	3) ≥10001	108	267,63			
KOYTK	1) <5500	201	215,11	6,686	,035*	1 < 2
	2) 5501-10000	156	250,88			
	3) ≥10001	108	240,46			

*p<.05; MR – mean rank

It can be seen that people with income levels of 5500 TL and below in the KOAD subdimension have a lower drive for muscularity than people with income levels of 10001 TL and above. In the KOYTK subdimension, people with income levels of 5500 TL and below were found to have a lower drive for muscularity than people with income levels of 5551-10000 TL (Table 4).

Table 5. Results of the Kruskal-Wallis H test between the meal frequency and the sub-dimensions of KODÖ

Sub Dimension	Meal frequency	n	RA	χ^2	p	Differences
KOT	1) 2 times	122	225,16	,807	,668	
	2) 3 times	219	233,10			
	3) 4 times	124	240,54			
KOAD	1) 2 times	122	191,14	23,772	,000*	1 < 2 2 < 3
	2) 3 times	219	232,84			
	3) 4 times	124	274,46			
KOYTK	1) 2 times	122	182,00	44,381	,000*	1 < 2 2 < 3
	2) 3 times	219	226,49			
	3) 4 times	124	294,67			

*p<.05; MR – mean rank

It was found that as the number of meals consumed per day in the sub-dimensions of KOAD and KOYTK increased, the drive for muscularity also increased (Table 5).

DISCUSSION

The purpose of the study was to examine the association between the drive for muscularity and variables including exercise frequency, meal frequency, monthly income and type of accommodation. The study's findings show that participants' attitudes toward being muscular, training practices, eating habits, and supplement use all rise as training frequency rises (Table 2). In this respect, the training frequency of individuals with a high drive for muscularity is also high (Piatkowski et al., 2020; Piatkowski et al., 2021). In the study of Yarar et al. (2022), a weak relationship was found between training frequency and supplement use. Additionally, a significant difference between the frequency of exercise and training practices focused at building muscle was revealed in another study; no significant associations between attitudes toward building muscle, eating, and supplement use were discovered (Katra et al., 2022). Even though there is no conclusive link between training frequency and muscle deprivation, Çağlayan and Koz (2020) argue that spending a lot of time in the gym is a marker of muscle depletion. In other words, men with a strong desire to be muscular can exhibit uncontrolled training behaviours, exercise addiction, eating, and supplement use (Cafri et al., 2002; EikNes et al., 2018; Katra et al., 2022; McCreary and Sasse, 2000). These findings show that the frequency of training and the use of supplements are also high in male individuals with a strong motivation drive for muscularity (McCabe et al., 2002; Raudenbush and Meyer, 2003). Furthermore, this shows that individuals who have a high motivation to be muscular can have uncontrolled training and use of nutrition and supplements to be muscular. When current studies and research findings are evaluated, it can be said that the frequency of training may be higher in individuals with a high motivation drive for muscularity (Ata, 2021; Tod and Edwards, 2015).

Accommodation styles of the participants, in other words, with whom they live, affect their training behaviour towards being muscular, while it does not affect their attitudes towards being muscular and the use of eating and supplements (Table 3). According to the current research findings, it has been determined that individuals living with their families have more drive for muscularity. This can be evaluated as a family effect. In general, women are anticipated to be thinner (Sai et al., 2020), whereas men are anticipated to be more muscular (Edwards et al., 2014). In this context, it can be said that male individuals staying with their families are encouraged to be more muscular, and this increases the training behaviour towards the drive for muscularity in the individual.

As the monthly income of the participants increases, their training behaviours drive for muscularity, eating and use of supplements also increase. However, it was determined that the income status of the participants did not affect their attitudes towards being muscular (Table 4). The research findings supporting the research results could not be found in the available literature. However, there is a study whose findings differ from the current research results. Katra et al. (2022) concluded that income status does not affect drive for muscularity The current literature has not sufficiently examined the relationship between income and the drive for muscularity. It can be said that the increase in the drive for muscularity as income increases, is due to the fact that individuals with higher incomes have better opportunities. This gives individuals the chance to devote more time to themselves.

On the other hand, while the number of meals consumed by individuals during the day does not affect their attitudes towards being muscular, their training behaviours towards being muscular, eating and supplement use do. As the number of meals consumed increases, both the training behaviours for being muscular and the use of eating and supplements increase (Table 5). Some studies and current research findings are similar (Dakanalis, et al., 2015; Edwards, et al., 2014; Galli, et al., 2014 McCreary and Sasse, 2002). In addition, some studies have determined that drive for muscularity causes eating disorders (Grossbard et al., 2013; He et al., 2021; Lavender et al., 2017). When the current research findings are evaluated by the literature, it is seen that the number of meals consumed by individuals with high drive for muscle increases during the day and, accordingly, nutritional and supplement use disorders may occur. Therefore, it can be said that people who eat a lot of meals throughout the day may exercise a lot to build muscle and use food and supplements.

CONCLUSION

The result of this study shows that the drive for muscularity was affected by variables including exercise frequency, meal frequency, monthly income and type of accommodation. With the results of this research, it can be said that the drive for muscularity will increase as the frequency of training increases. In addition, it can be stated that positive behaviours toward the drive for muscularity can develop in individuals living with their families. Furthermore, it has been determined that individuals with a high monthly income will have a high training behaviour toward the drive for muscularity, as well as a high use of eating and supplements. It should be emphasized that increasing the number of daily meals will increase drive for muscularity training behaviour as well as the use of eating and supplements. Considering the existing literature, the relationship between the motivation drive for muscularity and type of accommodation and monthly income has not been adequately studied. In this regard, it is advised that future studies look at the aforementioned variables.

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THE RELATIONSHIP BETWEEN FEMALE BASKETBALL PLAYERS' EATING ATTITUDES AND AGE GROUPS

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ABSTRACT

Playing sports, in addition to guiding an athlete towards a healthy lifestyle, provides personal satisfaction and fulfilment that facilitates into finding meaning and integration in the community. The aim of this research was to determine the association between eating attitudes and age groups among female basketball players. A sample of 67 female participants was taken within the counry of Serbia, which makes up 3 subsamples of the group, i.e. GR1 < 18 (n-28), GR2 19-21 (n-18), GR3 > 22 (n-21) years. The criterion for selecting participants was: age over 13 years, female participants who play basketball and are active. Based on the inclusion criteria in the study, the participants filled out online questionnaires about eating habits EAT-26 (Eating Attitudes Test). Based on the chi-square test, a significant association between eating attitudes and age groups was determined for 23 out of 26 statements. The association was absent only for items 11, 13 and 16. In addition, significant relations were observed between age groups and dieting scale ($\chi2=0.694$, $p=0.000$), bulimia & food scale ($\chi2=0.516$, $p=0.000$) and oral control scale ($\chi2=0.621$, $p=0.000$). Eating disorders are a serious problem among athletes, and the literature suggests that female athletes are a particularly vulnerable population. More investigation is required into the psychometric characteristics of tests like the EAT-26 in populations of female athletes. Given that the final model was inspired by an exploratory process, it is obvious that one should take these results with some caution.

Keywords: team sport, women’s, EAT-26

INTRODUCTION

Basketball as a sport has evolved and improved throughout time since its beginnings, passing through numerous periods of growth marked by development, innovation, and changes in game regulations. Basketball today is distinguished by rapid movements and high enthusiasm. It has progressed from a sluggish ball exercise to an exceedingly dynamic activity defined by the movement structure. The time required to complete technical-tactical tasks reduced, and the game's speed increased dramatically as compared to the early phase (Sampaio, Ibañez Gómez, Ruano, Lorenzo & Ortega, 2008).

Disordered eating attitudes appear to have a significant influence on athletes' physical health, mental health, and athletic performance (Costarelli & Stamou 2009; Currie & Morse 2005; Filaire et al. 2001). Although eating disorders do exist among men, up to 95% of the victims of these disorders are girls and women. The severe forms of disordered eating attitudes include anorexia nervosa and bulimia nervosa. Milder Disordered eating attitudes variables such as obsessive thinking about food and dieting, body image dissatisfaction, overweight preoccupation, and fear of fatness are also crucial because their presence is strongly associated with an increased risk of developing clinical eating disorders (Currie & Crosland 2009; Goldschmidt et al. 2008).

Playing sports, in addition to guiding the athlete towards a healthy lifestyle, provides personal satisfaction and fulfillment that facilitates finding meaning and integration in the community. Also, a wide range of negative and unwanted outcomes such as emphasis on the importance of results, exploitation of the athlete by the club, overtraining, eating disorder, can have a negative impact on the development and condition of the athlete (Wankel & Berger, 1990). Intrinsic motivation is associated with a lower risk of eating disorders, and extrinsic motivation is associated with a higher risk of eating disorders (Homan, Crowley, & Sim, 2019). Apart from the sport in which athletes compete, sociocultural or environmental factors can also be associated with eating disorders.

According to the US Department of Human Services (DHHS), inadequate eating is considered to be a change in eating habits related to problematic eating behaviors, such as restrictive dieting, binge eating, and purging, and as necessary to meet the full criteria for an eating disorder diagnosis. Crucial to the development of factors that influence nutrition is the athlete's perspective and understanding of sports infection, and on the other hand, coaches play a significant role in the physical and psychological health of their athletes (Heffner, Ogles, Gold, Marsden, & Johnson, 2003).

About 10 million women in the United States struggle with eating disorders such as anemia and bulimia (Crowther, Hobfoll, Stephens & Tennenbaum, 2013; Shisslak, Crago & Estes, 1995). The results of the research by Johnson, Powers, & Dick (1999) show that women have a more frequent disorder than men and that 1.1% of women meet the criteria for bulimia compared to men. Also, research by Gallagher, Sonneville, Hazzard, Carson, & Needham (2021) points out that risk assessment for eating disorders is independent of gender, but is more common in women. Coaches can be the ones who encourage athletes to various pathogenic methods, weight control and inadequate nutrition can lead to a reduction in body weight to improve performance on the field and thus cause a disorder in eating behavior and attitudes (Thompson & Sherman, 1999). In male athletes, eating disorders are significantly associated with media pressure (Greenleaf, Williams, Winfree & Kremen, 2007), while research in female athletes shows a connection between symptoms of eating disorders and various social pressures: from family, friends, team and coaches (Reel & Gill, 1996).

For the sports population, apart from general social pressures, the influence of coaches is especially important. It is undeniable that the coach for athletes has an important role. He directs and coordinates teams and individual athletes (Dosil, 2008). Coaches are the ones who observe and observe changes in body weight and note whether symptoms of an eating disorder have occurred (Heffner, Ogles, Gold, Marsden, & Johnson, 2003). Moreover, it was shown that almost one third of coaches who identified eating disorders adequately treated symptoms in athletes (Rockwell, Nickols-Richardson & Thye, 2001). In order to identify and adequately treat eating disorders, coaches need to have basic knowledge about eating disorders, and as research shows, a large number of coaches have participated in some form of education (Turk, Prentie, Chappell & Shields, 1999).

Basketball as a collective game that requires high cardiovascular intensity, strength, endurance, leanness or specific weight, which is considered an important element and due to its specificity, provides the risk of developing eating disorders. Research on the topic of eating disorders can clarify the role of self-esteem in the development of eating disorders in athletes, because previous research is contradictory, and can help explain the way in which negative behaviors of coaches and pressures affect the development of symptoms of eating disorders. Also, research in this area can contribute to the development of programs for the prevention of eating disorders, the development of the education of future coaches, and provide facts that confirm the importance of the influence of coaches and their behavior towards athletes. Based on all the above, the aim of this research is to determine the association between eating attitudes and age groups among female basketball players.

METHODS

Subjects

A sample of 67 participants, 67 of whom were female, was taken at the level of the whole of Serbia. The criterion for selecting participants was: age over 13 years, female participants who play basketball and are active. Participation in the study was voluntary and each of the subjects could withdraw from the study at any time. The participants were informed and informed about the research objective and the method and procedure of the work. The general parameters are presented in Tables 1. Anthropometric characteristics, body height and body mass, on a sample of 67 subjects, which make up 3 subsamples of the group, i.e. GR1 < 18 (n-28), GR2 19-21 (n-18), GR3 > 22 (n-21) years.

PROCEDURE

Each of the participants provided basic anthropometric characteristics, body height, body mass, number of years, how long they have been playing basketball and whether they are actively playing basketball or not. After obtaining the basic information, based on the inclusion criteria in the study, a sample of 67 participants was taken who filled out online questionnaires about eating habits EAT-26 (Eating Attitudes Test).

EAT-26

Eating Attitudes Test - EAT-26 or the eating habits questionnaire is the most frequently used questionnaire to examine the existence of the risk of developing eating disorders. It contains three subscales that depict dimensions of eating habits: (1) diet, which describes eating habits; (2) preoccupation with food - are there any deviations from normal eating habits; (3) oral control - whether any means are used to control food intake. A total score greater than 20 points indicates the need for further examination by a qualified professional, although low scores (below 20) may still be associated with serious eating problems, as denial of symptoms may be an eating disorder problem. The results should be interpreted together with the current BMI (body mass index).

STATISTICAL ANALYSIS

For the statistical analysis of the data, SPSS Version 20 (Statistical Package for Social Sciences, v20.0, SPSS Inc., Chicago, IL, USA) was used. In accordance with the previously established research design, the relationship between dietary habits and the age of basketball players will be analyzed. Based on the research objectives, the methodological approach in this study was to analyze the difference between groups in relation to participants' EAT-26 scores. The chi-square test was used to examine the association between the EAT-26 variables and defined age groups. The significance level was set at .05.

RESULTS

Table 1 shows descriptive parameters of anthropometric characteristics of female basketball players. It is noticeable that the group of girls up to 18 years of age has slightly lower average values of body height and body mass than the participantnts of older groups.

Table 1. Central and dispersion parameters and measures of asymmetry and flattening of the anthropometric characteristics of the subjects according to age groups.

Age		Mean±SD	Min	Max	Sk	Ku
<18	height	170.82±7.60	165.0	182.0	.60	-1.48
	weight	60.32±3.08	58.0	65.0	.68	-1.34
19-21	height	175.00±9.16	165.0	193.0	1.06	.12
	weight	66.72±9.63	52.0	83.0	.40	-.67
>22	height	175.81±9.23	165.0	190.0	.38	-1.25
	weight	69.57±13.15	51.0	95.0	.45	-.86

Table 2 shows the results of female basketball players on the Eating Attitudes Test, EAT-26. Therefore, the distribution of answers from totally disagree to totally agree was determined for each of the 26 statements. Numerical and percentage responses are given in the table, and it was determined whether there are significant differences between the representation of responses in a certain group. While, based on the chi-square test of independence, the relationship between attitudes about nutrition and age groups was determined for each statement individually. Based on the chi-square test, a significant association between eating attitudes and age groups was determined for 23 out of 26 statements. The association was absent only for items 11, 13 and 16.

Table 2. Table 3. Numerical (n) and percentage (%) representation of eating attitudes (Eating Attitudes Test, EAT-26) in relation to age (Chi-square test).

	Age	I completely disagree		I disagree to some extent		I neither agree nor disagree		I agree to some extent		I totally agree	
Variable		**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1. Assessment of a more beautiful body	<18	0	0	11	39.3*	17	60.7*	0	0	0	0
	19-21	4	22.2*	3	16.7	5	27.8	1	5.6	5	27.8*
	>22	2	9.5	3	14.3	8	38.1	0	0	4	19"
χ2=0.564, p=0.001											
2. When the exercise is shorter, I will make up for it with additional independent exercise or a smaller meal	<18	0	0	0	0	24	85.7*	4	14.3	0	0
	19-21	3	16.7"	1	5.6	8	44.4	1	5.6	5	27.8*
	>22	4	19.0*	7	33.3*	7	33.3	1	4.8	2	9.5
χ2=0.576, p=0.000											
3. I stick to a restrictive diet even outside of the sports season	<18	17	60.7*	0	0	11	39.3	0	0	0	0
	19-21	6	33.3	7	38.9*	3	16.7	0	0	2	11.1
	>22	4	19.0	7	33.3"	8	38.1	2	9.5	0	0
χ2=0.539, p=0.001											
4. Although the coach praises me, I think he thinks I can be better	<18	11	39.3	0	0"	17	60.7*	0	0	0	0
	19-21	7	38.9	6	33.3*	4	22.2	0	0	1	5.6
	>22	13	61.9	0	0	5	23.8	2	9.5	0	0
χ2=0.576, p=0.000											
5. I feel uncomfortable eating in front of my team members	<18	0	0	4	14.3	24	85.7*	0	0"	0	0"
	19-21	4	22.2"	1	5.6	5	27.8"	0	0	7	38.9*
	>22	8	38.1*	5	23.8	1	4.8	4	19.0*	0	0
χ2=0.697, p=0.000											
6. I often wish I was thinner, so that my success in sports would be higher	<18	21	75.0	7	25.0	0	0	0	0	0	0"
	19-21	12	66.7	2	11.1	4	22.2*	0	0	0	0
	>22	11	52.4	2	9.5	3	14.3"	1	4.8	4	19.0*
χ2=0.476, p=0.012											
7. I don't feel pressured to change my diet	<18	11	39.3	0	0"	0	0	17	60.7*	0	0
	19-21	4	22.2	4	22.2*	8	44.4*	1	5.6	1	5.6
	>22	12	57.1*	0	0	5	23.8"	1	4.8	3	14.3*
χ2=0.643, p=0.000											
8. It's hard for me to be close with other team members when we compete against each other	<18	17	60.7*	11	39.3	0	0	0	0	0	0
	19-21	5	27.8	4	22.2	7	38.9*	1	5.6	1	5.6
	>22	7	33.3	7	33.3	6	28.6"	1	4.8	0	0
χ2=0.465, p=0.018											
9. I worry that my nutrition program might prevent me from performing at my best	<18	17	60.7*	0	0	7	25.0	4	14.3	0	0
	19-21	1	5.6	6	33.3*	11	61.1*	0	0	0	0
	>22	3	14.3	2	9.5	10	47.6	6	28.6*	0	0
χ2=0.573, p=0.000											
10. I am trying to lose weight because of the sports I play	<18	4	14.3	7	25.0	0	0	17	60.7*	0	0
	19-21	5	27.8	5	27.8	8	44.4*	0	0	0	0

	>22	7	33.3	6	28.6	5	23.8"	1	4.8	2	9.5
$\chi^2=0.604$, $p=0.000$											
11. I trust my team members and tell them about my real feelings	<18	17	60.7	7	25.0	4	14.3	0	0	0	0
	19-21	7	38.9	7	38.9*	1	5.6	1	5.6	2	11.1*
	>22	9	42.9	3	14.3	6	28.6*	1	4.8	2	9.5
$\chi^2=0.379$, $p=0.187$											
12. I feel uncomfortable eating in front of my mother	<18	28	100.0*	0	0	0	0	0	0	0	0
	19-21	9	50.0	2	11.1"	7	38.9*	0	0	0	0
	>22	10	47.6	5	23.8*	5	23.8"	1	4.8	0	0
$\chi^2=0.519$, $p=0.000$											
13. I spend a lot of time thinking about how many calories I burned in my daily workouts	<18	28	100.0	0	0	0	0	0	0	0	0
	19-21	18	100.0	0	0	0	0	0	0	0	0
	>22	19	90.5	1	4.8	1	4.8	0	0	0	0
$\chi^2=0.341$, $p=0.251$											
14. My team members make me feel fat	<18	0	0	24	85.7*	4	14.3	0	0	0	0
	19-21	1	5.6	7	38.9	6	33.3	3	16.7"	1	5.6
	>22	9	42.9*	4	19.0	4	19.0	4	19.0*	0	0
$\chi^2=0.597$, $p=0.000$											
15. No matter how successful I am, I am never completely satisfied	<18	4	14.3	0	0	24	85.7*	0	0	0	0
	19-21	13	72.2*	3	16.7"	2	11.1	0	0	0	0
	>22	12	57.1"	7	33.3*	2	9.5	0	0	0	0
$\chi^2=0.616$, $p=0.000$											
16. Because of the sports I play, I am careful not to gain weight	<18	28	100.0*	0	0	0	0	0	0	0	0
	19-21	18	100.0"	0	0	0	0	0	0	0	0
	>22	17	81.0	3	14.3	1	4.8	0	0	0	0
$\chi^2=0.349$, $p=0.054$											
17. I feel guilty when my team rests before important competitions/performances	<18	0	0	17	60.7*	11	39.3*	0	0	0	0
	19-21	0	0	6	33.3	5	27.8"	1	5.6	4	22.2*
	>22	0	0	12	57.1	0	0	5	23.8*	4	19.0"
$\chi^2=0.548$, $p=0.001$											
18. My friends who don't play sports make me feel fat	<18	0	0	11	39.3*	17	60.7*	0	0	0	0
	19-21	3	16.7"	6	33.3	7	38.9"	2	11.1"	0	0
	>22	9	42.9*	3	14.3	3	14.3	6	28.6*	0	0
$\chi^2=0.553$, $p=0.000$											
19. In terms of sports, my parents expect more from me than I do myself	<18	17	60.7*	0	0	7	25.0	4	14.3	0	0
	19-21	1	5.6	6	33.3*	2	11.1	9	50.0*	0	0
	>22	3	14.3	4	19.0"	11	52.4*	2	9.5	1	4.8
$\chi^2=0.605$, $p=0.000$											
20. I feel uncomfortable eating in front of my father	<18	21	75.0*	0	0	7	25.0	0	0	0	0
	19-21	5	27.8	11	61.1*	2	11.1	0	0	0	0

	>22	8	38.1	10	47.6"	3	14.3	0	0	0	0
χ2=0.504, p=0.000											
21. I feel free to eat whatever I want regardless of what my teammates are eating	<18	17	60.7*	0	0	11	39.3	0	0	0	0
	19-21	6	33.3	6	33.3*	6	33.3	0	0	0	0
	>22	10	47.6	2	9.5	9	42.9	0	0	0	0
χ2=0.393, p=0.016											
22. Although my parents praise me, I think they think I can be better	<18	4	14.3	0	0"	0	0	17	60.7*	7	25.0*
	19-21	4	22.2	0	0	10	55.6*	3	16.7	1	5.6
	>22	13	61.9*	4	19.0*	2	9.5	2	9.5	0	0
χ2=0.677, p=0.000											
23. My mother makes me feel fat	<18	4	14.3	0	0"	7	25.0	0	0	17	60.7*
	19-21	9	50.0"	0	0	5	27.8	0	0	4	22.2
	>22	12	57.1*	4	19.0*	2	9.5	1	4.8	2	9.5
χ2=0.557, p=0.000											
24. I feel that my parents care more about my sports performances	<18	0	0	11	39.3*	0	0	17	60.7*	0	0
	19-21	10	55.6*	2	11.1	3	16.7"	2	11.1	1	5.6
	>22	8	38.1"	2	9.5	4	19.0*	7	33.3	0	0
χ2=0.587, p=0.000											
25. I worry that I will disappoint the coach if I do not meet his expectations	<18	0	0	0	0	0	0	28	100.0*	0	0
	19-21	0	0	0	0	3	16.7*	6	33.3	4	22.2"
	>22	0	0	1	4.8	3	14.3"	7	33.3	6	28.6*
χ2=0.582, p=0.000											
26. Society (social community) makes me feel fat	<18	0	0	4	14.3	7	25.0	0	0	17	60.7*
	19-21	6	33.3"	7	38.9*	4	22.2	1	5.6	0	0"
	>22	9	42.9*	7	33.3	2	9.5	3	14.3*	0	0
χ2=0.627, p=0.000											

Table 3 shows the association between the three scales, separated on the basis of the given claims, and the achieved points grouped according to the given scale. Based on the chi-square test (χ2=0.694, p=0.000) it was determined that there is a association between age and the dieting scale, given that the association is high. Also it was determined that there is a high association between age and the bulimia & food scale (χ2=0.516, p=0.000). And also it was determined that there is a association between age and oral control assessment (χ2=0.621, p=0.000)

Table 3. Numerical (n) and percentage (%) representation of summative assessments of the dieting scale, bulimia & food and oral control scale in relation to age (Chi-square test).

	Age	**<14**		**15-18**		**>19**	
1. Representation of dieting scale assessments	<18	0	0	28	100.0*	0	0
	19-21	6	33.3"	2	11.1	10	55.6*
	>22	12	57.1*	0	0	9	42.9"
χ2(3, n-67)=0.694, p=0.000							
		<4		**5-6**		**>6**	
2. Representation of	<18	0	0	17	60.7*	11	39.3

assessments of bulimia & food	19-21	4	22.2"	5	27.8	9	50.0
	>22	11	52.4*	2	9.5	8	38.1
χ2(3, n-67)=0.516, p=0.000							
		<8		**9-14**		**>14**	
3. Representation of oral control assessments	<18	4	14.3	0	0	24	85.7*
	19-21	6	33.3	9	50.0*	3	16.7
	>22	12	57.1*	8	38.1"	1	4.8
χ2(3, n-67)=0.621, p=0.000							

DISCUSSION

Eating disorders are a serious problem among athletes, and the literature suggests that female athletes are a particularly vulnerable population. The aim of this research was to determine the association between eating attitudes and age groups among female basketball players. Based on the chi-square test, a significant correlation between eating attitudes and age groups was determined for 23 out of 26 statements. The connection was absent only for items 11, 13 and 16. In addition, significant relations were observed between age groups and dieting scale (χ2=0.694, p=0.000), bulimia & food scale (χ2=0.516, p=0.000) and oral control scale (χ2=0.621, p=0.000).

Currently, there are very few studies on this topic that have basketball players as a sample of participants and an even smaller number of studies with female participants. Michou et al. (2011) showed that the prevention of disorders in non-athletes is somewhat higher than that of women who play basketball. According to Currie (2010), the risk of eating disorders in athletes can be reduced if the athlete is in a supportive environment, and one of the most important roles in their environment is played by the coach. When talking about the personal characteristics of an athlete, some of them are often associated with people with eating disorders. These are competitiveness, concern about performance, high need for achievement, compulsive concern about body shape (Sundgot-Borgen & Torstveit, 2010). It is very important not to look only at the type of sport a person plays, but to focus more on the individual athlete's perception of the importance of appearance in the sport he plays and more focus on the individual characteristics that can lead to the development of eating disorders.

In the context of body image, a number of longitudinal studies have consistently identified body image dissatisfaction as one of the most strong risk variables for eating disorders (Abraham 2003; Stice & Bearman 2001). A well-designed study that evaluated the presence of disordered eating in Norwegian male and female elite athletes (n =1,620) from 66 different sports and controls (n = 1,696) found that among female athletes competing in aesthetic sports, the prevalence of disordered eating was 42%, which was higher than that observed in endurance (24%), technical (17%), and team sports (16%) (Sundgot-Borgen & Torstveit 2004). In a smaller-scale study conducted in Spain in 283 elite sportswomen competing in 20 different sports, the proportion of athletes suffering from some kind of eating disorder was five times higher han in the general population (22.6% vs. 4.1%) (Toro t al. 2005).

Some authors discovered no significant differences in disordered eating attitudes (EAT-26) between female basketball players and non-athlete in their study. The actual prevalence of disordered eating attitudes in the basketball players (11%) was lower than in the non-athletes (15%), which is encouraging, given the fact that elite female athletes are more likely to develop disordered eating than the general population (Torstveit & Sundgot-Borgen 2005; Sundgot-Borgen & Torstveit 2004). Basketball, as a team sport that does not emphasize a thin body and does not require making weight regularly to improve performance, is a sport that does not increase the risk of developing disordered eating attitudes in females; female basketball players are likely to adopt healthier eating attitudes than women who do not participate in any sport activity. More research is needed, however, to better understand the incidence of disordered eating among females who participate in team sports (Michou, et al. 2011).

Skipping meals and reducing food intake, either because of lack of time or because of body aesthetics without the supervision and control of professionals, can cause a decrease in the efficiency of the basketball game and can lead to health problems and the risk of eating disorders. (Mavra et al. 2014)

Intensive consumption of energy increases the desire to eat and in that case negative psychological processes such as stress and anxiety occur. Also, the emotional desire for food has a negative effect on psychological and physical health, and thus on the distribution and performance of the game (Suel et al. 2020). More investigation is required into the psychometric characteristics of tests like the EAT-26 in populations of female athletes. Given that the final model was inspired by an exploratory process, it is obvious that one should take these results with some caution. Future studies ought to investigate at the EAT-26's factorial invariance in athletes of all ages and from different athletic disciplines.

CONCLUSION

The obtained results point it is very important to include coaches in training programs related to the proper nutrition of athletes, as well as training in the behavior, influence and role of coaches in the athlete's life. It is necessary to work on strengthening the positive influence that the coach has on the group and the individual, in terms of providing social support and positive feedback. the most important thing is to exclude negative patterns from the coach's behavior and help them change those habits in order to achieve the common goal of the athlete and the coach himself.

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TRADITIONAL GAMES AND FORMS OF PHYSICAL EXERCISE AND COMPETITION AND THEIR SIGNIFICANCE

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ABSTRACT

Abstract: Folk rites, rituals, customs and traditions represent a significant part of general and national cultures, actually certain patterns of behavior characteristic of the development of certain social communities, but also of the entire human society in different periods of time. These patterns are still present today and they represent a significant cultural heritage of different social communities. In order to understand their sources, one should study the history of the people, their culture and everyday way of life. Many peoples and social communities have managed to preserve their culture, customs, rites, rituals and traditions of their ancestors over the centuries. In the course of centuries of history, many peoples have created a system of education in which appropriate physical activity and physical exercise were present. Possession of appropriate psychophysical abilities were considered necessary qualities of members of those communities. Sports (exercise) traditions have been created since ancient times. They were perfected in accordance with the economic activity of man, in accordance with the perfection of his reason. During earlier eras, various games and skills were developed, which today constitute a heritage from the past and are an expression of folk creativity in the field of physical exercise within sports and recreation. The international professional public recognized the value of traditional games and sports and took important steps towards their preservation and revival around the world. These activities are motivated not only by the need to preserve such games and sports in the growing world globalization and general commercialization of modern sports, but also to preserve the traditional ethical values and rules of fair play that were an integral part of these games. Also, traditional games found their place in the tourist offer in the form of traditional manifestations of national and international importance. There are over 3,000 traditional games in the world that are or have the potential to be an element of the tourist offer.

Key words: traditions, folk rites, physical exercise, nation, culture.

INTRODUCTION

Every nation has a variety of phenomena that are complex in terms of their historical roots and the roles they play in daily life and culture. Folk rites, rituals, customs, and traditions make up a major portion of global and national cultures. They represent certain behavioral patterns that have evolved over time inside certain social communities as well as over the entirety of human society. These patterns still exist now and constitute an important part of the cultural history of various socioeconomic groups. One should research the history, culture, and way of life of the people in order to understand their sources. Any of these behavioral patterns emerge from our empirical and spiritual understanding of the world around us and essentially reflect the way of life of a certain group of people.

Many cultures over a period of centuries have developed educational systems that include suitable physical activity and exercise. Possession of appropriate psychophysical abilities were considered necessary qualities of members of those communities. National customs that encourage physical activity are an example of a system of mutually conditioned elements that include a variety of unique customs, specific behavioral stereotypes, and unique special measures designed to improve an organism's physical and adaptive qualities. Sports (exercise) traditions have been created since ancient times. They were fulfilled in accordance with the activity of people, in accordance with the improvement of their reason. Traditions involving physical exercise depended on many factors: terrain, climate, nature, etc. All traditional forms of physical training were aimed at the development of physical qualities: physical strength, endurance, speed, accuracy, speed, etc. Additionally, a lot of conventional physical activities are designed to improve an individual's determination to accomplish a particular assignment.

Various traditional celebrations were one of the components of the culture of certain social groups and communities. Numerous games, dances, and competitions, which were held outdoors, were an inseparable part of them, contributing to the strengthening of the human organism. By participating in physical activity, physical training serves as a means to get participants ready for competitive engagement. National holidays meant active rest, improvement of the emotional and mental state, which also had a favorable effect on the human body.

Traditional games and competitions represent the history of development and a reflection of the certain ethnos. Different nations develop a unique culture during every phase of their existence, which can be seen in all aspects of society, most notably in national holidays, national attire, and lastly national competitions and games.

National games and sports are forms of competition that are very popular and are mass manifestations that carry different elements of tradition and provide great opportunities for the development of human potential through physical education.

Additionally, it should be remembered that the sports that constitute up the modern Olympic Games were developed from national sports which made their popularity possible. In the process of many centuries of experience, the nations formed an educational environment in which, by means of traditional forms of physical exercise, games and competitions, they provided upbringing, education, military and work training that enabled the transfer from generation to generation of the invaluable experience of surviving in various difficult circumstances (Медведев, Клименко, Баландюк, Ермоленко & Попов).

During earlier epochs, various games and skills were developed, which today constitute a heritage from the past and are an expression of folk creativity in the field of sports and recreation. Many traditional games and parties entailed "the active participation of all present, with the aim of establishing and strengthening common values, in the interest of maintaining the community with the greatest degree of sociability. Thus, such forms of entertainment simultaneously occupied both the time of obligation and free time, at the same time combined with a recreational and relaxation character." (Božović, 2008).

Every nation in the world has its own national games, competitions and sports that characterize the nation itself, its character and traits of mentality.

"National games, competitions and sports of each nation reflect its natural and historical peculiarities, help to understand the ethnic character of the nation, peculiarities of mentality. In other words, national games, competitions and sports are the most important component of spiritual culture, and studying the specifics of these activities has practical value." This indicates that the national games as a whole can be marked as a generic fund of the sports and game culture of the people. Preservation of traditional folk dances, bringing them back to life is an enrichment of culture. Systematic participation in national games and sports associated with a significant volume and duration of muscle work contributes to the improvement of the work of the nervous system, increasing the functional capabilities of the cardiovascular and respiratory systems, and improving psycho-physical abilities (Глухарев & Сокаев, 2022).

Although the global expansion and popularization of modern sports has led to the neglect of traditional games and their marginalization, and in some cases to their extinction and loss to the local environment, significant progress has been made and activities to revive traditional games, forms of physical exercise and competition have been approached seriously. The international professional community understood the importance of traditional games and made significant contributions to their preservation and revival globally. These activities are motivated not only by the need to preserve such forms of physical exercise and games in the growing world globalization and general commercialization of modern sports, but also to preserve the traditional ethical values and rules of fair play that were an integral part of these games.

Additionally, traditional games and competitions have made an appearance in the tourist industry as a component of complex tourist goods in the shape of traditional manifestations of importance on a local, national, and international level (Bjeljac, Ćurčić, Brankov & Pešić, 2019).

METHODS

In order to conduct this study, relevant domestic and international literature as well as a number of informational sources linked to the study's issue were examined. The information obtained was systematized, and its adequate analysis based on which the collected knowledge was interpreted.

THE ESSENCE OF THE TERMS TRADITION, TRADITIONAL GAMES, MANIFESTATION

Most of the modern terms in the language are complex terms that do not have a single interpretation, as there are a number of different definitions that confirm the complexity of those terms.

In professional literature, the terms "tradition" and "custom" are often used as synonyms. Traditions and customs can be said to share some social functions in common, allowing for the stabilization (consolidation) of societal relationships as well as the reproduction of those relationships in the lives of future generations. These custom and traditional functions, though, are carried out in different ways. Customs directly, through detailed instructions for certain actions in concrete situations, stabilize certain links of family relations and reproduce them in the life and work of new generations. Such are, for example, the customs of caring for children, behavior in public places, receiving guests, etc. Naturally, every custom has its meaning, but it is not expressed in the form of an ideal. Custom determines in great detail what should or should not be done in a certain situation, and does not indicate how one should be. Customs are mostly formed by simple habits - activities that are stereotypically repeated, characterized by a certain degree of automaticity (for example: the habit of greeting people, sometimes a complete stranger).

At the base of tradition, on the contrary, there is always the value of the community, which determines the meaning of traditional behavior. That is why tradition does not give a detailed presentation of the procedure, it has no concrete connection to a specific situation. For example, the tradition of hospitality, which many modern families adhere to, is realized in different ways: someone pays attention to the guest, and for others it is the main communication with the guests. There is also a difference between them in the family upbringing of the child.

Traditions and customs reflect the ethnic, cultural and religious characteristics of the community, as well as the professional affiliation of its members. At the base of tradition is always an idea, value, norm, experience. As multi-functional norms and values of each specific community are, traditions are as diverse in their educational essence. Depending on the values and norms of the community, which are realized in a certain tradition, it is possible to talk about creative and destructive, constructive and non-constructive, stereotypical and non-stereotypical traditions.

Historical evidence confirms that the transition from one age group to another was associated with the fulfillment of certain requirements for skill, courage, strength and dexterity to be applied in the natural conditions of the surrounding environment. These ancient customs and traditions of the early era of clan society, which is based on survival, have survived to this day among certain peoples and social communities.

In the early stages of human society, requirements and specific types of confirmation in the area of physical activity were a fairly common occurrence. They concentrated on developing the life skills and habits at the same time (Živanović, Stanković, Ranđelović, Pavlović, 2010).

The existence of national forms of physical combat is characteristic of every nation. Since ancient times, different types of combat have been used as a kind of physical preparation of warriors for conducting warfare in direct combat. Regardless of the appearance of firearms, physical exercise associated with elements of combat has not lost its relevance. Centuries-old traditions of folk forms of fighting have been preserved to this day in many countries, and the training methodology is also used by experts in modern martial arts (Marjanović, 2005).

Traditional games are those that have survived into the modern era of civilization and have a ceremonial or ritualistic aspect. These games are typically those played in rural areas that have been handed down through the generations and are still appropriate to play today.

In foreign and domestic scientific and professional literature, different terms and definitions are used for old (traditional) games and forms of physical exercise: folk games (Eichberg, 1995; Bale, 2003), traditional ethnic sports (Sogawa, 2006; Hajra, 2015), old sports (Cvetković, 1982), traditional folk sports games and skills (Bjeljac, Ćurčić, 2017), traditional sport games (Renson et al., 1997; Bronikowska et al., 2014; Linaza et al., 2013), traditional sports and games.

There are a large number of divisions and classifications of traditional games and sports based on types of sports, period of performance, geographical area of performance, customs and rituals, gender-age structure, etc. (Bjeljac, Brankov, 2019; Liponski 2003; Linaza et al., 2013; Krasilnikov, 2006; Cvetković, 1982; Hajra, 2015; Renson et al., 1997). According to the European Association of Traditional Sports and Games, eight categories are distinguished: ball sports and games, throwing games, bowling sports, shooting sports and chariot fights, games with animals, locomotive games, acrobatics (Renson et al., 1997; Bronkovska et al., 2014; Linaza et al., 2013). Cvetković (1982) distinguishes: old athletic sports, old martial sports, old folk sports, old equestrian sports, old water sports, old winter sports, old folk games. He also divides them into: competitive games without the use of auxiliary objects, competitive games with the use of auxiliary objects, competitive winter games with the use of objects, competitive games with the use of animals (Bjeljac, Ćurčić, Brankov & Pešić, 2019).

As part of cultural heritage, UNESCO (2004) singles out "manifestational values (events and festivals, fairs in the field of culture, sports events related to traditional sports) and folklore heritage (buildings and spaces, objects of folk architecture, costumes, old crafts, naive painting, oral tradition, culinary traditions, traditional sports and games)".

Traditional games and sports are more and more often an integral part of various cultural manifestations that are also part of the tourist offer. In Serbia, event tourism gained importance only in the middle of the first decade of the 21st century. Since then, the manifestations have been highlighted as possible carriers of the tourism development of certain destinations, that is, some of them have been recognized as a potential brand of Serbian tourism. Research has established that slightly more than 2,000 traditional tourist events of different character and rank are held in Serbia annually (Željko, 2006).

The general term "manifestation" comes from the Latin word "manifestatio" to manifest, to show, to announce, to announce, that is, "public expression, arrangement". The term "manifest" (lat. manifestare) means "to express, publish, publish, publicly express one's opinion or mood", that is, "participate-participate, publicly express, express, show" (Milan, 1980).

Tourism economists, in their research, start from the English translation of the word event (which comes from the Latin eventus), which in Serbian means: experience, event, event, occurrence.

Manifestations can be defined as "organized social phenomena with specific content, profile of participants, number of visitors and duration, characterized by the importance of the content, importance of the participants, importance of the results, i.e. the mass of the visit".

TRADITIONAL GAMES, SKILLS AND FORMS OF PHYSICAL EXERCISE AND COMPETITIONS IN SERBIA

On the territory of the former SFR Yugoslavia, some of the traditional games, skills and competitions were an integral part of village meetings, village Olympics, workers' sports games, Adriatic meetings, meetings of mountaineers, scouts, etc., as part of recreational sports and entertainment.

The original old sports and games are part of the Serbian tradition and identity, as well as of other peoples in the area of the former SFR Yugoslavia. They were passed down from "generation to generation". Some of them, which were characteristic in the 19th century, already disappeared in the thirties of the 20th century, and today, in the 21st century, except for a few, they have been forgotten even by the older generations. Their gradual disappearance and oblivion was influenced by constant migration from rural to urban areas (Bjeljac & Ćurčić, 2017).

At the beginning of the 21st century, new places and regions are constantly emerging as desirable tourist destinations that attract tourists with their exceptional cultural attractions. The importance of folk sports and games as products in the tourist offer that promote rural, religious, cultural, sports-recreational event tourism is increasingly being recognized.

In the territory of the former Yugoslavia, where the Serbian people lived throughout history and still live today, a large number of different manifestations are held, within which a large number of different traditional games, skills and competitions that have an international character are represented. Heroic, folk competitions are the most represented within them. In the nations of this area, these games and competitions are most often designated as national all-around (competitions made up of a number of different disciplines). The most common disciplines are: standing stone throw, high jump, long jump, rope pull, arm wrestling, sack races, horse riding, baton pull.

Some manifestations are completely dedicated to traditional games, skills, forms of physical exercise and competitions, and some have included modern sports in addition to them in order to increase the number of participants and audiences. Their contents are usually supplemented with a cultural program of ethnographic content, as well as a program of entertainment and music content, which makes the event more attractive and strengthens creativity in the local environment (Bjeljac, Ćurčić & Brankov, 2020).

Since the 60s of the 20th century, a significant number of attractive tourist events have been held in Serbia, which represent traditions and customs, folklore, ways of doing business and other human achievements. In tourism theory and practice, this type of tourism is known as event tourism. At the end of the 80s and during the 90s of the 20th century, this type of tourism gained importance in the world and became a kind of industry, known as the event industry. In the offer of tourist destinations, there are more and more special manifestations, the design and execution of which is conditioned by strategic reasons, primarily of an economic nature. The role of events in the tourist offer is also significant due to their touristic, social and cultural functions, as well as their role in local and regional development.

As potential tourist products, but also as activities and events that contribute to the promotion of psychophysical abilities and engaging in physical exercise, a large number of manifestations that contain traditional games, sports and competitions can be singled out. On the territory of Serbia, these are:

Combined traditional sports competition events in village surrounding (Jablanica, Zlatibor), - June, (long jump, high jump, standing stone throw, horse race, rope pull, hands pull from the standing position, pole crawl, baton pull).

Village Olympics (Sefkerin), - June, (standing stone throw, standing long jump, sack races, darts, penalty kicks, making 3-pointer at the hoop).

Lika Olympiad (Banja Junaković, Apatin), - June, (sack races, pulling the hook, standing long jump, stick pull, walking on a log, arm-wrestling, standing high jump, climbing up the pole, standing stone throw, rope pull).

Days dedicated to Hajduk Veljko (Lenovac, Zaječar), - July (August), (combined disciplines, rope pull).

Shepherd's Days/Cobanijada (Kosjerić), - July, (standing stone throw, button pull, rope pull, long jump, high jump).

Days dedicated to Stanoje Glavas (Glibovac, Smederevska Palanka), - July (August), (standing long jump, standing stone throw, combat on the log, arm-wrestling, button pull, throwing a horseshoe).

Hajduk evenings (Crna Bara, Bogatić), - August (jumping over stump, standing stone throw, button pull, long jump, combat at the log, three climbing).

Village Olympiad (Nova Varoš, Zlatar), - August, (standing long jump, standing stone throw, button pull, rope pull).

Krajina combined traditional sporting event (Banatsko Novo Selo, Kikinda), - August, (sack races, walking on a log, standing stone throw, standing long jump, high jump, climbing up the pole, arm-wrestling, rope pull, button pull).

Tribal knight games (Lovćenac, Mali Iđoš), - August, (standing stone throw, rope pull).

“Banatske Sore” (Tomasevac), - Jul, (an old pastoral games played in Vojvodina and the Romanian part of the Banat).

Ljubičevo equestrian games (Ljubičevo, Požarevac), - September, (Ljubičevo combined traditional sporting events – cutting with a saber; spear shooting; courier riding; archery; mace shooting; jumping hurdles, galloping and trotting races).

Seleucus combined traditional sporting events (Seleucus, Alibunar), - September, (long jump, high jump, standing stone throw, climbing up the pole, button pull, running on the log, sack races, combat on the log, rope pull, ballots).

Vojvodina Ancient Sports Olympiad (Bačko Gradište) – September, ("pilcike", "ringlanje", "kandžijanje", standing stone throw, "krbanje", "štulanje", "dragače", "džakanje", a fight of honor, "natezanje mosora", "vranića", "strelanje", "preskakanje štapa", "čočak", "kozana", "pajvanisanje", "tokač", "izmesta").

CONCLUSION

Progressive elements of folk traditions accompanied by physical exercise have not lost their importance even today. They can be used in the modern practice of preserving and improving people's health and physical abilities. They can perform important functions in the life of the modern society of the individual nations to which they belong.

They can:

- contribute to the development of the culture of competition and physical exercise as part of the national culture;
- enable familiarization with national cultural values;
- traditional manifestations provide the opportunity for tourists to get acquainted with tradition, culture, folklore, original music, folk customs and other features of folk life;
- contribute to the spread of knowledge about the tradition of competition and physical exercise of a certain nation;
- influence the education of new generations in the spirit of respect for the culture and history of their ancestors;
- contribute to the study of the heritage of ancestors in the field of the tradition of competition and physical exercise;
- contribute to the emergence and development of new types of sports, based on folk games and competitions;
- traditional forms of physical exercise and competition represent an educational and healthy environment on the basis of which work discipline is gradually and systematically implemented, and life-important skills and habits are formed;
- as an integral part of the physical education curriculum, elements of folk traditions can contribute to improving the content of physical education classes and making them more interesting.

The significance of traditional games, skills and competitions in the culture and life of a nation is manifold. They preserve and transmit certain cultural values, customs and traditions from generation to generation; contribute to the socialization of the participants and the audience that follows them; they reflect the way of life of the people of a certain area and their history; they enable the color of customs, the originality and authenticity of the people's culture to be passed on to the next generations.

The value of traditional games, skills and competitions is recognized not only in a cultural, ethnographic or sociological perspective, but also as an important segment of the tourist offer that brings originality to that offer and activates numerous actors for their realization. Also, they affirm the environments in which they are held, which is another added value in the direction of affirming areas insufficiently involved in tourist movements.

All of the above shows that throughout history, tradition has managed to create a significant number of different ways of transferring accumulated knowledge and socio-cultural habits from older members of society to younger ones, and that is why it should not be forgotten, but left as a legacy to future generations through the education of young people.

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GENDER-BASED DIFFERENCES IN SELECTED VERTICAL JUMP PARAMETERS AND THEIR VARIABILITY: A CROSS-SECTIONAL STUDY

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ABSTRACT

The aim of this to study is to examine differences in the variability of selected parameters in vertical jumps between males and females to gain insights into the characteristics of explosive strength performance between male and female individuals. By comparing the differences in the coefficient of variation between males and females, we aim to mitigate the influence of higher average jumps in males. Exclusion criteria for entry into the study included any musculoskeletal injuries within the past year and any other health issues. We analyzed 32 male and 15 female students using the Optogait system. Key parameters included flight time, jump height, power output, reactive strength index and pace. The study also assessed variability within these parameters using the coefficient of variation. Shapiro Wilk W test was used to test normality. Since the data did not follow a normal distribution based on the results of the Shapiro-Wilk W tests, non-parametric statistics were used for subsequent analyses. To compare differences between male and female students, an initial assessment of variance homogeneity was conducted. Homogeneous results were evaluated using the Mann-Whitney U test. Statistical significance was set at $p < 0.05$. Statistically significant gender disparities were observed. Men outperformed women in several parameters: flight time ($p=0.00$), jump height ($p=0.00$), power output ($p=0.00$), and reactive strength index ($p=0.00$). Women excelled in pace ($p=0.00$) and the reactivity index ($p=0.04$). Importantly, the analysis of the coefficient of variation revealed that both genders exhibited similar levels of performance consistency, despite mean differences. This study underscores gender-based variations in vertical jump parameters, with men demonstrating superior explosive strength, while women exhibited strengths in jump rhythm and certain performance aspects.

Keywords: Vertical jump, Explosive strength, Performance variability

INTRODUCTION

Health, as defined by the World Health Organization (2020), encompasses complete physical, mental, and social well-being. Garcia-Falgueras (2020) further elaborates on the concept of physical health, describing it as a metabolic and cognitive state characterized by the absence of any disease, achieved through the practice of physical activity, proper nutrition, and, in some cases, the use of ergogenic aids to enable individuals to lead fulfilling lives with optimal functionality. Maintaining one's health requires physical activity, which extends beyond structured sports training and encompasses all movements of the musculoskeletal system (Garcia-Falgueras, 2015). What sets sports apart from other physical activities is its competitive dimension, with activities carefully planned and programmed to achieve specific athletic outcomes (Garcia-Falgueras, 2015). Elloumi et al. (2012) emphasize that the primary objective of every sports training regimen is to enhance or preserve physical performance.

In the development of effective training plans and programs, whether for professional athletes or recreational participants, diagnostic assessments play a pivotal role. Among the most frequently analyzed movements is the vertical jump, which is commonly utilized to assess explosive strength (Ferrero-Hernandez et.al., 2023). Vertical jump parameters that are often used in researches are jump height and contact time (García-López et al., 2005; Sattler et al., 2015). These two variables can further be used for getting other important information about muscles activated in jump performance. Some of these variables are muscle stiffness and reactive index.

Myofascial tone is distinguished by its characteristic 'stiffness,' which over time contributes to unfavorable loading conditions, giving rise to microinjuries and a spectrum of associated pathologies, including tendinopathy, osteoarthritis, enthesopathies, as well as vascular tension and claudication, leading to pain (Kjaer et al., 2009; Langevin, 2006). Muscle stiffness is a hallmark of pain or injury stemming from shear stresses and pressures (Picotti, Forte, & Serrentino, 2023). However, insufficient muscular rigidity can have a detrimental impact on athletic performance, underscoring the critical importance of assessing and understanding the level of muscular stiffness (Greguric & Aščić, 2023).

The capacity to generate rapid force is an essential skill in numerous sports. The Reactive Strength Index (RSI) serves as a pivotal metric for assessing explosive strength, calculated by dividing jump height by ground contact time during the execution of a depth jump (Ebben & Petushek, 2010). Ebben and Petushek (2010) have proposed a modified version of RSI that is applicable to the evaluation of explosive power in any vertical plyometric exercise.

The ability to maintain consistent vertical jump height during repeated jumps is often crucial in sports and can indicate desirable muscle-tendon capabilities, as well as effective force control. The coefficient of variation in repeated jumps is one method to assess variability between jumps. By comparing the differences in the coefficient of variation between males and females, we aim to mitigate the influence of higher average jumps in males. Accordingly, the objective of this study is to examine differences in the variability of selected parameters in vertical jumps between males and females. Our hypothesis is that there will be no difference in variability.

METHODS

Subjects

The sample of participants in this study consisted of 32 male students and 15 female students, all of whom were enrolled at the Faculty of Kinesiology in Osijek, Croatia. Prior to participation, all participants were familiarized with the execution of repeated vertical jumps. Exclusion criteria for entry into the study included any musculoskeletal injuries within the past year and any other health issues. All participants gave permission for participation in this study. The study was conducted in accordance with the current Helsinki Declaration guidelines.

Instruments

To obtain vertical jump parameters Optogait (Microgate, Italy) was used. Optogait is device used for different type of analysis and it is often used for gate and jumping analysis. It is conducted of 2 parallel bars. The device uses flight time and utilizes that variable to calculate jump height, stiffness, reactivity index, contact time and numerous other variables. Reliability and validity of Optogait for vertical jump analysis was confirmed by some researchers (Castagna et al., 2013; Glatthorn et al., 2011).

Variables

The vertical jump height was determined utilizing the formula elucidated in the study conducted by Bosco, Luhtanen, and Komi (1983). Muscle stiffness (KN) is calculated as the product of π times the sum of flight time (TFlight) and contact time (TCont), all divided by the square of contact time (TCont) multiplied by the difference between the sum of flight time (TFlight) and contact time (TCont) divided by π and contact time (TCont) divided by 4 (Dalleau et.al., 2004). The formula for calculating the reactivity index (RI) was obtained from the official Optogait manual (Microgate S.r.l., 2020), which involves computing it as the ratio of contact time to the sum of flight time and contact time. To assess the variation within the results of individual subjects, the coefficient of variation (CV) was employed. This metric is calculated as the ratio of the standard deviation to the mean and is conventionally expressed as a percentage to facilitate interpretation. Other variables are represented in table 1.

Table 1. Optogait output for repeated vertical jump

Variables	Explanation
TCont[s]	Contact times
TFlight[s]	Flight times
Height[cm]	Jump height calculated from formula
Power[W/Kg]	Power calculated from gravity acceleration, flight time and contact time
Pace[step/s]	Rhythm expressed in jumps (or steps) per second
RSI[m/s]	RSI[m/s]: Reactive Strength Index, defined as Height (in m) / Contact T
Verticality	The duration from the moment when the speed becomes > 0 until the moment of separation
DurationConcP[s]	The duration from the start of the movement to the instant before the speed becomes > 0
DurationEccP[s]	Rate of Force Development
RFD[N/kg/s]	Ration between Eccentric and Concentric phase
KN	Muscle stiffness
RI	Reactivity index

Procedure

The study was conducted at the "Gradski vrt" Academic Sports Hall in Osijek, Croatia. Upon their arrival, all participants received a comprehensive briefing on the research's purpose and objectives, accompanied by a presentation of the inclusion criteria. Additionally, it was emphasized to all participants that they could withdraw their participation at any point during the research without consequence. Subsequently, a concise warm-up regimen and orientation to vertical jump techniques were administered, during which any necessary technical adjustments were made. Each participant assumed a predetermined position located between Optogait markers. Upon the examiner's signal, each participant executed seven consecutive vertical jumps without intermission. A webcam was activated by the examiner immediately prior to jump execution to capture all jump performances. In cases where the vertical jump execution deviated from provided instructions, a 10-minute pause was allowed before the participant resumed testing. Following the completion of the research, participants were presented with their individual data for review.

Statistical analysis

For the purpose of this research, Tibco Statistica Enterprise (version 14.0.1.25.) was used. Shapiro Wilk W test was used to test normality. Since the data did not follow a normal distribution based on the results of the Shapiro-Wilk W tests, non-parametric statistics were used for subsequent analyses. The data is presented as mean (M), standard deviation (SD), minimum (Min) and maximum (Max). To compare differences between male and female students, an initial assessment of variance homogeneity was conducted. Homogeneous results were evaluated using the Mann-Whitney U test. Statistical significance was set at $p < 0.05$.

RESULTS

Table 2. Descriptive statistics and gender differences in selected parameters of vertical jump

Variables	All (N=47) M±SD (Min-Max)	Female(N=15) M±SD (Min-Max)	Male (N=32) M±SD (Min-Max)	p
TCont.[s]	0,71±0,18 (0,34-1,35)	0,78±0,24 (0,42-1,35)	0,68±0,13 (0,34-0,92)	0,27
TFlight[s]	0,49±0,07 (0,33-0,72)	0,43±0,05 (0,33-0,72)	0,51±0,06 (0,42-0,72)	**0,00**
Height[cm]	30,42±12,03 (13,70-97,10)	22,98±5,62 (13,70-97,10)	33,91±12,69 (21,70-97,10)	**0,00#**
Power[W/Kg]	21,20±8,81 (11,76-73,18)	16,59±3,34 (11,76-73,18)	23,36±9,74 (16,16-73,18)	**0,00#**
Pace[step/s]	0,90±0,34 (0,55-2,99)	0,86±0,17 (0,55-2,99)	0,92±0,39 (0,71-2,99)	0,21#
RSI[m/s]	0,48±0,39 (0,17-2,85)	0,32±0,13 (0,17-2,85)	0,56±0,44 (0,29-2,85)	**0,00#**
Verticality	9,58±5,13 (1,77-20,52)	11,83±5,07 (2,58-20,52)	8,52±4,88 (1,77-18,80)	**0,03**
DurationConcP[s]	0,38±0,13 (0,19-0,87)	0,44±0,20 (0,21-0,87)	0,35±0,08 (0,19-0,51)	0,30#
DurationEccP[s]	0,35±0,07 (0,19-0,51)	0,34±0,06 (0,24-0,51)	0,36±0,07 (0,19-0,51)	0,42
RFD[N/kg/s]	173,10±148,82 (16,86-756,55)	205,24±172,64 (16,86-756,55)	158,03±136,64 (22,57-742,97)	0,15
Ratio Ecc/Conc	1,08±0,56 (0,44-4,57)	0,94±0,28 (0,44-4,57)	1,15±0,65 (0,67-4,57)	0,83#
KN	41,87±19,85 (12,52-125,68)	39,05±19,31 (12,52-125,68)	43,20±20,26 (24,51-125,68)	0,58
RI	0,59±0,07 (0,37-0,72)	0,64±0,07 (0,46-0,72)	0,57±0,07 (0,37-0,66)	**0,00**

Notes: p – Mann Whitney U test

Table 2 displays descriptive statistics for selected parameters of vertical jump. When comparing men and women, statistically significant differences were observed. Men exhibited significantly larger values for flight time (p=0,00), jump height (p=0.00), power output (p=0.00), and the reactive strength index (p=0.00), while they displayed smaller values for verticality (p = 0.03) and the reactivity index (p=0.00). No significant differences were observed in other parameters. Differences between gender in those parameters are expected and in accordance with previous literature. These gender differences in the mentioned parameters align with expectations and are consistent with findings reported in previous literature.

Table 3. Descriptive parameters for the coefficient of variation and gender-based differences

Variables	All (N=47) M±SD (Min-Max)	Female(N=15) M±SD (Min-Max)	Male (N=32) M±SD (Min-Max)	p
TCont.[s]	8,33 ± 10,03 (1,70-45,00)	10,27 ± 11,05 (2,40 - 37,30)	7,42 ± 9,56 (1,70 - 45,00)	0,12
TFlight[s]	5,37 ± 11,91 (1,00-77,80)	2,27 ± 1,95 (1,00 - 9,00)	6,82 ± 14,21 (1,10 - 77,80)	**0,00***
Height[cm]	10,09 ± 22,36 (2,00-153,90)	4,53 ± 3,95 (2,00 - 18,20)	12,70 ± 26,70 (2,00 - 153,90)	0,52*
Power[W/Kg]	9,88 ± 23,65 (1,30-163,70)	5,19 ± 4,58 (1,30 - 20,40)	12,08 ± 28,37 (1,40 - 163,70)	0,06*
Pace[step/s]	7,99 ± 27,95 (1,10-194,00)	5,61 ± 5,13 (1,10 - 16,50)	9,10 ± 33,82 (1,10 - 194,00)	**0,00***
RSI[m/s]	14,75 ± 27,48 (2,10-191,60)	10,97 ± 8,71 (2,10 - 36,70)	16,52 ± 32,81 (2,80 - 191,60)	**0,04***
Verticality	92,94 ± 34,58 (39,90-180,80)	96,28 ± 25,46 (55,90 -138,00)	91,37 ± 38,38 (39,90-180,80)	0,44
DurationConcP[s]	12,80 ± 15,69 (1,50-70,20)	18,77 ± 20,53 (1,70 - 70,20)	10,00 ± 12,24 (1,50 - 55,40)	0,19
DurationEccP[s]	29,73 ± 15,90 (3,50-79,10)	30,56 ± 17,89 (4,00 - 59,20)	29,35 ± 15,18 (3,50 - 79,10)	0,78
RFD[N/kg/s]	73,53 ± 48,29 (6,80-183,20)	86,83 ± 47,62 (6,80 - 168,60)	67,29 ± 48,06 (9,20 - 183,20)	0,15
Ratio Ecc/Conc	36,47 ± 32,86 (5,10-198,00)	43,61 ± 34,68 (5,10 - 118,20)	33,12 ± 31,98 (9,40 - 198,00)	0,39

Notes: p – Mann Whitney U test

Table 3 presents descriptive statistics for the coefficient of variation in selected parameters of vertical jumps. When comparing men and women, statistically significant differences were identified. Men exhibited significantly larger values for flight time (p=0,00) and the reactive strength index (p=0,04), whereas women showed significantly larger values for pace (p=0,00). No significant differences were observed in other parameters.

DISCUSSION

The primary aim of this study was to investigate gender-based differences in selected parameters of vertical jumps, with a focus on the coefficient of variation. The study was conducted on a group of male and female students.

Our findings demonstrate that gender-based differences exist in several key parameters of vertical jumps. Notably, men exhibited significantly larger values for flight time, jump height, power output, and the reactive strength index (RSI), highlighting their superior explosive strength in comparison to women. These results are consistent with previous literature, reaffirming the established gender disparities in explosive strength (Bosco et al., 1983).

In contrast, women displayed significantly larger values for pace, indicating a higher rate of jumps per second. This outcome suggests that women may excel in terms of jump rhythm, an aspect that can be advantageous in specific athletic activities. Additionally, women exhibited significantly larger values for the reactivity index (RI), further highlighting their proficiency in certain aspects of jump performance.

The coefficient of variation (CV) served as a crucial tool in this study, enabling the assessment of variability within the results of individual subjects. While some parameters exhibited significant gender-based differences, the CV analysis revealed that there were no significant differences in variability between males and females. This finding suggests that, despite disparities in mean values, both genders displayed similar levels of consistency and variability in their vertical jump performance. This is an important observation as it indicates that the observed gender differences in jump parameters are not due to differences in the consistency of performance.

LIMITATIONS

It is essential to acknowledge the limitations of this study. The sample size was relatively small, consisting of students from a specific educational institution. Therefore, the generalizability of the findings to broader populations and diverse age groups may be limited. Additionally, other potential factors, such as training history and technique, were not extensively examined in this study and could influence jump performance. Future research should consider larger and more diverse samples and incorporate a comprehensive assessment of these factors to provide a more comprehensive understanding of gender-based differences in vertical jumps.

CONCLUSION

In conclusion, this study explored gender-based differences in various parameters of vertical jumps, revealing that men exhibited greater explosive strength, while women displayed advantages in jump rhythm and certain aspects of jump performance. Importantly, the analysis of the coefficient of variation demonstrated that both genders exhibited similar levels of consistency and variability in their vertical jump performance, despite mean differences.

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CHANGES IN BODY COMPOSITION UNDER THE INFLUENCE OF DIFFERENT DIETARY PATTERNS - SYSTEMATIC REVIEW

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ABSTRACT

Ensuring a nutritious and environmentally sustainable diet is one of the largest worldwide issues. The phrase "vegetarian diet" refers to four different eating regimens: semi-vegetarian, lacto-ovo-vegetarian, lacto-vegetarian, and vegan. The other eating strategies known as intermittent or religious fasting can have a significant negative influence on physical health even if it is often done for spiritual reasons. The aim of this research is to examine the literature and assess the effects of various plant-based eating patterns, intermittent or religious fasting, and other lifestyle choices on body composition. A systematic review of the literature was conducted using Google Scholar, Web of Science, and PubMed. The following criteria were used to evaluate the papers: they had to have been peer-reviewed and published between 2013 and 2022, be in English, be of an experimental character, and involve adult subjects. Based on the defined criteria, 20 articles from the final analysis were chosen and provided for analysis. All studies included a total of 1414 individuals, who were split equally between the sexes and ranged in age from 18 to 80. It may be inferred from the findings that various plant-based dietary regimens affect body composition characteristics as determined by instruments that work on the principles of dual-energy X-ray absorptiometry (DEXA) and bioelectrical impedance (BIA). It may be inferred from the findings that various plant-based dietary regimens affect body composition characteristics as determined by instruments that work on the principles of DEXA and BIA. Following a specific plant-based nutritional regimen led to statistically significant beneficial variations in body composition indices among all participant groups, according to the data acquired.

Keywords: plant-based diet, body composition, adults.

INTRODUCTION

The processing of animal-based meals has raised concerns regarding rising emissions of hazardous gases and the greenhouse impact on the atmosphere on a global scale (Springmann et al., 2018). The most common justifications for switching to a plant-based diet are concern for animal welfare and the numerous health advantages it provides, including the ability to regulate weight and alter body composition. There are many causes for individuals to modify their eating behaviors, with health-related, weight-loss, environmental, religious, ethical, and economic motivations being the most prevalent ones (Corrin & Papadopoulos, 2017; Rosenfeld & Burrow, 2017). The phrase "vegetarian diet" refers to four different eating regimens: semi-vegetarian (no meat), lacto-ovo-vegetarian (no meat or seafood), lacto-vegetarian (no meat or seafood, eggs, or dairy products), and vegan (no animal products at all). According to Ho-Pham et al. (2009), a vegan diet is unquestionably a "true" vegetarian diet for this reason. It is crucial for public health that more people adopt veganism, which vehemently forbids the use of any goods produced from animals (Medawar, Huhn, Villringer, & Witte, 2019). The eating strategy known as intermittent fasting (IF) involves alternating periods of increased and decreased calorie intake. Alternate-day fasting, whole-day fasting, and time-restricted eating are the three types of IF protocols that may be characterized (Tinsley & La Bounty, 2015; Patterson & Sears, 2017;). Periodic fasting (PF) and the 5:2 intermittent fasting plan (two days of fasting per week) are the two most well-known variations of these nutritional methods. Additionally, there are alternate-day fasting (ADF) and time-restricted feeding (TRF), which allow for alternating days of fasting and reduced daily food consumption (Kennedy et al., 2014; Mattison et al., 2017; Di Francesco et al., 2018). Christianity, Judaism, and Islam all practice various types of religious fasting (Trepanowski & Bloomer, 2010). The following times of religious fasting are covered in this analysis: the three primary fasting occasions in Greek Orthodox Christian tradition (Christmas fast, Easter fast, and Assumption of the Virgin Mary fast) and Islamic Ramadan. Each of the fasting periods may be seen as a form of vegetarianism due to how similar they are (Trepanowski & Bloomer, 2010). According to Sarri, Tzanakis, Linardakis, Mamalakis, and Kafatos (2003), the diet during these fasting times consists mostly of bread, fruits, legumes, nuts, shellfish, snails, and vegetables. In fact, compared to those who eat meat, vegetarians might have lower body weight and a lower body mass index (BMI) thanks to a properly balanced diet. There have been attempts to cure obesity and overweight using vegetarian diets. A well-balanced vegetarian diet more effectively reduces body weight (expressed as BMI), improves blood plasma quality, lowers blood pressure, and lowers the incidence of cardiovascular, cerebrovascular, metabolic, and atherosclerotic diseases than other dietary approaches, according to the findings of recent research. In order to manage obesity and excess body weight, nutritionists recommend following a vegetarian diet (Rosenfeld & Burrow, 2017). The aim of this research is to examine the literature and assess the effects of various plant-based eating patterns, intermittent or religious fasting, and other lifestyle choices on body composition.

METHODS

To gather the relevant literature from 2013 to 2022, a search of electronic databases including Google Scholar, Web of Science, and PubMed was carried out. Then, the studies that met the following criteria were chosen for analysis: they were published and peer-reviewed in English, the research was of an experimental character, and involved adult participants. Systematic reviews, meta-analyses, master's theses, doctoral dissertations, and abstracts were all excluded throughout the search. The following keywords were used in the database search: plant-based diet, body composition, adults.

RESULTS

Based on the keywords, 4730 papers were identified. The titles, abstracts, goals of the research, and participants were used to choose the articles. Using the aforementioned techniques and criteria, 20 experimental articles were chosen for the final study. The procedure for gathering, examining, and excluding reviewed papers is shown in Figure 1.

Figure 1. Study flow diagram

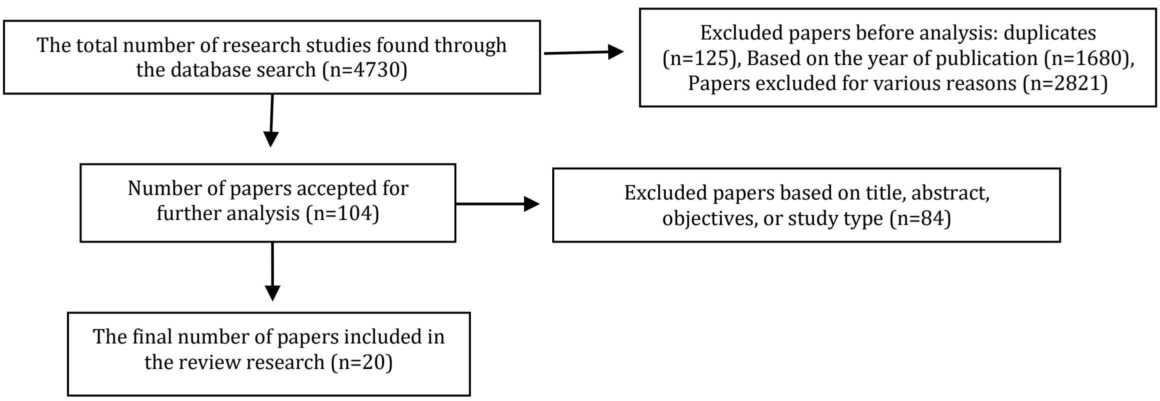

Table 1. includes the papers which fulfilled the requirements. The following details are included in a summary for each research study: the reference (authors and year), a sample of participants (number of participants, gender, age, and dietary pattern), monitored variables, and research findings.

Table 1. Analysis of Collected Papers

FIRST AUTHOR AND YEAR	SAMPLE OF PARTICIPANTS				VARIABLES				
	n	Gender	Years	Participants	Devices	Program Duration	Dietary Pattern	Body Composition Parameters	Results
Balliett & Burke (2013)	50	36 f 14 m	20-60 (31±10,3)	vegans	Bioimpedance (BIA)	3 weeks	vegan diet	body composition (BC); body weight (BW)	BC ↑ BW ↓
Nadimi et al. (2013)	40	20 f 20 m	21-55	vegetarians (n=20) non-vegetarians (n=20)	Bioimpedance (BIA);	1 year	vegetarian diet	body composition (BC); body fat (FM); free body fat (FFM); resting metabolic rate (RMR);	Both groups: BC ↑, BMI, FM and FFM → non-vegetarians: RMR ↑, vegetarians: BW↓,
Moro et al. (2016)	34	34 m	29,21±3,8	TRF(n=17) ND (n=17)	Dual-energy X-ray absorptiometry (DXA)	5 years	time-restricted fasting TRF (16/8)	body composition (BC); muscle mass (MM); Body Mass Index (BMI)	TRF: BC ↑ BMI ↓ MM →
Jakše et al. (2017)	295	m, f	≤ 18	EXP (n=241) CON (n=84)	Bioimpedance (BIA)	10 weeks	low-fat plant-based diet	body composition (BC); body fat (BF); visceral fat (VF); body weight (BW)	EXP: BC ↑ BF ↓ VF ↓ BW ↓ CON: →
Kahleova et al. (2018)	75	67 f 8 m	53.2 ± 12.6	EXP (n=38) CON (n=37)	Dual-energy X-ray absorptiometry (DXA);	16 weeks	plant-based diet	body composition (BC); body weight (BW)	EXP: BC ↑ BW ↓
Vanacore et al. (2018)	30	m	25±5	omnivores (n=10), vegetarians (n=10) vegans (n=10)	Bioimpedance (BIA)	2 years	1. plant-based diet; 2. with the addition of dairy products and eggs; 3. all types of food	body composition (BC); muscle mass (MM); lean body fat (LBF);	vegans: BC ↑ MM ↓ LBF ↓
Pertusa & Mavrommatis	14	10 f	20 - 30	intermitent fasting (IF); caloric restriction (CR)	Anthropometric assessment of body composition (Jackson and	5 weeks	Intermittent fast 5:2 (IF); traditional caloric restriction protocol	body composition (BC); Body Mass Index (BMI)	IF: BC ↑ BMI ↓

(2018)		4 m			Pollock)				
Byrne et al. (2018)	51	m	25–54	continuous energy intake (CONT); intermittent energy restriction (INT)	Plethysmography (BOD POD)	30 weeks	16 weeks continuous(ER); 16 weeks intermitent (INT); 14 weeks energy balance	body composition (BC); Body Mass Index (BMI); resting metabolic rate (RMR)	BC ↑ BMI ↓ RMR↓
Kahleova et al. (2019)	75	67 f 8 m	53.2 ± 12.6	low-fat vegan diet (n=38); control diet (n=37)	Dual-energy X-ray absorptiometry (DXA);	16 weeks	low-fat vegan diet	body composition (BC); body weight (BW); visceral fat (VF)	BC ↑ BW ↓ VF ↓
Mekonen & Haile (2019)	98	52 f 46 m	18-55	omnivorous diet (OM); vegan diet (VD) during Orthodox Lent (EtOC)	StadiometerTanita HR-200	14 weeks	vegan diet	body composition (BC); Body Mass Index (BMI); body fat (BF);	BC ↑ BMI ↓ BF ↓
Domaszewski et al. (2020)	45	f	65±5	CON=20 EXP=25	Analyzer SECA mBCA	6 weeks	16-hour intermittent fasting (TRF)	body composition (BC); body weight (BW); muscle mass (MM)	EXP: BC ↑ BW ↓ MM →
delli Paoli et al. (2020)	107	m	21 – 61 (41.7 ± 9.7)	three periods of low-fat vegan diet	Dual-energy X-ray absorptiometry (DXA)	10 days	Sportfasting protocol 1.-3. day:1800, 1200 and 800 kcal daily; 4.-6. day: 189 kcal daily beverage; 7.-10. day: 800, 1200, 1800 and 2200 kcal daily	body composition (BC); body weight (BW); body fat (BF); muscle mass (MM)	BC ↑ BW ↓ BF ↓ MM ↓
Ağagündüz et al. (2021)	27	16 f 11 m	≤ 18	vegan diet (VD) during Ramadan fasting (16:8)	Analyzer InBody720	4 weeks	fasting during daylight hours; light meal before dawn and after sunset (TRF)	body composition (BC); basal metabolism (RMR); Body Mass Index (BMI);	BC ↑ RMR ↓ BMI ↓
Daradkeh et al. (2021)	92	30 f 62 m	21- 64 42,0 ± 9,5	vegan diet (VD) during Ramadan fasting (16:8)	Analyzer SECA mBCA514	4 weeks	fasting during daylight hours; light meal before dawn and after sunset (TRF)	body composition (BC); body fat (FM); free body fat (FFM); muscle mass (MM); visceral fat (VF)	BC ↑ BW ↓ FM↓ FFM ↓ MM → VF ↓
Bains et al. (2021)	16	7 f	34,0 ± 11,7	vegan diet (VD) during Ramadan	Analyzer InBody 770	4 weeks	fasting during daylight hours;	body composition (BC);	BC ↑ BF ↓

		9 m		fasting (16:8)			light meal before dawn and after sunset (TRF)	body fat (BF); visceral fat (VF)	VF ↓
Jakše et al. (2022)	151	f, m	18 - 80	1. short-term (0,5 - ≤2 years); 2. mid-term (2 - ≤5 years), 3. long-term (5-10 years) plant-based diet	BioimpedanceTanita 780 S MA	12 weeks	plant-based diet; 60 minutes of lectures per week; 30 minutes of moderate physical activity (MVPA); support system	body composition (BC); body fat (BF); muscle mass (MM); Body Mass Index (BMI);	3 groups: BC ↑ BF ↓ BMI ↓ MM →
Crosby et al. (2022)	219	f, m	≤ 18	EXP – vegan diet (n=117) CON - conventional dietary pattern (n=102)	Dual-energy X-ray absorptiometry (DXA)	16 weeks	low-fat vegan diet	body composition (BC); body weight (BW); body fat (BF).	BC ↑ BW ↓ BF ↓
Barnard et al. (2022)	62	f, m	≤ 18	16 weeks Mediterranean or vegan diet; 4 weeks conventional dietary pattern; 16 weeks opposite of original	Dual-energy X-ray absorptiometry (DXA)	16 + 4 + 16 weeks	Mediterranean, vegan diet andconventional dietary pattern	body composition (BC); body weight (BW); visceral fat (VF);	Mediterranean: BC → BW → vegan: BC ↑ BW ↓ VF ↓
Domaszewski et al. (2022)	46	m	65-74	time-restricted feeding (TRF) EXP=23 CON=23	Analyzer SECA mBCA 515	6 weeks	complete fasting during 16 hours daily	body composition (BC); visceral fat (VF); muscle mass (MM);	EXP: BC ↑ BW ↓ VF ↓ MM →
Georgakouli et al. (2022)	23	19 f 4 m	≤ 18	vegan diet	BioimpedanceTBF-521 Tanita	7 weeks	similarity to the Mediterranean diet; milk, dairy products, eggs, meat, and fish were excluded, while seafood, except for fish, was allowed	body composition (BC); Body Mass Index (BMI);	BC ↑ BMI ↓

Legend: ↓ - Statistically significant decrease; ↑ - Statistically significant increase; → - No statistically significant changes; BC - Body composition; BW - Body weight; FM - Fat mass; FFM - Free fat mass; RMR - Resting metabolic rate; MM - Muscle mass; BMI - Body Mass Index; BF - Body fat; VF - Visceral fat; LBF - Lean body fat; EXP - Experimental group; CON - Control group; CONT - Continuous energy intake; INT - Intermittent energy restriction; TRF - Time-restricted feeding; VD - Vegan diet; EtOC - Ethiopian Orthodox fasting; OM - Omnivores (eating both plant and animal-based foods); IF - Intermittent fasting; CR - Caloric restriction; ND - Normal diet.

DISCUSSION

A total of 1414 individuals took part in all research. Male and female participants were represented in 14 studies (Balliett & Burke, 2013; Nadimi et al., 2013; Jakše et al., 2017; Kahleova et al., 2018; Pertusa & Mavrommatis, 2018; Kahleova et al., 2019; Mekonen & Haile, 2019; Ağagündüz et al., 2021; Daradkeh et al., 2021; Bains et al., 2021; Jakše et al., 2022; Crosby et al., 2022; Barnard et al., 2022; Georgakouli et al., 2022). The analysis of the studies shows that the age of the participant samples ranged from ≤ 18 years (Jakše et al., 2017; Ağagündüz et al., 2021; Crosby et al., 2022; Barnard et al., 2022; Georgakouli et al., 2022) up to 18-80 years in the study by Jakše et al. (2022). In the majority of studies (11), participants were divided into two groups (Nadimi et al., 2013; Moro et al., 2016; Domaszewski et al., 2020; Jakše et al., 2017; Kahleova et al., 2018; Pertusa & Mavrommatis, 2018; Byrne et al., 2018; Kahleova et al., 2019; Mekonen & Haile, 2019; Crosby et al., 2022; Domaszewski et al., 2022). Vegans (Balliett & Burke, 2013; Georgakouli et al., 2022), participants in the Sport fasting protocol (delli Paoli et al., 2020), and participants in the vegan diet during Ramadan fasting (Aagündüz et al., 2021; Daradkeh et al., 2021; Bains et al., 2021) were the only participant groups in which authors documented changes in body composition. The studies also varied in their program durations, ranging from ten days in the study by delli Paoli et al. (2020) to five years in the study by Moro et al. (2016). The most commonly used device for measuring body composition (in six studies) was DXA. The results obtained using this device are presented in the following studies: Moro et al., 2016; Kahleova et al., 2018; Kahleova et al., 2019; delli Paoli et al., 2020; Crosby et al., 2022; Barnard et al., 2022. In four studies, BC analysis was conducted using BIA (Balliett & Burke, 2013; Nadimi et al., 2013; Jakše et al., 2017; Vanacore et al., 2018). The Tanita device, was used to monitor participant results in three studies: Mekonen & Haile, 2019; Jakše et al., 2022; Georgakouli et al., 2022. The SECA analyzer was used in three studies: Domaszewski et al., 2020; Daradkeh et al., 2021; Domaszewski et al., 2022. The InBody analyzer was used in two studies: Ağagündüz et al., 2021; Bains et al., 2021. The BOD POD plethysmography device was applied in the study by Byrne et al. (2018), and anthropometric assessment of body composition (Jackson and Pollock) was used in the study by Pertusa & Mavrommatis (2018). Changes in body composition measures such as BC, BW, FM, FFM, MM, BMI, BF, VF, and LBF were observed in all the studies that were examined. All 20 studies' findings confirmed a statistically significant difference in body composition parameters following the finishing of various experimental programs involving various dietary approaches. BW was the most frequently tracked variable, and all investigations supported the fact that after a certain amount of time, the chosen dietary programs showed a statistically significant change from the baseline values. There were no statistically significant differences in BC and BW for the group of individuals following the Mediterranean diet only in the research by Barnard et al. (2022). The findings of the MM variable did not vary statistically significantly across various investigations (Moro et al., 2016; Domaszewski et al., 2020; Daradkeh et al., 2021; Jakše et al., 2022; Domaszewski et al., 2022).

CONCLUSION

This systematic review was conducted with the aim of using a high-quality analysis of selected studies to determine whether different plant-based diets, as well as intermittent or religious fasting, influence the body composition parameters of participants of different genders and ages. The BW, FM, FFM, MM, BMI, BF, VF, and LBF were the body composition parameters that were examined. Data were gathered based on measurements made with DXA, BIA, SECA and InBody analyzers, BOD POD plethysmography, as well as anthropometric body composition assessment using the Jackson and Pollock method. It can be concluded that there are positive statistically significant differences in BC parameters among all groups of participants after the duration of a specific program. The presented results of positive changes in BC are in line with reduced values, primarily BW, but also fat quantity in the body. In several studies, the results indicate unchanged values of MM, suggesting a redistribution of tissue in the body, which also supports weight reduction and a decrease in BF and VF.

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COMBINED EXERCISE PROGRAMS FOR OLDER ADULTS - SYSTEMATIC REVIEW

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ABSTRACT

Aerobic training and strength training are two primary types of exercise being able to reduce blood pressure and lipid levels, increase cardiovascular fitness, and have a positive impact on the size, function, and thickness of artery walls. The combination of aerobic exercise and strength training, known as concurrent training (CT), has received special attention in the scientific literature due to its potential for antagonistic muscle adaptation. The aim of the research is to determine through a literature review whether combined exercise programs influence changes in various parameters of motor and functional status in older adults. Electronic databases such as Google Scholar, Web of Science, and PubMed were searched to gather available literature in English between 2013 and 2022. Finally, a total of 15 studies were included in the qualitative analysis. Men and women between the ages of 40 and 86 participated in the study, with sample sizes ranging from 20 to 123, for a total of 973 individuals. In all studies, participants underwent a combined or concurrent training program of varying durations (from 8 weeks to 12 months). The most commonly used approach was combined training, followed by concurrent training, combined with aqua fitness, high-intensity interval and vibration training, along with whole-body electrostimulation. Based on the obtained data, it can be concluded that there are positive statistically significant differences in the parameters of motor and functional status for the majority of groups of participants after the duration of a specific combined or concurrent training program. The results of this systematic review provide additional evidence supporting the use of combined exercise as an effective method for improving the motor and functional status of older adults.

Keywords: training, older, physical fitness, functional status.

INTRODUCTION

Aging is associated with a decrease in physical fitness levels (Izquierdo et al., 2001), which can lead to unfavorable outcomes such as limited mobility, an increased risk of falls (Rubenstein, 2006), and reduced quality of life (Izquierdo Redín et al., 2021). It is essential to determine appropriate physical activity programs for older adults. Aerobic training and strength training are two primary types of exercise being able to reduce blood pressure and lipid levels, increase cardiovascular fitness, and have a positive impact on the size, function, and thickness of artery walls (Morat et al., 2017). Strength training has been shown to enhance static and dynamic balance in older people and lessen their mobility restrictions by experts (Keogh, 2019). The combination of aerobic exercise and strength training, known as concurrent training (CT), has received special attention in the scientific literature due to its potential for antagonistic muscle adaptation (Hakkinen et al., 2003). Concurrent training can be an effective strategy for improving various parameters of physical fitness in older adults (Izquierdo Redín et al., 2021; Izquierdo et al., 2004). The aim of the research is to determine through a literature review whether combined exercise programs influence changes in various parameters of motor and functional status in older adults.

METHODS

Electronic databases such as Google Scholar, Web of Science, and PubMed were searched to gather available literature that could provide data on the impact of combined exercise programs on changes in various parameters of motor and functional status in older adults. Studies published between 2013 and 2022 were reviewed. The selected studies were written in English, peer-reviewed, and published in scientific journals. Review articles, systematic reviews, meta-analyses, master's and doctoral theses, and abstracts from scientific congresses were not considered.

RESULTS

The complete search revealed 1033 publications. Finally, a total of 15 studies were included in the qualitative analysis. The publications included in this review contain data on sample size, participants' age, training methods, parameters of motor and functional status, key findings, and conclusions. The procedure for gathering, examining, and excluding reviewed papers is shown in Figure 1.

Figure 1. Study flow diagram

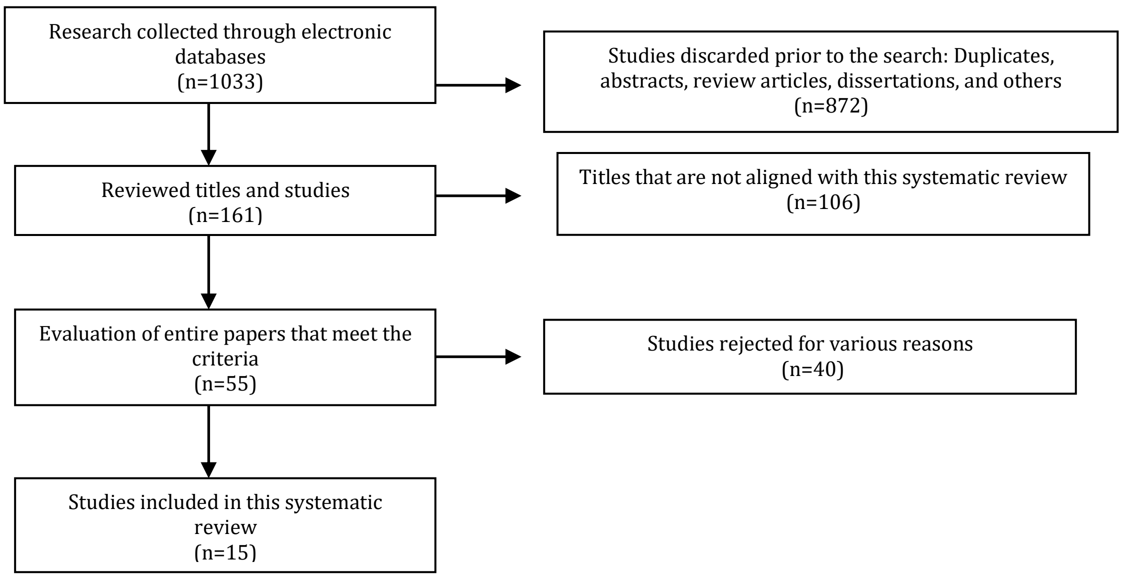

Table 1. includes the papers which fulfilled the requirements. The following details are included in a summary for each research study: the reference (authors and year), a sample of participants (number of participants, gender, and age), variables, and research findings.

FIRST AUTHOR AND YEAR	SAMPLE OF PARTICIPANTS			VARIABLES				
	N Gender	Years	Participants	Program Duration	Training method	Parameters of motor and functional status	Results	Conclusion
Cadore et al. 2013	26 m	64.7±4.1 years	2 experimental groups: (SE, n=13) (ES, n=13)	12 weeks	Concurrent training (simultaneous strength and endurance exercise)	1 RMH; 1RML; MT; EMG; Ptiso	1RMH ↑ 1RML ↑ MT ↑ EMG ↑ Ptiso ↑	Strength exercises before aerobic exercises during concurrent training resulted in greater lower body strength.
Fisher et al. 2013	63 f	60-77 years	3 experimental groups: (RET/AET 1, RET/AET 2 and RET/AET 3)	16 weeks	Combined strength and aerobic training	MS; CF; FT; EE	MS ↑ CF ↑ FT ↑ EE ↑	Combined training improves muscle strength, cardiovascular fitness, exercise economy, and functional tasks
Hunter et al. 2013	72 f	60-74 years	3 experimental groups for aerobic+strength training: 1+1weekly (n=26) 2+2 weekly (n=26) 3+3 weekly (n=22)	16 weeks	Combined strength and aerobic training	BC; 1RM; TEE; AEE; NEAT	BC ↑ 1RM ↑ 2+2group: TEE ↑ AEE ↑ NEAT ↑ 3+3group: NEAT ↓	Combined 1+1 training improves body composition, strength, and aerobic capacity. Combined 2+2 training increases total energy expenditure; Combined 3+3 training once a week reduces energy expenditure during periods of physical inactivity
Roma et al. 2013	96 f	60-86 years	2 experimental groups: (RG, n=46) (AG, n=50)	12 months	Combined strength and aerobic training	FL; SB; SPPB; 6MW	RG: FL ↑ SB ↑ SPPB ↑ AG: 6MW ↑ SB ↑ SPPB ↑	Strength training improves flexibility and static balance and the result on the SPPB test. Aerobic training improved walking speed, static balance, and the result on the SPPB test.
Wilhelm et al. 2014	36 m	63-73 years	2 experimental groups: (ES, n=11) (SE, n=12) control group (CON, n=13)	12 weeks	Concurrent training (simultaneous strength and endurance exercise)	1RML; 30SS; RFEI; ME	30SS ↑ 1RML ↑ RFEI ↓ ME ↑	Concurrent training enhances muscle activities of the lower extremities, increases muscle mass, and reduces muscle fat.
Banitalebi et al. 2015	40 f	65-75 years	3 experimental groups: (E+S, n=9) (S+E, n=10) (ACT, n=12) control group (C, n=16)	8 weeks	Concurrent training; strength and aerobic training	1RML; 1RMH; BC; VO_2max	1RML ↑ 1RMH → BMI ↑ VO_2max→	Concurrent training made positive changes in body composition and physical fitness were observed, but it was not shown whether the training order affects strength and VO_2max.

Barros et al. 2016	123 f	≥ 60 years	3 experimental groups (AG, n=30) (SG, n=30) (PG, n=30) control group (KG, n=33)	8 weeks	Combined strength and aerobic training	6MWT; 1RM; SW	6MWT ↑ 1RM ↑ SW ↑	Training programs resulted in increased aerobic endurance, strength, and agility.
Leirós-Rodríguez et al. 2018	108 f,m	50-79 years	3 experimental groups: (SG) (AG) (AF)	6 months	Combined strength and aerobic training; Aqua fitness	BMI; BW; SFT; SF12; SL; HST; FL	BMI ↓ BW ↓ SFT ↑ SF12 ↑ SL ↑ HST ↑ FL ↑	Training programs are effective in improving functional abilities, especially aerobic endurance, strength, and agility.
Shiotsu et al. 2018	45 m	63-85 years	2 experimental groups: (AR) (RA) control group (CON)	10 weeks	Combined strength and aerobic training	BC; HST; EA	BC → EA → HST→ 10MW ↑ 1LBEO ↑ SAR ↑	Performing aerobic exercises before strength exercises does not affect artery elasticity.
Timmons et al. 2018	84 f,m	69,3±3,5 years	3 experimental groups: (AER) (RES); (CEX); control group (CON)	12 weeks	Combined strength and aerobic training Concurrent training	HST; 1RML; 1RMH; TUGT	RES, CEX: HST ↑ 1RMH ↑ AER, RES, CEX: 1RML ↑ TUGT ↑	Strength training and concurrent training lead to changes in upper extremity strength. All programs increase walking speed and lower extremity strength compared to performing these trainings individually.
García-Pinillos et al. 2019	90 f,m	65–80 years	experimental and control group: (EG, n=47) (CG, n=43)	12 weeks	Concurrent training; Aerobic training	BC; 30-s CST; HST; 10mGS; BAL	BC ↑ 30-s CST ↑ HST ↑ 10mGS ↑ BAL ↑	Concurrent training improves body composition, muscle strength, agility, and balance compared to a regular low to moderate continuous training program.
Amaro-Gahete et al. 2019	74 f,m	40-65 years	3 experimental groups: (PAR) (HIIT) (WB-EMS)	12 weeks	Concurrent training; HIIT; Whole-body vibration training with electrical stimulation	VO_2max; EF; HST; ET	VO2max ↑ EF ↑ HST ↑ ET ↑	Only whole-body vibration training with electrical stimulation improves muscle strength and aerobic fitness

Singh et al. 2019	76 f	60-74 years	3 experimental groups: 1 x week(n=23) 2 x week (n=30) 3 x week (n=23)	16 weeks	Combined strength and aerobic training	VO_2max; WE; SSCP; 1RML	1.and 2.group: SSCP → VO2max ↑ 1RML ↑ 2. group: SSCP ↑ VO2max ↑ 1RML ↑	Combined training improved walking economy as well as aerobic fitness in older women.
Park et al. 2020	20 m	68.8±0.9 years	experimental and control group: (EXP; n=10) (CON; n=10)	12 weeks	Combined strength and aerobic training	BMI; PWV; VO_2max; HST	BMI ↑ PWV ↓ VO2max ↑ HST ↑	Combined training improved body composition, reduced risk factors for cardiometabolic diseases, arterial stiffness, aerobic fitness, and handgrip strength.
Graça et al. 2022	20 f	60.0±7.0 years	2 experimental groups: HIIT-TR (n=10) TR-HIIT (n=10)	8 weeks	Combined strength and aerobic training	BC; ADB; 30-s AC; 6MWT	BC → ADB ↑ 30-s AC ↑ 6-mWT ↑	Combined training improved agility, dynamic balance, repetitive hand strength, and aerobic fitness in older women, but did not lead to changes in body composition parameters.

Legend: ↓ - Statistically significant decrease; ↑ - Statistically significant increase; → - No statistically significant changes; **SE** - strength training before endurance training, **ES** - endurance training before strength training, **1RM** - one-repetition maximum test, **1RMH** - one-repetition maximum test for arms, **1RML** - one-repetition maximum test for legs, **Ptiso** - maximum isometric strength, **MT** - muscle thickness, **EMG** - electromyography, **RET** - resistance training, **AET** - aerobic endurance training, **MS** - Muscle Strength, **CF** - Cardiovascular Fitness, **FT** - Functional Tasks, **EE** - Exercise Economy, **BC** - Body Composition, **TEE** - Total Energy Expenditure, **AEE** - Activity Energy Expenditure, **NEAT** - Non-Exercise Activity Thermogenesis, **RG** - Resistance Training, **AG** - Aerobic Training, **FL** - Flexibility, **SB** - Static Balance, **SPPB** - Short Physical Performance Battery, **6MW** - 6-Minute Walk Test, **CON** - Control Group, **30SS** - 30-Second Sit-to-Stand, **RFEI** - Fat in rectus femoris, **VO_2max** - Aerobic capacity, **ME** - Muscle endurance, **SG** - Strength training, **PG** - Strength and speed training, **KG** - Control group, **SW** - Standing-walking, **AF** - Aqua fitness, **BMI** - Body mass index, **BW** - Body weight, **SFT** - Functional fitness, **SF12** - Health assessment, **SL** - Leg strength, **HST** - Hand grip strength, **AR** - Aerobic training before strength training, **RA** - Strength training before aerobic training, **10MW** - 10-meter walk, **1LBEO** - One-leg balance with eyes open, **SAR** - Sit and reach, **AER** - Aerobic training, **RES** - Strength training, **CEX** - Concurrent training, **TUGT** - Leg strength, **30-s CST** - Lower body muscle strength, **10mGS** - Agility, **BAL** - Balance, **EF** - Knee joint muscle strength, **ET** - Trunk muscle endurance**, PAR** - Combined training**, HIIT** - High-intensity interval training**, WB-EMS** - Whole-body electrical stimulation training**, SSCP** - Stretch-shortening cycle of leg muscles, **EXP** - Experimental group, **PWV** - Arterial wall stiffness, **TR** - Strength training, **ADB** - Agility and dynamic balance, **30-s AC** - Repetitive arm strength

DISCUSSION

Men and women between the ages of 40 and 86 participated in the study, with sample sizes ranging from 20 to 123, for a total of 973 individuals. A total of 7 studies were done on women (Fisher et al., 2013; Hunter et al., 2013; Roma et al., 2013; Banitalebi et al., 2015; Barros et al., 2016; Singh et al., 2019; Graça et al., 2022) and 4 studies on men (Cadore et al., 2013; Wilhelm et al., 2014; Shiotsu et al., 2018; Park et al., 2020). Mixed samples of participants were in 4 studies (Leirós-Rodríguez et al., 2018; Timmons et al., 2018; García-Pinillos et al., 2019; Amaro-Gahete et al., 2019). In 5 studies participants were divided into two groups (Cadore et al., 2013; Roma et al., 2013; García-Pinillos et al., 2019; Park et al., 2020; Graça et al., 2022). In all studies, participants underwent a combined or concurrent training program of varying durations. In 3 studies the training programs lasted a minimum of 8 weeks (Banitalebi et al., 2015; Barros et al., 2016; Graça et al., 2022). The study by Roma et al. (2013) lasted for 12 months. Looking at the various training programs employed in the studies, it can be concluded that the most commonly used approach was combined training (Fisher et al., 2013; Hunter et al., 2013; Roma et al., 2013; Barros et al., 2016; Shiotsu et al., 2018; Singh et al., 2019; Park et al., 2020; Graça et al., 2022), followed by concurrent training (Cadore et al., 2013; Wilhelm et al., 2014). Combined and concurrent training were both employed in the study by Timmons et al. (2018). The most frequently monitored motor status parameters include: 1RM, 1RMH, 1RML, Ptiso, MS, FL, SB, SPPB, 6MW, ES, SE, 30SS, SW, SL, HST, PF, 10MW, 1LBEO, SAR -, 30-s CST, 10mGS, BAL, EF, ET, SSCP, ADB, 30-s AC. The functional status parameters considered in the selected studies include: MT, EMG, CF, FT, EE, BC, TEE, AEE, NEAT, RFEI, VO2max, BMI, BW, SFT, SF12, WE, PWV.

Combined or concurrent training, incorporating endurance and strength training in the same or separate sessions, within a chosen exercise program, is often recommended (Cadore & Izquierdo, 2013). Most commonly, combined training is recommended, which involves a combination of aerobic activities and strength exercises (in any order), performed either in the same session or alternated throughout the week, with the aim of improving both aerobic conditioning and muscle strength (Hickson, 1980). Concurrent training makes use of the advantages of both strength and endurance training to improve general health and fitness in older adults (Izquierdo et al., 2004; Izquierdo, Häkkinen, Ibañez, Kraemer & Gorostiaga, 2005; Cadore, Pinto, Lhullier, Correa, Alberton, Pinto et al., 2011; Cadore et al, 2010). When examining changes in motor status parameters, a positive impact of these training programs can be observed on almost all the observed variables, except for RMH (Banitalebi et al., 2015) and SSCP (Singh et al., 2019), where no statistically significant change was observed. Reduced values of the variable PWV (Park et al., 2020) can be interpreted as a positive effect of combined strength and aerobic training on vascular health. Positive changes in body composition variables were observed in terms of reducing values of BMI and BC, except in the study by Graça et al. (2020), where no statistically significant change in BC was observed. The results of the studies on VO_2max assessment show statistically significant increases after the implementation of a concurrent training program involving separate aerobic and strength training (Banitalebi et al., 2015; Singh et al., 2019; Park et al., 2020) and after a concurrent training program using HIIT and whole-body electrical stimulation (Amaro-Gahete et al., 2019). According to data from earlier studies, these programs can be utilized to help older persons with their motor and functional status parameters.

CONCLUSION

Based on the collected data, there are statistically significant positive differences in the parameters of motor and functional status in the majority of participant groups. There is significant uncertainty regarding the effects of combined training in a single session compared to aerobic training or strength training performed separately. The limitations of this systematic review are that the majority of the analyzed studies only used two training programs with the application of aqua fitness, HIIT, and WB-EMS. Various activities were applied and measured among the participants to objectively assess the impact of physical activity through combined and concurrent training programs on the status of motor and functional parameters. In the future, research on trends in physical activity programs for older adults could employ a method consisting of subjectively selected physical activities, followed by objective monitoring of the training program's results.

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THE DIFFERENCE IN THE POSTURAL STATUS OF THE SPINAL COLUMN IN FOOTBALL PLAYERS OF DIFFERENT CATEGORIES

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ABSTRACT

The aim of this research was to find the difference in the postural status of the spinal column among football players of differente categories. The study included 69 soccer players who had been involved in the training procedure for at least three years. Male respondents aged 12 to 14 years (U14=24), 14 to 16 years (U16=24), and 16 to 18 years (U18=21) were included in the group of participants, which was separated into three age groups. The results indicate the statistical significance of the difference in the sagittal plane (Sig=.014) for category U14, and no statistical analysis indicates difference in the frontal plane of the spinal column (Sig=.167). For the U16 category, neither in the sagittal nor in the sagittal plane (Sig=.683) neither in the frontal plane of the spinal column (Sig=.102). For the U18 category, statistical analysis shows that neither in the sagittal plane (Sig=.275) nor in the frontal plane was there a statistically significant difference (Sig=.275). Future research should consider longitudinal studies and investigate additional factors, such as training intensity, playing position, and injury history, which may contribute to postural variations among football players. In conclusion, this study provides valuable insights into the postural status of the spinal column in football players across different age categories. While significant variations were observed, the absence of statistically significant differences between age groups suggests that age alone may not be the primary determinant of these variations. Addressing spinal deformities in young athletes should remain a priority to promote their long-term health and athletic success.

Keywords: team sport, postural disorders, kyphosis, lordosis

INTRODUCTION

In the modern world, children and youth's regular posture presents an important problem. Children's optimal physical and spiritual development requires good posture in addition to their bodily health (Całka-Lysis, Jankowicz-Szymańska, & Adamczyk, 2008). Children's regular activities make good posture all the more uncommon. Therefore, it is important to include children in planned, professionally supervised, daily variety of physical activities that promote appropriate posture habits in children even at a young age (Protić-Gava & Krneta, 2010). Postural disorders are primarily brought on by a variety of factors, including prolonged incorrect sitting and standing, inadequate educational equipment, overweight schoolbags, decreased physical activity, and others that impact the spine and lower extremities and cause loads that exceed the permissible zone, resulting in the appearance of muscle imbalance (Đokić & Stojanović, 2010). In the daily lives of children, good posture has become less prevalent. The practice of good posture and behaviors of regular participation in different types of physical activity, if they start in early childhood, contribute not only to children's proper growth and development but also have a positive impact on their well-being and quality of life (Protić–Gava & Krnjeta, 2010). Children's postural status might be consistently monitored and evaluated to identify a variety of health issues early on, before they progress. Due to a child's body's sensitivity, establishing a healthy postural position is essential during both the preschool period and the initial years of school (Sabo, 2006). In childhood and adolescence, postural problems are most prevalent (Levangie, & Norkin, 2011). They can impact the abdomen, lower extremities, and spinal column (Milenković, 2007). The most common functional postural deviations of the spinal column when observed in the sagittal plane includes kyphosis, lordosis, kypho-lordosis, and flat back (Czaprowski, et al., 2018; Kosinac, 2008). The concave and rounded back are less prevalent postural problems that also appear in the sagittal plane (Živković, 2009). Several studies have examined the issue of hypokinesis as well as how it negatively affects children's abilities and locomotor condition (Biddle et al., 2001; Živković, D., 2000; Riddoch, 1998). Children who are challenged by a variety of collected stresses can experience injury to their ligament, bones, muscles, and cartilage, specifically to their spinal column (Bogduk, 2005). There are several morphological and functional changes that influence the spinal column's regular posture between between the ages of 7 and 14, consequently active corrective exercises from the right programs should be performed all through this period. The muscular conflict between the agonists and antagonists of the blades of the shoulder and chest musculature, or the muscle imbalance between the lumbar, pelvic, gluteal, and upper-knee musculature, is the cause of postural deformities that include kyphotic and lordotic body positions, irrespective of whether they are brought on by hypokinesis and a sedentary lifestyle or excessive participation in different sports (Dejanović & Fratrić, 2007).

Football practice significantly influences the growth and development of motor abilities, including improved leg muscular strength, greater speed, mobility, coordination, and both general and particular endurance. The muscles across the entire body are used when running, kicking a ball, leaping, and other technical activities, which have an impact on posture (Bogdanović, Ilić & Vidaković, 2015). An excessive training load may accelerate meniscus, tendon, and joint recovery, increasing the risk of injury and increasing the possibility of early osteoarthritis (Bogdanović, Ilić & Vidaković, 2015). Around the world, there are thought to be 5.5 million children and adolescents who play football, and according to Dompier, Powell, Barron & Moore (2007), up to 28% of young players (aged 5 to 14 years) sustain injury. Due to the strong relationship between these abilities and growth and biological development in young athletes, body composition (Ciorsac, Isvoran, & Ostafe, 2010) and posture are significant variables. According to Gorecki (2009), a person's posture is influenced by both their different ontogenetic development and elements of daily living, including their lifestyle and the amount and type of physical exercise they participate in. According to Starosta (1993), asymmetrical lower limb movement and symmetrical upper limb movement are predominant in football. The dominance of one leg over the other has been seen in games played at the international level (Bergier & Nowicki, 2004), even though elite players may use both legs efficiently in gaming (Starosta, 1988). Similar findings were reported by McLean and Tumilty, who claimed that most players exhibit leg dominance based on their own study (McLean & Tumilty, 1993). The influence of football training on posture and the feet has been analyzed in several studies (Asadi, Nourasteh & Daneshmandi, 2014; Grabara, 2012; Jorgić, Živković, Milenković & Živković, 2017; Marencakova et al., 2018; Negrini et al., 2009; Wodecki et al., 2002). Negrini et al. (2009) determined a statistically significant greater prevalence of postural kyphosis among football players aged 11 to 16, compared to their non-athlete peers. Unlike the previous study, Grabara (2012) found no variations in the index of body symmetry, or in terms of postural problems, in a study conducted on football players and non-athletes aged 11 to 14. According to Asadi, Nourasteh & Daneshmandi (2014) research, abnormalities such lordosis and a forward head position are more common among former football players with at least 15 years of training. Jorgić et al. 2017 determined a statistically significant lesser prevalence of flat feet among football players aged 10 to 12, compared to non-athletes of the same age. Despite the recognized significance of spinal postural status in football, there is a scarcity of studies investigating the differences in postural alignment among football players across various categories. Previous research has primarily focused on specific populations, such as elite or professional players, without considering the potential variances between different levels of competition, age groups, or playing positions. Thus, there is a need for a comprehensive study to assess and compare the postural status of the spinal column among football players of different categories, encompassing various competitive levels and positions.

The aim of this research was to find the difference in the postural status of the spinal column among football players of differente categories.

METHODS

Subjects

The study included 69 soccer players who had been involved in the training procedure for at least three years. Male respondents aged 12 to 14 years (U14=24), 14 to 16 years (U16=24), and 16 to 18 years (U18=21) were included in the group of participants, which was separated into three age groups.

Procedure

To determine the postural status in the frontal and sagittal planes of the spinal column, a measuring instrument (Formetric 4D System, Diers, Germany) was used. "Diers" represents the most modern instrument from the group of non-invasive diagnostic methods, i.e. assessment of the postural status of the whole body in the frontal and sagittal planes in static circumstances (Betsch et al. 2011; Mangone, Raimondi & Paoloni,2013). The validity and reliability of the instrument (Formetric 4D System, Diers, Germany) was established in research (Somoskeöy, Tunyogi-Csapó, Bogyó & Illés, 2012; Lason et al.,2015). The instrument has also been used with subjects of various ages (Sung, Yoon & Park, 2015; Knott et al.,2016). Based on the data on the postural status of the spinal column in the sagittal and frontal planes, obtained during the measurement with this instrument, the following variables were distinguished: NPS-Normal posture of the body in the sagittal plane of the spinal column; DS- deformity in the sagittal plane of the spinal column; KYPH-hyper kyphosis; LLOR-hyper lordosis lumbar; KYPHLOR-kypholordosis; RLT-straight back in the thoracic part of the spinal column; SBL-straight back in the lumbar part of the spine; SBTL-straight back in the thoracic and lumbar spine; KYPHFBL-hyper kyphosis with a flat back in the lumbar region; SBTLLOR-straight back in the thoracic part of the spine and hyper lordosis in the lumbar part; NPF-Normal posture of the body in the frontal plane of the spine; DF-deformity in the frontal plane of the spine; TLSC-thoracic left scoliosis; TRSC-scoliosis thoracic right; LLSC-left lumbar scoliosis; RLSC-right lumbar scoliosis; SCTL-scoliosis total left; SCTR-scoliosis total right; CSCTLLR-compensatory scoliosis in the thoracic part on the left side and the lumbar part on the right side of the spinal column; CSCTRLL-compensatory scoliosis in the thoracic part on the right side and the lumbar part on the left side of the spinal column.

Statistical analysis

The statistical data processing program SPSS "version 20" was used to process the obtained data. The obtained measurement results are presented through frequency and percentage. The Kruskal Wallis test was used to determine the differences in the postural status of the spine in football players of different age groups, while the Chi-square test was used to determine the differences in the prevalence of deformities and normal posture of the spine.

RESULTS

Tabela 1. Postural status of the sagittal plane of the spine in football players of different categories

	U14 **N/%**	**U16** **N/%**	**U18** **N/%**	**Total** **N/%**
	24/34.8%	24/34.8%	21/30.4%	69/100%
NPS	5/20.8%	11/45.8%	8/38.1%	24/34.8%
DS	19/79.2%	13/54.2%	13/61.9%	45/65.2%
KYPH	12/50%	7/29.2%	10/47.6%	29/42.0%
LLOR	1/4.2%	/	/	1/1.4%
KYPHLOR	3/12.5%	3/12.5%	2/9.5%	8/11.6%
SBT	/	/	/	/
SBL	3/12.5%	2/8.3%	/	5/7.2%
SBLT	/	/	/	/
KYPHFBL	/	1/4.2%	1/4.8%	2/2.9%
SBTLLOR	/	/	/	/

U14- players under 14 years old; U16- players under 16 years old; U18- players under 18 years old; N- the number of players; NPS- Normal posture of the body in the sagittal plane of the spinal column; DS- deformity in the sagittal plane of the spinal column; KYPH- hyperkyphosis; LLOR- lumbar hyperlordosis; KYPHLOR- kypholordosis; SBT- straight back in the thoracic part of the spine; SBL; - straight back in the lumbar part of the spine; SBTL-straight back in the thoracic and lumbar spine; KYPHFBL-hyper kyphosis with a flat back in the lumbar region; SBTLLOR-straight back in the thoracic part of the spine and hyper lordosis in the lumbar part.

In the age category U14 out of a total of 69 respondents, 24 football players are in the age category U14, which is 34.8% of the total number of respondents. In the age category U14, a total of 5 football players (20.8%) show normal body posture in the sagittal plane of the spinal column (NPS), 19 football players (79.2%) have deformity in the sagittal plane. In the age category u16, 11 football players (45.8%) show normal body posture in the sagittal plane of the spinal column (NPS), 13 football players (54.2%) have deformity in the sagittal plane. In the age category U18, 8 football players (38.1%) show normal body posture in the sagittal plane of the spinal column (NPS), 13 football players (61.9%) have deformity in the sagittal plane.

Tabela 2. Postural status of the frontal plane of the spine in football players of different categories

	U14 N/%	**U16 N/%**	**U18 N/%**	**TOTAL N/%**
	24/34.8%	24/34.8%	21/30.4%	69/100%
NPF	13/54.2%	16/66.7%	13/61.9%	42/60.9%
DF	11/45.8%	8/33.3%	8/38.1%	27/39.1%
TLSC	2/8.3%	1/4.2%	/	3/4.3%
TRSC	3/12.5%	2/8.3%	2/9.5%	7/10.1%
LLSC	/	/	/	/
RLSC	1/4.2%	/	/	1/1.4%
SCTL	/	/	/	/
SCTR	/	/	2/9.5%	2/2.9%
CSCTLLR	3/12.5%	1/4.2%	3/14.3%	7/10.1%
CSCTRLL	2/8.3%	4/16.7%	1/4.8%	7/10.1%

U14- players under 14 years old; U16- players under 16 years old; U18- players under 18 years old; N- the number of players; NPF-Normal posture of the body in the frontal plane of the spine; DF-deformity in the frontal plane of the spine; TLSC-thoracic left scoliosis; TRSC-scoliosis thoracic right; LLSC-left lumbar scoliosis; RLSC-right lumbar scoliosis; SCTL-scoliosis total left; SCTR-scoliosis total right; CSCTLLR-compensatory scoliosis in the thoracic part on the left side and the lumbar part on the right side of the spinal column; CSCTRLL-compensatory scoliosis in the thoracic part on the right side and the lumbar part on the left side of the spinal column.

In the age category U14 out of a total of 69 respondents, 24 football players are in the age category U14, which is 34.8% of the total number of respondents. In the age category U14, a total of 13 football players (54.2%) show normal body posture in the frontal plane of the spinal column (NPF), 11 football players (45.8%) have deformity in the frontal plane. In the age category U16, 16 football players (66.7%) show normal body posture in the frontal plane, 8 football players (33.3%) have deformity in the frontal plane. In the age category U18, 13 football players (61.9%) show normal body posture in the frontal plane, 8 football players (38.1%) have deformity in the frontal plane.

Tabela 3. The difference in the state of the postural status of the spine in buddle ballers of different age categories

	Chi-Square	df	Asymp. Sig
SPSC	.789	2	.674
FPSC	2.266	2	.322

SPSC-sagittal plane of the spinal column; FPSC-frontal plane of the spinal column.

In these results, Chi-Square statistics and asymptotic significance (Asymp. Sig) are used to analyze the difference in the postural status of the spine between different age categories of soccer players. In the case of sagittal plane of the spinal column, the Chi-Square value is 789 with 2 degrees of freedom and an asymptotic significance of 0.674. This indicates that there is no statistically significant difference in the state of the postural status of the spinal column in the sagittal plane between different age categories of football players. In the case of frontal plane of the spine, the Chi-Square value is 2.266 with 2 degrees of freedom and an asymptotic significance of 0.322. This also indicates that there is no statistically significant difference in the condition of the postural status of the spine in the frontal plane between different age categories of soccer players. This analytical approach and results allow us to conclude that no statistically significant difference was recorded in the postural status of the spinal column in football players of different age categories, neither in the sagittal nor in the frontal plane.

Tabela 4. The difference in the postural status of the spine within the age categories of football players

	U14			U16			U18		
	Chi-Square	df	Asymp. Sig	Chi-Square	df	Asymp. Sig	Chi-Square	df	Asymp. Sig
SPSC	6.000	1	.014	.167[a]	1	.683	1.190[a]	1	.275
FPSC	.167[a]	1	.683	2.667[a]	1	.102	1.190[a]	1	.275

SPSC-sagittal plane of the spinal column; FPSC-frontal plane of the spinal column.
a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 12.0.

The results indicate the statistical significance of the difference in the sagittal plane (Sig=.014) for category U14, and no statistical analysis indicates difference in the frontal plane of the spinal column (Sig=.167). For the U16 category, neither in the sagittal nor in the sagittal plane (Sig=.683) neither in the frontal plane of the spinal column (Sig=.102). For the U18 category, statistical analysis shows that neither in the sagittal plane (Sig=.275) nor in the frontal plane was there a statistically significant difference (Sig=.275).

DISCUSSION

Our study found that a substantial percentage of youth football players in all age categories exhibited deformities in the sagittal plane of the spinal column (DS). This finding aligns with previous research that has documented the presence of spinal deformities in young athletes (Grabara,2012). The findings revealed that the group of soccer players had a lower BMI than untrained boys. With the exception of the horizontal symmetry of the waist triangles (higher incidence of symmetry in some ages groups of soccer players) and the horizontal symmetry of the shoulder blades (higher frequency of asymmetry in some ages groups of football players), the alignment of the other measured parameters was similar between the two groups. The position of the pelvis in the frontal plane was more symmetrical (p 0.001) in soccer players. The prevalence of these deformities suggests that they are not uncommon among youth engaged in sports activities that involve repetitive movements and physical contact. Our results also indicate age-related variations in spinal health. In the U14 category, hyper kyphosis (KYPH) was prevalent, which is consistent with previous studies highlighting the susceptibility of young athletes to this condition (Barczyk-Pawelec,2022). A total of 245 young males aged 8–13 who participated in the study were divided into two groups: "Group F—Footballer", elite youth soccer players comprising 132 male athletes, and "Group C—Control group", consisting of 113 boys from primary schools. In the group of footballers in all age groups, higher angular values of thoracic kyphosis and greater tilt of the torso forward were found, compared with their untrained peers. There were also significant differences in body posture between children of different ages, both in the group of footballers and in the group of untrained children. Similarly, our study revealed that hyper kyphosis remained a concern in the older age groups, emphasizing the need for ongoing monitoring and intervention throughout an athlete's development. The percentage of football players exhibiting normal body posture in the sagittal plane (NPS) was lower than those with deformities in all age groups. While our study did not directly investigate interventions, prior research has explored interventions such as posture training and physical therapy that may benefit athletes in maintaining normal spinal posture (Berdishevsky,2016). The seven main schools of scoliosis were thoroughly examined in the publication (Berdishevsky,2016), along with their methods for bracing patients with PSSE (Observation, Physiotherapy Scoliosis Specific Exercises) and supporting scientific research. More than a year after the growth peak has passed, PSSE can momentarily stabilize progressing scoliosis curves throughout the secondary progression era. Regular PSSE therapy can result in a transient and considerable reduction in the Cobb angle in non-progressive scoliosis. One area that requires further investigation is the long-term impact of these spinal conditions. While our study focused on youth athletes, understanding how these conditions may evolve as individuals age and continue to participate in sports is essential. Longitudinal studies tracking athletes into adulthood can provide valuable insights into the consequences of early-life spinal issues (Kongsted,2015). The purpose of this study was to analyze the outcomes obtained using various analytical methodologies and to discover the trajectories of low back pain applying the severity and frequency of low back pain measured once a week for a year. There were 1,082 patients in the trial. The 12 models produced 5 to 12 subgroups, with many stable trajectories among models that varied in pain severity, the number of days with low back pain, and the form of the trajectories. Only a tiny percentage of primary care patients report continuous, severe pain, and the majority do not have pain relief within a year. The prevalence of normal frontal plane posture (NPF) appears to increase with age, with U16 and U18 players having a higher percentage of normal posture compared to U14 players. This could be indicative of improved spinal alignment or the effects of training and development as athletes age The occurrence of deformities (DF) is noticeable in all age categories, albeit at varying rates. Addressing these deformities, particularly in the U14 category where it is more prevalent, may be crucial to prevent the progression of spinal issues into later years. The presence of scoliosis, both thoracic and compensatory, in some football players underscores the importance of early detection and intervention. Scoliosis can lead to pain, discomfort, and potential long-term musculoskeletal issues if not managed appropriately. It's noteworthy that no cases of lumbar scoliosis were recorded in any of the age categories. This may indicate that certain types of scoliosis are more prevalent in the thoracic region among youth football players, which warrants further investigation. To compare the difference in the state of the postural status of the spine in buddle ballers of different age categories and the difference in the postural status of the spine within the age categories of football players with existing literature, we should consider studies that have examined the relationship between age and spinal posture in athletes, especially football players.

CONCLUSION

These results underscore the importance of early assessment and intervention to address spinal deformities in youth football players. Implementing routine postural screening and targeted interventions, such as physical therapy and corrective exercises, may help mitigate the risk of musculoskeletal issues and enhance athletic performance. Future research should consider longitudinal studies and investigate additional factors, such as training intensity, playing position, and injury history, which may contribute to postural variations among football players. In conclusion, this study provides valuable insights into the postural status of the spinal column in football players across different age categories. While significant variations were observed, the absence of statistically significant differences between age groups suggests that age alone may not be the primary determinant of these variations. Addressing spinal deformities in young athletes should remain a priority to promote their long-term health and athletic success.

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THE 800 AND 1500 METERS RUNNING TECHNIQUE ANALYSIS: A SYSTEMATIC REVIEW

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ABSTRACT

This aim of this study was to conduct a comprehensive systematic review focusing on the running techniques employed in the 800 and 1500 meters. To achieve this, we meticulously examined recent literature by searching electronic databases such as PubMed, Google Scholar, and ScienceDirect. A stringent set of inclusion criteria was applied, resulting in the inclusion of 14 studies published within the last 25 years. These selected studies are presented in a structured tabular format, offering essential information including the primary author, year of publication, details about the respondent sample (comprising both male and female participants, totaling 311 individuals), monitored variables, and the outcomes of these investigations. The synthesized findings consistently demonstrated that middle-distance runners achieved higher speeds when making ground contact with the forefoot or midfoot. In contrast, slower runners predominantly employed a heel-first landing technique, often accompanied by a more pronounced forward body lean. Fatigue-induced alterations included increased stride lengths, greater maximum knee flexion during the swing phase, and enhanced maximum thigh angles during hip flexion. The key takeaway from this systematic review is that more successful middle-distance runners exhibited a heightened level of efficiency in their hip joint function. These findings have significant implications for both athletes and coaches, offering valuable insights into optimal running techniques that not only enhance performance but also reduce the risk of injury during middle-distance running events.

Keywords: athletics, track and field, middle-distance running, biomechanics.

INTRODUCTION

Running is a natural form of cyclic movement that has an impact on the development of motor and functional characteristics of an individual (specific muscle groups, respiratory, endocrine and cardio-vascular systems) and represents an important parameter in the physical preparation of athletes (Stanković & Raković, 2010). Also, running can be defined as the product of integrated movement activities performed by different joints and body segments (Pizzuto, Rago, Bailey, Tafuri, & Raiola, 2016). Middle-distance running (800 and 1500 meters) represents a combination of aerobic and anaerobic capacity that enables the runner to maintain the appropriate speed during the race (Brandon, 1995; Trowell, Phillips, Saunders, & Bonacci, 2021). Many factors influence competitive middle-distance running success, including the athlete's anthropometry, training, physiology, environment and biomechanics (Saunders, Pine, Telford, & Hawley, 2004). Furthermore, a good knowledge of the physiological characteristics and kinematic parameters of the runner is necessary in order for him to be successful in this discipline (Cunningham, Hunter, Seeley, & Feland, 2013). Knowing the kinematics required for competitive middle-distance running has a positive effect on success by improving strength, endurance and economy of running (Cunningham, et al., 2013).

There are many studies that have described the structural analysis of the 800 and 1500 meters running technique (Cunningham, et al., 2013; Hayes & Caplan, 2012; Kyröläinen, Avela, & Komi, 2005; Skof & Stuhec, 2004; Tartaruga, L.A.P., Larronda, Joss, & Kruel, 2000). Hayes & Caplan, (2012) found that faster middle-distance runners have an initial ground contact with their forefoot or midfoot and a shorter overall ground contact time. On the other hand, slower runners make initial ground contact with the heel and have a greater forward body lean (Trowell et al., 2019). Namely, Tartaruga et al., (2000) found that the angular range of trunk movement and angular velocity increased with effort. Furthermore, there was an increase in stride length, maximum knee flexion angle during swing and maximum thigh angle during hip flexion when fatigue occurred (Fourchet, Girard, Kelly, Horobeanu, & Millet, 2015; Möhler, Fadillioglu & Stein, 2021).

Until now, the authors have studied more the structural analysis of sprint or long-distance running technique and its influence on the runner's success (Ciacci, Di Michele, & Merni, 2010; Krzysztof & Mero, 2013; Saunders, Pyne, Telford, & Hawley, 2004; Yuda, Yuki, Aoyanagi, Fujii, & Ae, 2007). Knowledge about middle distance running technique and its importance for sports success is limited. Due to all of the above, the aim of this study was to conduct a systematic review of recent studies in order to analyse the 800 and 1500 meters running technique.

METHOD

Literature Identification

The following electronic databases were used to find relevant literature: PubMed, Google Scholar and ScienceDirect. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines was used for searching and analyzing the studies (Page et al., 2021). The following terms were used during the search: (athletics OR track and field) AND (biomechanics OR structural analysis OR kinematics OR kinetics) AND (middle-distance runners). Table 1 contains the literature search strategy.

Table 1. Search strategy

Search 1	Search 2	Search 3
athletics track and field	biomechanics structural analysis kinematics kinetics	middle-distance runners

Two writers (S.M. and D.S.) conducted the literature search. Then the studies were cross-identified by each author. Thereafter, studies were either rejected or accepted for further analysis. Studies were thoroughly screened and identified as appropriate for inclusion in this study based on titles, abstracts, and full articles. Also, method of systematization and analysis and descriptive method were used for the study purpose.

Inclusion Criteria

All studies had to meet certain criteria for the final analysis. The first criterion was that the studies analyzed the 800 and 1500 meters running technique. These are the athletic disciplines of middle-distance running. Therefore, studies that analyzed the technique of other athletic disciplines were not included in the final analysis. The next criterion was that all studies included in the analysis had to be published in the last 25 years. Also, the studies had to be original and written in English. Figure 1. shows the data collection method.

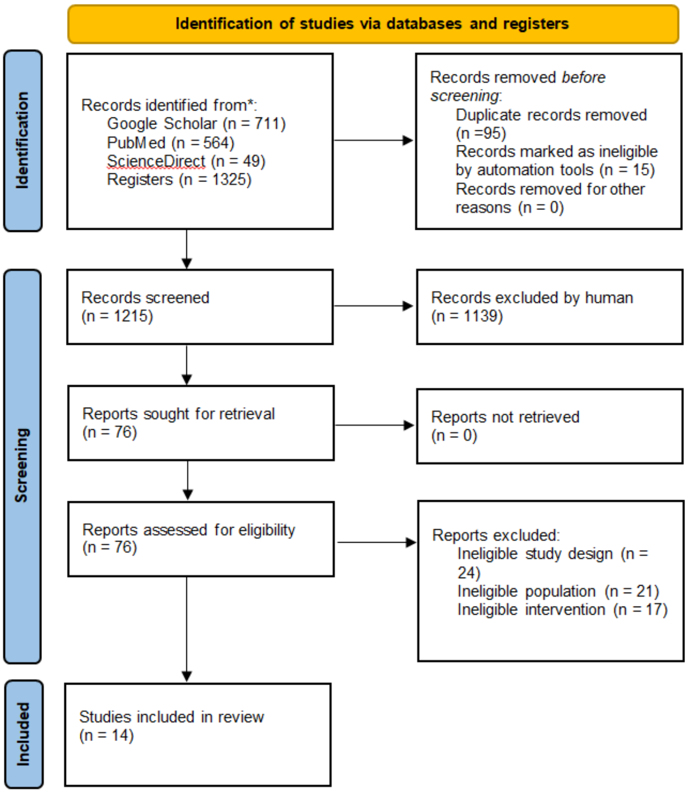

Figure 1. PRISMA flow diagram.

Risk of Bias Assesment

The study's quality and eligibility for inclusion in the final analysis were independently assessed by two authors (S.M. and D.S.). A third author (A.R.) reviewed the collected data and had the final say in cases of dispute over the conclusions regarding the risk of bias.

RESULTS

Fourteen studies were presented in Table 2. The table contains the following information: first author and year of publication, sample of respondents (number, sex and age), variables and the results of the studies.

Table 2. Analysis of the studies.

First author and year of publication	Sample of Respondents			Variables	Results
	Number	Sex	Age		
Tartaruga et al., (2000)	7	M	17.8±2.6	AVL, JAL	AVL↑r800 JAL↑r800
Skof et al., (2004)	1	F	28	CMS, AVL, JAL	CMS↑ r800(er) AVL↑ r800(er) JAL↑r800(er)
Kyröläinen et al., (2005)	17	M	23±3	GCF	GCF↑
Leskinen et al., (2009)	11 (6-nr;5-er)	M	nr- 20.0±1.7 er-	AVL, JAL, RS	AVL↑r1500(er) JAL↑r1500(er) RS↑r1500(er)

			26.4±2.7		
Coleman et al., (2012)	19	M	21.1±4.1	GCF, RS, LRT, LRK, LRM, LRH, LRST	GCF↑ RS↑
Hayes et al., (2012)	181	M= 123 F= 58	x	RS, GCF	RS↑GCF(r1500)
Cunningham et al., (2013)	30	F	19.8 ± 2.5	JAL, GCF, SL, CMS	JAL↑
Craighead et al., (2014)	18	M	23-66	SL, SF, KFV, GCF	SL↑ SF↑
Fourchet et al., (2015)	11	M	16.9 ± 2.0	GCF, FT, SF, SL, CMS, LC, LS, MMF, MPP	SF↑ SL↑
Dobre et al., (2019)	5	M= 1 F= 4	x	GCF, JAL	GCF↑r1500(nr) JAL↑r1500(nr)
Trowell et al., (2019)	11	M	22.3±5.1	RS, GCF, JAL, CMS,	GCF↑ JAL↑
Dobre (2020)	3	F	x	GCF, JAL, HHV, ADIP, PA	GCF↑r1500(nr) JAL↑r1500(nr) HHV↑r1500(nr) ADIP↑r1500(nr) PA↑r1500(nr)
Dobre et al., (2021)	1	M	17	HHV, HKV, HAV	HHV↑r1500(nr) HKV↑r1500(nr) HAV↑r1500(nr)
Möhler et al., (2021)	13	M	23.5 ± 3.6	GCF, FT, SF, LS, VS	GCF↑ FT↑ LS↑ VS↑

Legend: ↑ - statistical significance; **x** – no information; **M** – male; **F** – female; **r800** – 800 meters running; **r1500** - 1500 meters running; **nr** – national runners; **er** – elite runners; **AVL** - angular velocity of lower limb; **JAL** – joint angles of lower limb; **RS**- running speed; **GCF** - ground contact force; **LRT** - left and right greater trochanter; **LRK** - left and right knee joints; **LRM** - left and right lateral malleoli; **LRH** - left and right heels; **LRST** - left and right second toes; **SL** - stride length; **SF** – stride frequency; **CMS** - center of mass separation; **KFV** - knee flexion velocity; **HHV** - horizontal hip velocity; **HKV** - horizontal knee velocity; **FT** – flight time; **LC** - leg compression; **LS** - leg stiffness; **VS** – vertical stiffness; **MMF** – maximum and mean force; **HAV** - horizontal ankle velocity; **MPP** – mean and peak pressure; **ADIP** – active duration of the impulse phase; **PA** - pulse angle.

Fourteen studies met the criteria for analysis in this systematic review. The oldest study was published in 2000 (Tartaruga, Larronda, Joss, & Kruel, 2000) while the most recent study was published in 2021 (Möhler, Fadillioglu, & Stein, 2021). The sample of respondents consisted of only male or only female. Two studies had both male and female as a sample of respondents (Dobre, Mereuță, & Grigore, 2019; Hayes & Caplan, 2012). The largest number of respondents was 181 (Hayes & Caplan, 2012), and the smallest number was one (case study) (Dobre & Gheorghe, 2021; Skof & Stuhec, (2004). The results of studies have shown that middle-distance runners were faster if they made the ground contact with their forefoot or midfoot, ground contact time gradually increased with fatigue and vertical displacement of the body's mass centre helped improve running economy.

DISCUSSION

The aim of this study was to conduct a systematic review of recent studies in order to analyse the 800 and 1500 meters running technique. The analysis of middle-distance running technique has been the topic of many authors (Dobre et al., 2019, Dobre, 2020, Dobre & Gheorghe, 2021; Kyröläinen, Avela, & Komi, 2005). Modern methods and video analysis were used in these studies. It was determined that it is necessary to eliminate certain acquired running mistakes in order to improve the technique itself (Dobre & Gheorghe, 2021; Kyröläinen, Avela, & Komi, 2005). Furthermore, it was found that runners who made ground contact with their forefoot or midfoot had a higher average speed compared to runners who made ground contact with the heel (Hayes & Caplan, 2012). Also, the ground contact time was significantly shorter in the first lap of the race compared to the last one (the occurrence of fatigue) (Hayes & Caplan, 2012).

Midstance to Midstance Running (MMR) is a method of analyzing running technique used by Craighead, Lehecka & King, (2014). They used an experimental design to determine the effect on running kinematics and economy. The following was established: no significant changes were found in heart rate, running economy or effort, MMR was effective in improving stride length and stride frequency, but there was no effect on ground contact time and maximal knee flexion during swing and MMR had no effect on running economy. It could be concluded that MMR was suitable for recreational runners who want to reduce the stride length and increase the stride frequency. It was established that the angular range of trunk movement and angular velocity increase with effort (Tartaruga et al., 2000). Namely, Skof & Stuhec, (2004), aimed to analyze the important kinematic variables of Jolanda Čeplak's running technique. They found the following: the vertical displacement of the body's center of mass is optimal, which leads to an improvement in running economy, creating a running force and increasing the stride length is achieved by plantar flexion range, high angular velocity of ankle plantar flexion and knee extension and large movement amplitude of the thigh of the swing leg.

The analysis of the running technique during fatigue was studied by the authors Fourchet et al., (2015) and Möhler, Fadillioglu & Stein, (2021). It was established that there was a significant increase in stride length, an increase in the maximum angle of knee flexion during the swing and an increase in the maximum angle of the thigh during hip flexion when fatigue occurred. Namely, Fourchet et al., (2015) reported that leg stiffness decreased as leg compression increased relative to peak vertical ground reaction force. Also, the same study established that adolescent runners worsened their stride pattern due to fatigue caused by high constant running speed. More experienced middle-distance runners were found to vary their stance time rather than stride frequency or length to maintain a constant running speed (Möhler, Fadillioglu & Stein, 2021). Also, there are increased movements of the upper body to reduce the angular momentum of the lower body (Möhler, Fadillioglu & Stein, 2021).

Slower middle-distance runners were found to make initial ground contact with the heel and a greater forward body lean (Trowell et al., 2019). It was established that elite 1500 m runners have better kinematic characteristics than national 1500 m runners (Leskinen et al., 2009). Namely, both elite and national runners were found to have similar ground contact times. However, elite runners have a higher knee angle during the stance phase and a slower average knee angle velocity than national runners. It can also be said that the running technique of elite runners is characterized by a more efficient function of the hip joint. Cunningham et al., (2013). stated that runners of different athletic running disciplines were distinguished based on the physiological and biomechanical characteristics of the runners. Sprinters have less ground contact time and less knee flexion during the stance phase compared to middle and long-distance runners. It has also been observed that separation of the body's center of mass is shorter for sprinters than middle and long-distance runners based on the distance they compete.

The limitation of this systematic review is reflected in the small number of published studies that aimed to analyze the middle-distance running technique. Also, many studies did not have an adequate sample of respondents. Sprinters or long-distance runners have been studied more. Therefore, the results of this study cannot be generalized and applied to the entire population.

CONCLUSION

Based on previous studies, it can be concluded that middle distance runners have higher speed if they have ground contact with their forefoot or midfoot. On the other hand, slower runners have ground contact with the heel and have a greater forward body lean. The elite runners' running technique was characterized by a more efficient function of the hip joint. Ground contact time gradually increased as fatigue occurred. Also, there was an increase in stride length, maximum knee flexion angle during swing and maximum thigh angle during hip flexion when fatigue occurred. This study completes the theoretical knowledge about the technique of middle-distance running. Also, the results could be usefully used for better guidance and selection of athletes.

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