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Faculty of Sport and Physical Education

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„FIS COMMUNICATIONS 2021"
in physical education, sport and recreation

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FOREWORD

Dear Authors, esteemed Scientists, with a great pleasure and honor I am writing this Foreword to the Proceedings of the XXIII International Scientific Conference "FIS COMMUNICATIONS 2021" held in Niš, October 21 - 23, 2021. This year is particularly important because the Faculty of Sport and Physical Education of University of Niš is celebrating 50th anniversary. Organizing the conference in this year brought a big challenges to the organizers, as well to the participants. Global crisis caused by the pandemic COVID-19 brings different measures of protection which changed and burden organization of the big events such as our conference. However, International Scientific Conference "FIS COMMUNICATIONS 2021" continues a tradition of bringing together researchers, academics and professionals from all over the world, experts in sport, physical education and recreation. The Book of Abstracts is consisted of 69 abstracts written by more than 190 authors from 14 countries. Abstracts are divided into four sessions depending on the topics investigated as follows: Individual and Team Sports, Physical Activity and Health, Physical Education and Interdisciplinary. In addition to the contributed abstracts, two invited keynote presentations were given by professor Antonio Tessitore from the Foro Italico University of Rome (Italy), professor Rıdvan Ekmekçi from the Faculty of Sport Sciences, Pamukkale University, Turkey. Distinguished keynote speakers covered very interesting topics from Decision making in team sports to the always needed planning of the training of elite athletes. This Book of Abstracts will furnish the scientists of the world with an excellent reference book. I believe also that this will be an impetus to stimulate further study and research in the field of sports science. We thank all authors and participants for their contributions.

Chair of the Scientific Committee

Nenad Stojiljković, PhD

CONTENTS

Plenary Sesion

WHAT DOES IT TAKE TO BE AN ELITE ATHLETE- HOW THE CHAMPIONS WORK?

Rıdvan Ekmekçi

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UDC 796.01:159.9

ABSTRACT

Mental Successful athletes are those who can maintain their positive attitudes and behaviors. A high level of personal motivation forms the basis of an athlete's success. When realistic goals, proper concentration, good emotional control, and the ability to cope with stress are added to this, it is certain that you will always be one step ahead of the others.

To realize all these features, it is important for the athletes to discover themselves mentally. Developing skills requires long training and lots of repetition. However, to maintain these skills well and to exhibit the desired high-level performance in every competition, it is essential and necessary that the mental control and mental preparation process need to be a very good or excellent.

How we know and understand what we need to do to become an elite athlete. Well, it all started after your birth. Your genetics and innate talent and abilities are the first initiators in the process of making you an elite athlete. Today, we can tell from gene analysis how talented you are, your injury susceptibility, recovery speed, explosive strength, or stamina. Also, we can learn with DNA test your concentration level or calmness. In addition to these, we can learn whether you have gluten sensitivity, your lactate tolerance, or your metabolic rate. Athletic skill tests, psychometric tests, blood test and performance analyze are other analyzes that must be done on the way to become an elite athlete. In addition to all these, emotional control, stress management, good sleep, quality nutrition, exercises to increase mental endurance, attention and concentration exercises are the things that should be on the way to become an elite athlete. Professional elite athletes today work with their own training programs prepared by experts. These experts are doctors, physiotherapists, mentors, sport psychologists, nutritionists, personal trainers, conditioners, and athletic trainers. They prepare for competitions with their own expert teams. For example, LeBron James spends 1.5 million dollars a year for his expert team. It is possible to add more examples like Cristiano Ronaldo, Novak Djokovic, or Michael Phelps. On the other hand, especially with the growth of the economy in professional sports, not only athletes but also teams have started to include such experts in their staff.

To be a professional elite athlete, you need to know very well what your physical and mental capacity is and how you can improve it. In addition, you must learn what you need to do to maintain the skills you have acquired. Especially positive psychology, meditation and mindfulness exercises are very valuable in developing mental skills. Good performance at a professional elite level depends on the small details. To reach physical and mental potential, athletes need to work in discipline and detailed.

Talents makes you successful but if you want to be a champion or a legend, you must live professionally and work in discipline.

Living like a champion – to do list

Good sleep: Sleep between 22.00 – 06:00.

Good food: Eat what you need not what you want.

Good physical training: Improve your physical condition in proper way.

Good mental training: Improve your mental abilities and cognitive skills like focusing, mental toughness and problem-solving skills.

Good concentration: Be aware of type of your brain and learn how to concentrate yourself.

Positive psychology: Learn what positive psychology is and apply it in your life.

Positive manner: It is important to have positive manner, keep smile and keep your head up.

Positive energy: Think positive, be positive. Remember, motivation comes from positive energy.

Learn stress management: Stress is a performance creator, just focus on and manage it.

Learn time management: Yesterday is a history, tomorrow is a mystery but today is a gift, don't waste your time.

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Keywords: sport, elite athletes, champion, sport psychology, mental training

DECISION MAKING IN TEAM SPORTS: ANALYSIS OF DETERMINANT FACTORS AND METHODOLOGIES OF TRAINING

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UDC 796.015.5
796.332

ABSTRACT

In addition to a high level of physical and physiological conditions, to succeed in team sports require players to possess a high level of technical and tactical skills. Decision making is the process through which players choose what they will do in a play, mainly to support the tactical component of the game. It impacts on the performance through two dimensions: individual solutions generated in the moment of the action (*reading the play*) and collective strategy (*pre-determined solutions*). In particular, the variability and unpredictability characteristics of actions, require team sports players to continuously take successful decisions in the play in both ball possession and not possession conditions (Grehaigne, Godbout, & Bouthier, 1997). To have an idea of the flow of decision has been estimated that a normal person makes about 6000 decisions throughout the day while a football player usually makes more than 2500 decisions during a single match (Teoldo, Guilherme, & Garganta, 2017). In some instances, the choice may be simple, based on a yes-o-not context, in others be more complex. The more players are skilled, the more they are able to extrapolate and process information from the competitive environment in order to identify salient, predictive, global cues within the context of the play and their intended goal. In addition to expertise, and other covariables that influence the quality and accuracy of decisions, mental fatigue can play a relevant role (Kunrath, Nakamura, Roca, Tessitore, & Teoldo Da Costa, 2020). It has been reported that mental fatigue compromises the ability to maintain attention on what is important during a task, compromising focus, performance adjustment, rapid and accurate reaction, and interpretation of meaningful cues in the visual field, as well as reducing technical performance (Coutinho, Gonçalves, Wong, Travassos, Coutts, & Sampaio, 2018). Among other well-known factors, a related decision making training might include: a) to play exploring different degrees of freedom, b) to elicit eliciting reinvestment by leaving room for mistakes (Petiot, Bagatin, Aquino, & Raab, 2021).

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Keywords: Decision Making, Mental Fatigue, Team Sports Training

Individual and Team Sports

INITIAL DESCRIPTIVE MODEL INDICATORS OF FOOT MOVEMENT FREQUENCY IN HIGHLY TRAINED DANCERS MEASURED BY THE FITLIGHT METHOD: A PILOT STUDY

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UDC 796.012.2.226:793.3

ABSTRACT

The main goal of the experiment is to describe the initial model indicators for estimating the frequency of foot movement in dancers of national and international level, in dance disciplines Latin and Standard, Latin formation and Contemporary dance, using four taping tests, which are designed for this study. The sample was comprised of 12 experienced dancers, of which 10 were youth, aged 16-19 and two were adult dancers, aged 19+. Participants were introduced to the method of performing the tests immediately before the measurement, after which the dancers were warmed up for 10 minutes. The tests were randomly assigned to the participants through two attempts with the right and left foot. The study used FitLight Trainer, a wireless system of interconnected sensors that registered runtime. The results of descriptive statistics showed great homogeneity of raw results from two attempts, within 26% coefficient of variation, and could be considered for the target group-population of dancers as generally reliable. The results of differences in relation to gender, expressed as a percentage, between the average values of the examined time variables are in favor of men, except in Test 3, performed with the left foot, where women have an advantage of 10.9% over total time and 19.11% over average time. In order to define the final model indicators and furthermore, metric characteristics of the applied tests for estimating the frequency of leg movements in dancers, it is necessary to repeat the measurement on a representative sample, which would include athletes from other sports and non-athletes.

Keywords: sports testing, coordination, precision, balance, FitLight

INTRODUCTION

Malacko and Radjo (2004) say that motor abilities are those human abilities that participate in solving motor tasks and condition successful movement, regardless of whether they were acquired through training or not. Zaciorski (1975) singled out seven basic physical characteristics of an athlete, namely: speed, strength, endurance, coordination, balance, precision and flexibility. The analysis of basic motor skills in sport dance gives information about the abilities that have the greatest impact on the results and that should be especially monitored and developed in the training process, for example ballet dancers have a greater range of motion and strength in the hip joint but insufficient strength in the upper body, trunk, thigh tendons and quadriceps (Twitchett et al., 2009). Specific motor abilities are acquired and are conditioned by the specificity of the training process of different dance discipline. According to Malacko and Radjo (2004), this refers to abilities that directly affect the sports result, since they are very close in structure, character and intensity of load to the activities performed at competitions and show the greatest connection with the achieved sports success. Speed of movement is very important for dancers in a way of changing the dynamics of movement, making choreography vivid and interesting, respecting the rhythm, phrase, melody, but also is the ability that should be developed respecting precision, balance and not disturbing posture.

The aim of this pilot study is to describe the initial model indicators for estimating the frequency of foot movement in dancers of national and international level, in dance disciplines Latino and Standard, Latino formations and Contemporary dance, using four taping tests. The tests are specifically designed for this research and include leg movements in all three planes. The goal was to complete the set task as quickly as possible, without disturbing the precision - contact with the sensor and balance. Obtaining relevant quantitative information is the goal of the study using Fitlight method. The new FitLight Trainer technology allows users to perform tests while performing pre-planned movement and motion structures, and allows direct comparison. Moreover, this technology is an effective tool for training and developing sports performance. In the theory and practice of sports, there is significant interest in developing appropriate diagnostic tests and specific methods that would help coaches both to predict, identify future talents, and to improve work with existing dancers.

METHODS

Sample

Participants in the study were experienced dancers (seven female and five male dancers) from three dance disciplines: Latino and Standard couples, Latino formations and Contemporary dance. The mean age of the participants was 18.9±4.45 years. The dancers were from Belgrade dance clubs: DC Vračar, DC Latino dance, DC Kreativa and DC Aurora. All participants were of national level, with experience on the international scene, with an average dance experience of 9±3.08 years. None were injured and they actively participated in regular trainings. Participants were informed about the purpose of the experiment and measurement, as well as the procedures. They signed a written consent in accordance with the Helsinki-Tokyo Declaration, stating that their participation was voluntary and could withdraw at any time. Parental consent was obtained for individuals under 18 years of age.

Procedure

The study used a FitLight Trainer, a wireless system, interconnected with light-powered sensors, manufactured by Sport Corp. Ontario, Canada. This system has been used to measure the frequency of foot movements in experienced dancers. For the needs of research and measurements, 4 tests were made, taping with the foot, which included light sensors on the surface. The LED sensor system is controlled using an Android application. Activation of each light module was triggered by direct foot contact. The LED was adjusted for distance and sensitivity. The distance between the sensors was set at 25 cm, except in Test No. 3 where the upper sensor relative to the lower one was set at a distance of 50 cm. The goal of the tests was to complete the task as quickly as possible, without disturbing the precision-contact with the sensor and balance. Variables - the total time and average run time (average time from one sensor to the next) of each individual test were measured and registered on the control panel of the FitLight instrument. After familiarization with the tests (up to 30 min), a 10-minute warm-up followed and the subjects were informed about the testing scenario. Each test was performed twice with the right and left foot, with a break of at least half an hour between attempts. The order of tests during the measurement was random and set by the rater. Two raters were included throughout the test, one recorded and determined the order of the tests, while the other measured the time via Fitlight. The times recorded on the control panel are entered manually in the Excel table. The measurements were performed in a period of three days in the sports gym, in the period from 11 am to 2 pm, under favorable climatic conditions.

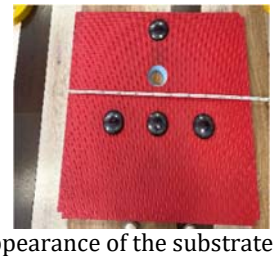

Figure 1. Appearance of the substrate with sensors

TEST 1. Forward-backward. Starting position as in the Figure 2. The beginning is the contact of the right foot with the sensor (green signal) in front of you and tapping the foot forward to the third sensor

(the sensor in the middle is skipped) and back to the first. Repeat the cycle 10 times, until the sensor signal stops (blue signal), which is also registered automatically on the device panel.

Figure 2. Starting position of Test 1

TEST 2. Left-right (right-left). Starting position as in the Figure 3. The beginning is the contact of the right foot with the sensor (green signal) in front of it and tapping the foot to the left to the third sensor (the sensor in the middle is skipped after the initial one) and then to the right to the first sensor. Repeat 10 times, until the sensor signal stops (blue signal), which is also registered automatically

Figure 3. Starting position of Test 2 and Test 4

TEST 3. In the shape of a triangle. Starting position as in Figure 5. The beginning is the contact of the right foot with the sensor (green signal) in front of it and taping the foot forward to the third sensor (the sensor in the middle is skipped) and then as in Figure 4, the pattern is repeated 5 times, until the signal stops sensor (blue signal), which is also registered automatically.

Figure 4. Movement pattern of Test 3

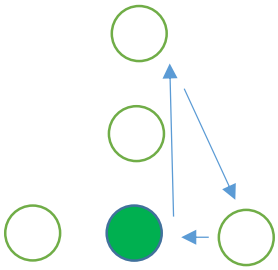

Figure 5. Starting position of Test 3

TEST 4. In the shape of the letter A. The starting position is as in Figure 3. The beginning is the contact of the right foot (when working with the right foot) with the sensor (green signal) in front of it and taping the foot to the left to the third sensor. initial tap with the foot) and then, as in Figure 6, the pattern is repeated 5 times, until the end of the sensor signal (blue signal), which is registered automatically on the device.

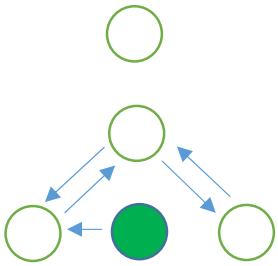

Figure 6. Movement pattern of Test 4

Statistical analysis

All results were firstly analyzed by the basic descriptive statistical method, which calculated measures of central tendency (mean value of variable - AS) and measures of dispersion (standard deviation - SD, coefficient of variation - CV%, range limits minimum - Min, and maximum - Max), as well as standard measurement error absolute and relative. Differences (%) between the average values of the examined variables in relation to gender were calculated, as well as the percentiles of the measured test variables in relation to the sample. Statistical processing was realized using the software package Excel 2003 and SPSS Statistics 20.0.

RESULTS

Table 1 and 2 give descriptive indicators of the tested tests for female and male dancers. The results showed that the coefficient of variation for all indicators, as the basic measures for assessing the homogeneity of raw data for the total and average time of completion of the task, in male dancers ranges from 5.31% to 25.13%, and in female dancers from 6.1% to 17.83%. The coefficient of variation is in the range of values less than 30%, which indicates very homogeneous results and it could be considered for the target group-population of dancers as generally reliable.

Table 1. Basic descriptive indicators of tested tests: female dancers (n=7)

Females						**95% Confidence Interval for Mean**				**KSZ**	
Tests	**Mean**	**SD**	**cV%**	**Std. Err (Aps)**	**Std. Err. (Rel)**	Lower Bound	Upper Bound	**Min**	**Max**	t	p value
T1_R_Sum (s)	5.039	0.461	9.15	0.123	2.44	4.773	5.305	4.280	5.910	0.168	0.200
T1_R_Avg (s)	0.147	0.022	14.97	0.006	4.08	0.134	0.160	0.120	0.190	0.174	0.200
T2_R_Sum (s)	5.531	0.494	8.93	0.132	2.39	5.246	5.817	4.610	6.100	0.166	0.200
T2_R_Avg (s)	0.164	0.024	14.63	0.006	3.66	0.150	0.178	0.119	0.196	0.125	0.200
T3_R_Sum (s)	3.904	0.419	10.73	0.111	2.84	3.664	4.143	3.360	5.000	0.166	0.200
T3_R_Avg (s)	0.145	0.025	17.24	0.007	4.83	0.130	0.160	0.113	0.208	0.214	0.200
T4_R_Sum (s)	5.325	0.325	6.10	0.087	1.63	5.137	5.513	4.870	5.810	0.183	0.200
T4_R_Avg (s)	0.154	0.015	9.74	0.004	2.60	0.145	0.163	0.124	0.179	0.145	0.200
T1_L_Sum (s)	4.975	0.470	9.45	0.126	2.53	4.704	5.246	4.100	5.590	0.119	0.200
T1_L_Avg (s)	0.143	0.018	12.59	0.005	3.50	0.133	0.155	0.104	0.170	0.100	0.200
T2_L_Sum (s)	5.672	0.602	10.61	0.161	2.84	5.325	6.019	4.100	6.600	0.167	0.200
T2_L_Avg (s)	0.169	0.020	11.83	0.005	2.96	0.158	0.181	0.141	0.205	0.103	0.200
T3_L_Sum (s)	4.111	0.434	10.56	0.116	2.82	3.860	4.361	3.590	5.220	0.171	0.200
T3_L_Avg (s)	0.157	0.028	17.83	0.008	5.10	0.140	0.173	0.123	0.234	0.164	0.200
T4_L_Sum (s)	5.591	0.559	10.00	0.150	2.68	5.268	5.914	4.800	6.680	0.136	0.200
T4_L_Avg (s)	0.165	0.028	16.97	0.008	4.85	0.149	0.181	0.126	0.214	0.095	0.200

Legend: T1(2,3,4)_R_Sum– total time of Test1(2,3,4) with right foot, **T1(2,3,4)_R_Avg–** average time of Test 1(2 ,3,4) with right foot, **T1(2,3,4)_L_Sum–** total time of Test1(2,3,4) with left foot, **T1(2,3,4)_L_Avg–** average time of Test 1(2 ,3,4) with left foot

Table 2. Basic descriptive indicators of tested tests: male dancers (n=5)

Males	Mean	SD	CV%	Std. Err (Aps)	Std. Err. (Rel)	95% Confidence Interval for Mean		Min	Max	KSZ	
Tests						Lower Bound	Upper Bound			t	p value
T1_R_Sum (s)	4.981	0.325	6.52	0.103	2.07	4.748	5.214	4.160	5.300	0.226	0.200
T1_R_Avg (s)	0.132	0.016	12.12	0.005	3.79	0.120	0.143	0.096	0.150	0.146	0.200
T2_R_Sum (s)	5.140	0.273	5.31	0.086	1.67	4.945	5.336	4.750	5.590	0.144	0.200
T2_R_Avg (s)	0.142	0.010	7.04	0.003	2.11	0.134	0.149	0.129	0.159	0.189	0.200
T3_R_Sum (s)	3.893	0.401	10.30	0.127	3.26	3.606	4.180	3.470	4.800	0.169	0.200
T3_R_Avg (s)	0.141	0.023	16.31	0.007	4.96	0.125	0.158	0.107	0.186	0.133	0.200
T4_R_Sum (s)	4.974	0.440	8.85	0.139	2.79	4.659	5.289	4.560	6.090	0.258	0.200
T4_R_Avg (s)	0.134	0.022	16.42	0.007	4.48	0.118	0.150	0.112	0.184	0.227	0.200
T1_L_Sum (s)	4.902	0.495	10.10	0.156	3.18	4.548	5.256	4.100	5.570	0.180	0.200
T1_L_Avg (s)	0.136	0.020	14.71	0.006	4.41	0.122	0.151	0.112	0.170	0.137	0.200
T2_L_Sum (s)	5.380	0.443	8.23	0.140	2.60	5.063	5.697	4.820	6.080	0.174	0.200
T2_L_Avg (s)	0.149	0.023	15.44	0.007	4.70	0.132	0.165	0.113	0.186	0.161	0.200
T3_L_Sum (s)	4.559	0.806	17.68	0.255	4.94	3.983	5.135	3.370	5.870	0.140	0.200
T3_L_Avg (s)	0.187	0.047	25.13	0.015	7.49	0.153	0.220	0.116	0.256	0.145	0.200
T4_L_Sum (s)	5.453	0.388	7.12	0.123	2.26	5.176	5.730	4.870	6.240	0.185	0.200
T4_L_Avg (s)	0.158	0.020	12.66	0.001	0.63	0.144	0.173	0.127	0.196	0.140	0.200

Legend: T1(2,3,4)_R_Sum– total time of Test1(2,3,4) with right foot, **T1(2,3,4)_R_Avg–** average time of Test 1(2 ,3,4) with right foot, **T1(2,3,4)_L_Sum–** total time of Test1(2,3,4) with left foot, **T1(2,3,4)_L_Avg–** average time of Test 1(2 ,3,4) with left foot

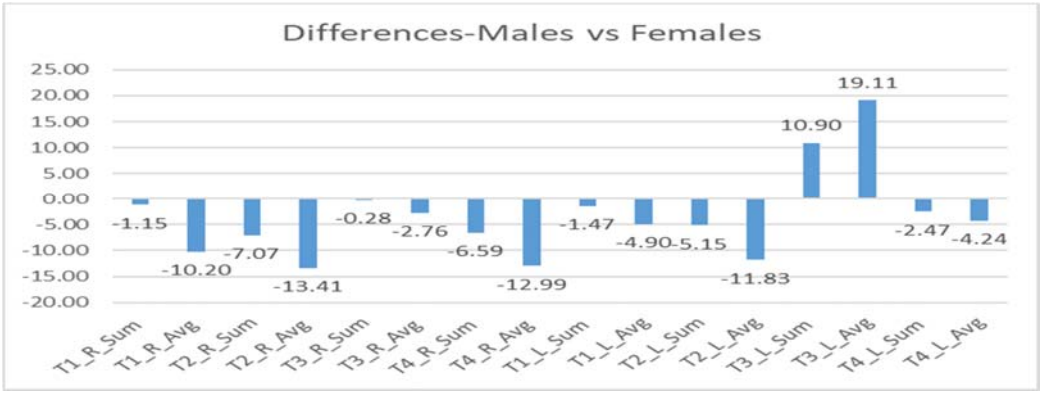

Figure 1. Differences (%) between the average values of the examined variables in relation to gender

Figure 1 shows the differences (%) between the average values of the examined variables in relation to gender in favor of male dancers, except in Test 3 with the left foot, where girls did the task faster by 10.90% of the total time, or 19.11% of the average time.

DISCUSSION

Experienced dancers, participants in this pilot study, were introduced to four specially designed tests on the Fitlight instrument, with the aim of determining the initial descriptive model indicators to assess the frequency of foot movement in dancers. Four tests were designed to include the foot movement in the sagittal plane (forward, backward) Test1, in frontal plane (left, right) Test 2 and in the horizontal plane (circular) Test 3 and 4. The tests were conducted right and left foot from two measurements. The study involved 12 participants, 5 men and 7 women, so that 24 items were analyzed. The dependent variables, total time and average time, were measured for all four tests, performed with the right and left foot, from two attempts. The results of descriptive statistics showed great homogeneity of raw results from two attempts. The results of differences in relation to gender, expressed as a percentage, between the average values of the examined time variables are in favor of men, except in Test 3, performed with the left foot, where women have an advantage of 10.90% over total time, or 19.11% average time. It is a test that is performed with a circular movement of the leg, and it is possible to explain that women, due to more frequent use of a specific circular movement in dance than men, have better results. Table 2 shows the initial percentile standards for the evaluation of the examined tests in relation to the sample, on the basis of which a framework can be given - the zones in which the execution times of the tasks are based on the results. It can also be seen that in Test 1 the task was done faster with the left foot in both men and women, as well as by zones (percentiles) for Test 3 in men with the left foot, and in women for Test 2 and 4 in favor of the left foot, although all reported right leg as dominant. The reason for this may be better familiarization with the tests (the right leg was first).

CONCLUSION

In order to define the final model indicators and furthermore, metric characteristics of the applied tests for estimating the frequency of leg movements in dancers, it is necessary to repeat the measurement on a representative sample, which would include athletes from other sports and non-athletes. The practical message for dance coaches and trainers is that the frequency of movement in dance disciplines represents different physical qualities and should be diagnosed and developed through separate assessments and tests, taking into account the requirements of dance discipline in terms of technique, music, dynamics, choreography.

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CHANGES IN SPEED AND AGILITY OF YOUNG FOOTBALL PLAYERS UNDER THE EXPERIMENTAL TRAINING PROGRAMME

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ABSTRACT

The aim of the research was to determine to what extent motor abilities, speed and agility, in young football players (aged 7 to 10) would change after a six-week long programmed training process. Thirty football players aged 7 to 10 from football club 'Vučje' in Vučje (Serbia) participated in the research. They had been training football for at least one year. The following measuring instruments were applied for estimating speed and acceleration: 5m Sprint, 10m Sprint and 40m Sprint. A different set of measuring instruments was applied for estimating agility: 505 agility test, Balsom run and Arrowhead agility drill. The subjects were tested before and after the training programme which took place during the preparation period in 45-minute sessions in the first part of the training, two times a week. The results show that there is a statistically significant difference between the first two speed tests (5m - .000; 10m - .001), whereas the third test shows no such statistically significant difference (40m - .118). There is no statistically significant difference in the first agility test between two testing situations (505 agility test - .116) but there is a significant difference in the remaining two agility tests (Arrowhead agility drill - .000; Balsom agility test - .001). Student's t-test results show that the applied 6-week long training process had a positive effect on the changes in the starting speed (5m Sprint) and acceleration (10m Sprint) results. However, there was no improvement in the maximum speed results (40m Sprint). The applied training programme positively affected agility in two out of three applied measuring instruments (Arrowhead agility drill and Balsom agility test).

Keywords: young football players, speed, agility, changes

INTRODUCTION

Each of the motor abilities has its own sensitive phase or a plastic period with an increased development sensitivity and the period which must not be missed, since the gaps in development of motor abilities in that period cannot be undone later on (Petković, 2008). Football is a sport characterised by various complex kinaesthetic activities including cyclic and acyclic movements. The ability to change directions in professional football is considered an extremely important characteristic (Loturco et al., 2020). Another very important characteristic is players' speed. Consequently, substantial research has dealt with the influence of the training process on these two characteristics, even in young players (Erceg, Yagorac, & Katić, 2008; Buzolin, Barbieri, Barbieri, & Gobbi, 2009; Sporiš, Jukić, Ostojić, & Milanović, 2009; Jovanović, Sporiš, Omrcen, & Fiorentini, 2011; Milanović, Sporiš, Trajković, James, & Šamija, 2013; Michailidis et al., 2013; Trecroci et al., 2016; Chaalali, et al., 2016; Azmi & Kusnanik, 2017). Some research has analysed the difference in motor abilities in boys aged 7 to 10 who played and did not play football. The results of this research showed that boys who trained football regularly had better speed and agility test scores than the ones who did not (Erceg, Yagorac, & Katić, 2008; Buzolin, Barbieri, Barbieri, & Gobbi, 2009). Research has also been done in the influence of the SAQ (speed, agility, quickness) training programme on football players' motor ability (Jovanović, Sporiš, Omrcen, & Fiorentini, 2011; Milanović, Sporiš, Trajković, James, & Šamija, 2013; Trecroci et al., 2016; Azmi & Kusnanik, 2017). The results showed that the 8 to 12 week-long programmes had a positive effect on football players' motor abilities, such as speed and agility. Another training type has also been analysed: the agility and direction change training and the influence it had on the forward sprint speed, direction changes and agility (Chaalali et al.,

2016). The results of this research showed that young football players' performance could be enhanced with the aid of the direction change training programme. Another important fact that needs to be accounted for is that each player's position in the team has its own specific characteristics. For example, forwards are the fastest players in the team and central midfielders are the most agile ones (Sporiš, Jukić, Ostojić, & Milanović, 2009). The aim of this research was to determine the speed and agility changes in football players after they had undergone the six-week long training process during the preparation period.

METHODS

Subjects

Thirty football players aged 7 to 10 from football club 'Vučje' in Vučje (Serbia) participated in the research. They had been training football for at least one year. All the players and their parents had been acquainted with the research aim and protocol, as well as the subject testing, beforehand. Their parents gave the written consent to the children's participation in the research.

Procedure

Measuring instruments

The following measuring instruments were applied for estimating speed and acceleration (Altmann, Ringhof, Neumann, Woll, & Rumpf, 2019):

- Sprint in 5 m,
- Sprint in 10 m
- Sprint time in 40 m.

The following measuring instruments were applied for estimating agility:

- 505 agility test (Dugdale, Sanders, & Hunter, 2020),
- Balsom run (Balsom, 1994),
- Arrowhead agility drill (Rago, Brito, Figueiredo, Ermidis, Barreira, & Rebelo, 2019).

505 Agility test is a test of 180 degree turning ability. The athlete runs from the 15 meter marker towards the line (the run in distance is to build up speed) and through the 5 m markers, turns on the line and runs back through the 5 m markers. The time is recorded from when the athletes first runs through the 5 meter marker, and stopped when they return through these markers (that is, the time taken to cover the 5 m up and back distance - 10 m total). The best of two trails is recorded. The turning ability on each leg should be tested. The subject should be encouraged to not overstep the line by too much, as this will increase their time.

Balsom run is a test of agility designed for the soccer player, in which the participants are required to run around a series of cones, making several changes of directions and two sharp 180 degree turns. The subject starts at A and runs to cones at B before turning and returning to A. Subject then runs through cones at C, turns back at D, and returns through C. The subject turns to the right and runs through cones at B and through the finish. Two trials are allowed and the fastest time recorded. The best (fastest) total time is recorded.

In Arrowhead agility drill the player starts with their foot behind the starting line in a sprint start position. When ready, they run as fast a possible to the middle cone (A), turn to run around the side cone (C) or (D), around the far cone (B) and back through the start/finish line. The subject completes four trails, two to the left then two to the right (as shown). The trail does not count if they step over a cone instead of around it. Record the best time to complete the test for the left and right turning trails.

Experimental treatment

The experimental treatment was applied for six weeks during the preparation period with the frequency of twice a week for 45 minutes in the first part of the training session. After it, the players continued with their regular technical and tactical training. The experimental training programme focused on the development of specific motor abilities, speed and agility. It was comprised of the movements typical of football, with and without direction changes and with and without the ball. The most prominenet working method in the sessions was group work. The load intensity had the span of 80% to 90% from the maximum. The numbers of exercise series and the repetition were 2-3 and 3-5, respectively.

Statistical analysis

Basic dispersion parameters were calculated for the research. The changes between the initial and the final testing were determined by Student's t-test.

RESULTS

Student's t-test

Table 1 shows football players' speed t-test results in two testing situations (the initial and the final). The two testing situations of the first two speed tests show a statistically significant difference (5m - .000; 10m - .001), whereas no statistically significant difference is observed in the third test (40m - .118).

Table 1. The significance of the differences between the mean values of the speed tests done by football players

Tests	Mean (initial)	Mean (final)	T-value	p
5m Sprint	1.64	1.61	4.34	.000**
10m Sprint	2.74	2.71	4.17	.001**
40m Sprint	8.19	8.15	1.64	.118

Table 2 shows football players' agility t-test results in two testing situations (the initial and the final). No statistically significant difference between the two testing situations is detected in the first agility test (505 agility test - .116.). The other two agility tests show a statistically significant difference (Arrowhead agility drill - .000; Balsom agility test - .001).

Table 2. The significance of the differences between the mean values of the agility tests done by football players

Tests	Mean (initial)	Mean (final)	T-value	p
505 agility test	3.66	3.57	1.65	.116
Arrowhead agility drill	10.81	10.77	5.30	.000**
Balsom agility test	17.82	17.76	4.10	.001**

DISCUSSION

The training programme for the speed and agility development (SAQ – speed, agility, quickness) applied in our research included the exercises and the equipment which provoked neural adaptations in the programmed and unexpected conditions of the football game. The predominant movements were quick forward, with direction changes and with and without the ball.

The significant improvement in the initial speed (5m Sprint) and acceleration (10m Sprint) can be ascribed to the specificity of the SAQ training programme (e.g. skips, various jumps and leaps, short sprints) based on a short period of contact time between a foot and the ground. What was very useful for children aged 10 to 11 was the application of explosive activities (based on a quick cycle of extending and reducing), with the aim of improving sprint due to high levels of neuromuscular adaptations (intramuscular coordination) (Michailidis et al., 2013). The obtained results confirmed the fact that almost 90% of all maximum movements during a football match are done in distances ranging from 5m to 10m (Bloomfield, Polman, O'Donoghue, & McNaughton, 2007). Also, modern football requires the players' ability to react in such distances (Sporis, Jukic, Ostojic, & Milanovic, 2009). The obtained results rely on the results of the previous research (Jovanovic, Sporis, Omrcen, & Fiorentini, 2011; Milanovic, Sporis, Trajkovic, James, & Samija, 2013; Trecroci et al., 2016; Azmi & Kusnanik, 2017) in which the application of the SAQ training programme of various duration (from 8 to 12 weeks) led to the improvement in speed, acceleration and agility of the players. There were no changes in the maximum speed in 40 meters (40m Sprint) after the experimental treatment due to the fact that football is characterised by short-distance movements, which were more prevalent in the research as well. Kusnanik & Rattay (2017) considered speed and agility to be the most dominant abilities in football.

Taking into account the fact that short-distance movements and sprints, with and without direction changes and with and without the ball, jumps and leaps (as planned by the SAQ programme) were used in

the training sessions, the results obtained were expected. The age of the subjects (from 7 to 10 years old) matches the extremely sensitive period suitable for developing almost all motor abilities (Đurašković, 1997; Petković, 2008), which justifies the obtained results after the six-week long training programme.

Another thing that might have contributed to the positive changes was the contents of the technical and tactical training which followed the experimental programme.

CONCLUSION

The aim of the research was to determine to what extent motor abilities, speed and agility, in young football players (aged 7 to 10) would change after a six-week long programmed training process. The experimental programme contributed to the improvement in the results of most of the applied measuring instruments estimating speed and agility. The results show that acceleration and speed can be successfully improved in young football players (aged 7 to 10) after the application of the organised SAQ training programme. However, it is also shown that the same programme is not suitable for increasing the maximum speed in 40m sprint.

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RESEARCH OF THE RESULTS FROM ONLINE STUDIES IN TACTICS AMONG 10-13-YEAR-OLD CHESS PLAYERS

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ABSTRACT

The aim of the research was to establish the actual possibilities of 10-13-year-old chess players studying online in order to learn certain topics in the field of chess tactics. Our major question was whether there is a significant correlation between teaching chess tactics in person and online. The research was done among 37 competitors with Elo rating 1050-1400 points from four chess clubs in Bulgaria. They were divided into two groups. In one of the groups the sessions were conducted only online, and in the other group – only in a training hall. As an organizing framework of our research we used a unified lecture course on chess tactics which included 10 basic topics. For each topic we created a test battery consisting of six tasks graded according to their difficulty level. At the end of the two-month lecture course, we checked the degree to which the pupils from the two groups had learnt the educational material. The applied Student's t-test for two independent samples showed that the difference in the results from the two forms of testing was insignificant, i.e., it was not a consequence from the form of testing but from fortuitous factors. The result from this research can help chess coaches working with this age group to take a much more professionally conscious choice regarding the ways of teaching chess tactics during their training sessions.

Keywords: chess education, chess tactics, face-to-face and online training

INTRODUCTION

At a time sporting activity has been hit hard across the globe due to Covid-19 pandemic chess has rebranded itself as a lively enough sport to adapt successfully to the online form of education and practice (Petkova, 2020). COVID-19 has prompted the cancelation of traditional, in-person chess training process which pivoted to online activities. Unlike popular sports like football or basketball, chess can be taught flawlessly within the confines of your room, provided you have internet access. Chess sport was less affected than almost any other thanks to a fairly smooth transition to online chess, as could be seen both at the elite and at amateur or club levels. For example, Chess.com, the most-visited global website for online chess play, received 1.5 million new subscribers in April 2020, compared to 670,000 in January (Forbes, 2020). Many chess clubs and organizations around the world do their best to change the situation for the better by holding online tournaments and team competitions, offering workshops and lessons, and starting different chess initiatives. Obviously, preparing and practicing in both a virtual and in-person setting will develop parallel in future. This fact leads to their in-depth analysis for the purposes of educational, training, and competitive practices.

Regardless of the variety of sources for chess self-studying, however, the corrective function of the coach has its significant role in the training of 10-13-year-olds (Krogius, 1976; Charness, 1981; Hartson & Wasonq 1984). At this age and level of chess skills they still don't know how to work on chess by themselves. Having an in person contact with a coach helps better understanding basic chess concepts such as strategical and tactical thinking, plans, typical middlegame and endgame patterns etc. According to chess experts (Gobet et al., 2017; Bart, 2021) offline coaching is still the best option as you can pass on to student more information in a shorter time frame. Additionally, at above mentioned age group the human-to-human interaction is still very significant and important (Kulikov, 2020). Having face-to-face chess lessons also adds a social element to a training session that requires a high level of focus and concentration. On the other hand, conducting chess classes online is nothing new, but because of the

lockdown more coaches have opted for it. The online coaching is only drawback seems to be that students can tend to get distracted when they are logging in for an online class. Undoubtedly, the benefit of learning chess through the computer has expedited the process of mastering the game. Online chess games and puzzles are superior to printed ones since the chess player can move the pieces until the final move and get the answer forthwith.

Taking these factors into account, as well as the opportunities which the present pandemic situation provides, we formulated the aim of this research: to establish the efficiency of online training sessions in chess practice among 10-13-year-old chess players.

In the light of the current pandemic situation, such a topic is new in the scientific field due to the few surveys on the subject we found. Among them, a certain contribution for the theory can be found in the surveys of Fuentes et al. (2020) and Iliescu (2020), but they did not view the training process of growing chess players. The theoretical significance of this study can be mainly seen in the application of new data and analyses regarding the subject and object of the research, as well as outlining some practical recommendations for chess coaches.

We used specific distance forms of teaching and control, such as the application Microsoft Teams and chess program for working with different databases ChessBase. First one is ideal for online chess coaching as it is easy to use, and involves all of the features we needed, such as HD audio or video calling, a chat, screen sharing. In our eyes, it's still vital to use decent chess software (like ChessBase) with some high-quality training tools to work with, although chess websites like chess.com, chess24 or lichess are on the rise and are very comfortable for online chess coaching. ChessBase provides you with plenty of key functions such as using a chessboard, searching for games in huge databases, analyzing games and variations with the help of chess engines, using cloud databases and share them with other ChessBase users, preparing your openings and a lot more.

METHODS

Subjects

We examined 37 chess players aged between 10 and 13 years from four chess clubs in Bulgaria. The participants in the research were selected with an entrance test including 12 tasks chosen by us. The aim of the test was to establish that the chess players could meet the requirement for the chess level within the range of Elo rating 1050- 1400 points. All the participants' parents provided written consent after being informed of the test protocol. The research was carried out in the period February-May 2021.

Procedure

The participants were divided into two groups according to the club they belong to. In the first group, consisting of the chess players from two of the clubs (19 children), the training sessions were conducted only face-to-face. In the second group, consisting of the chess players from the other two clubs, the trading sessions were conducted only online. The face-to-face education was carried out in two of the chess clubs, while we used the application Microsoft teams for the online education. We used the program ChessBase for chess visualization with both groups. This program enables the coach to demonstrate and translate on the screen various annotated games, to search the games of similar structure, to show examples from video archive, to suggest interactive exercises on the theme.

Measuring instruments

For the purposes of the pedagogical experiment, we created a chess tactics lecture course based on modern materials (Reinfeld, 2014; Huczek, 2017; Kravtsiv, 2020). For the chess tactics part of this course we designed 10 topics in compliance with the recommendations of FIDE Trainers' Commission, with leading specialists in this area, as well as with our own coaching experience. Many tactical patterns share similar ideas with other named patterns and because of this overlap it's difficult to say exactly how many unique tactics exist. There are no shortages of chess tactics, from highly complicated, to the super-simple. However, there are several that occur all the time so they are a major part of every player's chess foundation. The patterns in question are 1. Forcing moves 2. Deflection 3. Decoy 4. Removing the Defender 5. Blockade 6. Clearing a square 7. Interference 8. Using open Files 9. Pin 10. Windmill & Double Check.

Aiming to present a structured approach to tactics, each lecture has a companion afterward test. Each test contains six tasks graded by difficulty with examples that have the biggest instructional value for our

players. Each test contains special instructions and guidance in order to help students solving the tasks. The solutions are not just lists of moves, but include clear detailed explanations.

Statistical analysis

The data were processed with correlation analysis; Mann-Whitney *U* Test; One-Sample Kolmogorov-Smirnov Test; Frequency analysis (Konchev, 2018). The conclusions were drawn at significance level of 95% (α=0.05).

RESULTS

Figure 1 shows the relation between the correct answers to the chess tactics test tasks in the two forms of chess training– face-to-face and online.

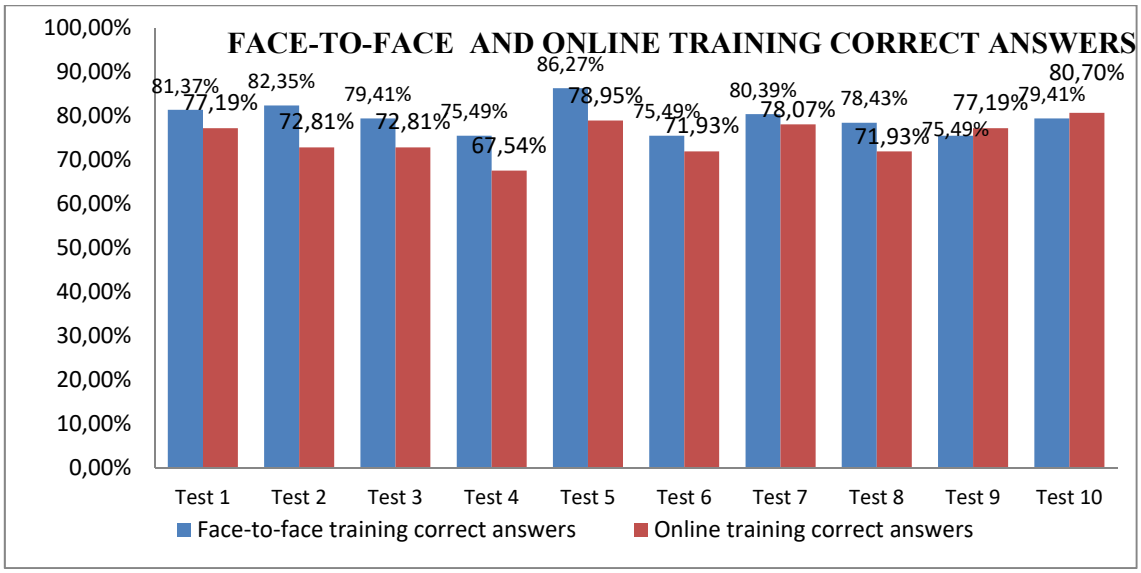

Figure 1. Percentage of correct answers to the tests covering each of the 10 chess tactics topics in the two groups– face-to-face and online

We can see in the graph that in both groups of 10-13-year-old chess players, the percentage of correctly solved test tasks (an indicator of the degree of acquisition of the material taught) was high and stable – between 67.54 and 86.27 %. Among all of 10 tests, those who studied online showed better performance in two topics - №9 (Pin) and №10 (Windmill & Double Check).

Figure 2 shows the relation between the correct answers to the test №2 (Deflection) and test №5 (Blockade) in the two forms of chess training – in person and online.

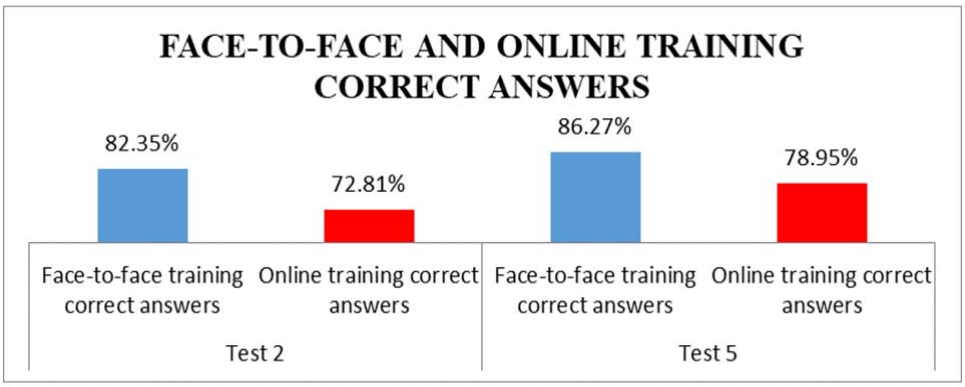

Figure 2. Percentage of correct answers to the test №2 (Deflection) and test №5 (Blockade) in the two groups– face-to-face and online

Table 1. Group statistics for chess players' performance in the tests №2 and №5

	Type of teaching group	N	Mean	Std. Deviation	Std. Error Mean
Test № 2 correct answers	*face-to-face*	18	5	1.28338	0.3025
	online	19	4.0526	1.61499	0.3705
Test № 5 correct answers	*face-to-face*	18	5.2222	0.94281	0.22222
	online	19	4.4211	1.50243	0.34468

The results from test 2 showed that the average number of correct answers in face-to-face studies was 5, and in online studies 4.05. The applied Student's t-test for two independent samples showed that the difference in the results of the two groups was insignificant, i.e. it was not predetermined by the form of testing but by accidental factors. The dispersion in the results of two groups was the same as shown by the Levene's test (Sig=0.698, i.e. p>0.05). The conclusion was drawn on the basis of significance level α=0.05 (Sig=0.057, i.e. p>0.05).

The results from test 5 showed that the average number of correct answers in face-to-face studies was 5.22, and in online studies 4.22. The applied Student's t-test for two independent samples showed that the difference in the two forms of testing was insignificant, i.e. it was not predetermined by the form of testing but by accidental factors. The dispersion in the results obtained by the two groups was the same as shown by the Levene's test (Sig=0.363, i.e. p>0.05). The conclusion was drawn on the basis of level of significance α=0.05 (Sig=0.060, i.e. p>0.05).

The applied Students's t-test for two independent samples showed that the difference in the results from the two forms of testing was insignificant, i.e. it was not due to the form of testing but to fortuitous factors. The dispersion in the results for the two groups was the same, as shown by the Levene's test (test №2: Sig=0.698, i.e. p>0.05; test №5: Sig=0.363, i.e. p>0.05). The conclusion was drawn at a significance level α=0.05 (test №2: Sig=0.57, i.e. p>0.05; test №5: Sig=0.62, i.e. p>0.05).

Table 2. Results from Student's t-test for two independent samples

Independent Samples Test

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	**Sig**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	Upper
Test № 2 correct answers	Equal variances assumed	.153	.698	1.968	35	.057	.94737	.48132	-.02976	1.92450
	Equal variances not assumed			1.981	33.999	.056	.94737	.47831	-.02467	1.91940
Test № 5 correct answers	Equal variances assumed	.849	.363	1.930	35	.062	.80117	.41510	-.04152	1.64386
	Equal variances not assumed			1.954	30.495	.060	.80117	.41011	-.03581	1.63815

DISCUSSION

Nowadays internet provides many chess training resources such as online lessons, books, videos, puzzles, but this vast array of learning tools can make improvement difficult (Polgar, 2017). With players as young as 12 years old hitting the ranks of Grandmaster it is obvious that the very sport Chess is getting "younger" (Jensen, 2020; Zakharov, 2020), and the training time shortens. To selected examples that have big instructional value for students is among most important coaches' tasks (Neishtadt, 2011). Given the fundamental importance of chess tactics, there are surprisingly few books that teach the subject in a systematic way. Mastering tactics approach used in our lecture course ensures that each concept is explained and tested before the next one is introduced.

After the tactics course, all chess players who took part in the research, showed a significant improvement in their tactic skills, no matter whether they studied face-to-face or online. The big (but statistically insignificant) difference in the correct answers of the two groups in tests №2 (Deflection) and №.5 (Blockade) can be explained with the great complicacy of these topics and their close relation to other tactic motives. For example, Deflection is often combined with winning resources (like promoting a pawn or delivering checkmate) and often can be seen together with other patterns, such as a fork, a skewer or a discovered attack. In Blockades usually many chess pieces are involved that makes calculations hard. According to Encyclopedia of Chess-Combinations these two topics are among most important chess tactics motives.

The results show that the other eight topics did not provoke such difficulty and can be taught without additional explanations online. It is also obvious that the more complicated topics, where tactic ideas and motives interweave, require a more in-depth and detailed explanation when taught online. This can be achieved by adding more examples explaining the interrelation among the different elements in the tactic scheme. In Blockade topic for example there are several subtopics, such as Blockade with checkmate, Blockade with pawn promotion, Blockade with stalemate, Prophylactic blockade. Considered in detail Deflection theme has even much more subtopics: Deflection with a double attack, Deflection of defending piece, Deflection a piece from pawn promoting square, Deflection of a pinning piece etc. Namely, the organization of these motives in an overall, structured lesson requires that the coach should not only know them in detail but that he should be able to arrange them well. In such cases, face-to-face education is easier for both the coach and the players because it allows for rearranging different subtopics depending on the level of acquisition demonstrated by the students at a certain moment.

CONCLUSION

The criteria for including topics in a chess tactics lecture course for 10-13-year-old chess players with Elo rating 1050-1400 points must be as follows: 1. study of a huge amount of chess literature, 2. analysis of major chess tactics teaching models, 3. educational needs of learners, 4. personal coaching experience. When taught online, the multicomponent topics from the field of chess tactics require that they should be divided into different subtopics with detailed explanations and visualization of each of them.

Due to the possibility of further lockdowns and uncertainty chess coaches will be able to meet pandemic challenges with online program on chess tactics that gives the same results as face-to-face coaching in groups of 10-13-year-old chess players with Elo rating 1050-1400 points.

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MINI HANDBALL- A TOURISM PRODUCT FOR INCITEMENT AND IMPROVEMENT OF SPORTS TOURISM OFFER

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ABSTRACT

Sports tourism is one of the fastest growing types of tourism to which many researchers have devoted their attention over the past three decades. Therefore, there has been constant need to expand and improve the offer due to the increasingly demanding shareholders both on domestic and international markets. This paper aims to point to attractiveness of a new type of handball (mini handball) that could incite and improve sports tourism offer of a destination. Mini handball concept and resources are some of the crucial factors that can qualify this sports game to be included in sports tourism offer. In addition to the concept and resources, this paper considers benefits of expanding sports tourism offer by including mini handball.

Keywords: mini handball, sports tourism, destination development, offer development

INTRODUCTION

Sports tourism is one of the fastest growing types of tourism to which many researchers have devoted their attention over the past three decades. It represents a unique combination of people, sports activities, and the destination where an activity takes place. One of the first research papers on this topic in the international literature is Anthony Don's paper "Sport and Tourism" that was published in 1966 (Weed & Bull, 2004). The paper was prepared for the Central Council of Physical Recreation in the United Kingdom. However, the research was reduced to the possibilities that sports games and recreation could have had in the most common type of tourism travel – leisure travel. Nevertheless, most authors agree that a significant change in researchers' interest for this field (sports tourism) occurred in the 1970s. The decade saw a number of papers presented at scientific conferences covering this field (De Knop, 1990). Most authors agree that basic categorization in sports tourism can be done in relation to the participants both the active (those who take part in sports games) and the passive ones (those who watch sports games) (Borovčanin & Lesjak, 2021). This can be seen as the first ever categorization that dates back to the very beginning of this type of tourism, namely to the first sports tourism event which is believed to be the Olympic Games in 776 BC, which at the time were organized as Panhellenic Games in Olympia, Greece (The International Olympic Committee, 2021). At the beginning they were held only in ancient Greece up till 393 AD. The Games were revived in the 19th century thanks to French Baron Pierre de Coubertin. This signified the start of the modern Olympic Games, which paved the way for development of sports tourism. Pierre de Coubertin believed that by developing sports, we bring people closer and, in that way, contribute to peace and better understanding between peoples and nations, which is still stated in the UN's recommendations. The two social activities, namely tourism and sport, have been strengthening and expanding through centuries, and thus sports tourism has acquired its new form and quality. This form of tourism is branching into expanding activities even further to competitions, recreation, time spent in sports facilities and attending sports events. Popularization and globalization of sports has contributed to the increasing participation in numerous sporting events, not only by professional athletes, but also amateur participants, as well as to other recreational activities including fitness, social contact, health, wellness, and, in some cases, the enriched lifestyle (Loy et al., 1989). Sports tourism has a lot of potential and is a growing field, which attracts increasingly more people every year. Normally, this implies that tourism offer should be adjusted to demands of sports tourism. This leads to expansion and construction

of new larger sport venues which can be used for different sport disciplines, athletes' trainings, as well as for various recreational activities. Research conducted by the World Tourism Organization (UNWTO) has established that the main motives for travel are leisure, vacations, and recreation, and together they account for 53%. Today, significance and impacts of sports tourism are considered from various aspects, but predominant research is focused on:

- Direct and indirect economic consequences
- Use of sports tourism as a political factor
- Promotion of health and healthy lifestyle with population
- Role of sports tourism in promoting social causes
- Popularization of sports games and impacts on achieving top results

Sports tourism and sporting events can create significant positive economic benefits for the destination and tourism and hotel facilities (Borovčanin et al., 2020). According to the United Nations World Tourism Organization report, the size of the global sport tourism industry was US $800 billion dollars in 2016, accounting for approximately 10 percent of the global tourism industry (Parker, 2019). TechNavio reported that the size of the global sport tourism industry is much larger at US $1.41 trillion dollars and that the market is expected to continue to grow from 2019 to 2023 at a compound annual growth rate of about 36 % (Businesswire, 2019). In the United States (US), sport related travel spending reached US $45.1 billion dollars in 2019 and totaled up to US $103.3 billion dollars when including indirect and induced spending (Sports ETA, 2020). The annual growth of the sports tourism industry accounts for more than 10%, and the forecasts are that sports tourism will soon have an increasingly significant share in the global tourism industry.

Sports tourism is interesting to all population, from the pre-school children to the retired. Everyone has found something of interest in it. The thing that is rarely encountered in modern society, though it might have been one of the guidelines for sports tourism development, is that most activities cannot be modified to suit all age groups. This is specific for team sports which are seen as a mean for socialization and fight against alienation as a negative feature of modern society. Mini handball can certainly be one of the methods to achieve the overall benefits for people, i.e., the desired effects of socialization, physical activities, competitions, and mental health.

BASIC FEATURES OF MINI HANDBALL

Mini handball is a relatively new form of handball. The official promotion of mini handball by the European Handball Federation was in 1994. Mini handball is intended primarily for the children aged 6-12, but it can be played by everyone, without any restrictions.

Rules of mini handball are simple and are based on the Rules of the Game issued by the International Handball Federation (International Handball Federation, 2020). The rules may be amended by the organizer of the mini handball competition depending on the needs of certain age groups. There are several things that make this type of handball different from the standard one. Primarily, it is the size of the court, which is 20-23m long and 12-15 metres wide. Goals are smaller than the standard ones, i.e., 1.7m in height and 2.4m in width. The optimal number of players on the court is 4+1 (four players and a goalkeeper), and the team can consist of a larger number of players. In indoor venues where there are no goals, those can be makeshift goals made out of self-adhesive tape, mats, etc. Goal area is also smaller. Optimally, it should be a semicircle with 5 metre radius and the centre in the middle of the goal line. Smaller balls are used. It would be best for those to be of the standard sizes 0 or 1 depending on whether the children are 6-7 or 11-12 years old or adults. It is desirable that the balls be made of the same material as the balls for the classic handball whereas some age groups best use sponge balls, which are of the same size and characteristics as the regular ones but are easier to catch and throw and are softer when they come in contact with the goalkeepers and players. Teams can be made up of both boys and girls, i.e., it is allowed for teams to be mixed.

Rules of mini handball are the same as the classic handball rules. Nevertheless, depending on the age groups those should be applied liberally. That would mean that the game should not be stopped due to small deviations from the rules, especially when the actions performed lead to positive emotions in the participants. One referee is enough for these matches, and if they are a coach, a teacher, or an animator, they can simultaneously instruct both teams. The team consists of 10 to 14 players. The match starts with four players and a goalkeeper. The team should not have less than eight players. The duration of the match is 2x12 minutes. The half-time lasts for 5 minutes. The duration of the match can be shorter depending on the age of participants and the type of competition (2x10 min, 2x8 min, 1x15 min, etc.). The following is allowed: to use hands and arms to block and take the ball; to interfere with the opponent not in possession of the ball with the body; to control the movement of the opponent with bent arms when

standing in front of them. The following is not allowed: pulling and kicking the ball out of the opponent's hand; grabbing and holding the opponent's body or jersey, pushing, bumping, and jumping on the opponent.

MINI HANDBALL – NEW PRODUCT IN SPORTS TOURISM DEVELOPMENT

Concept

Primarily, concept of mini handball was to include children in a lighter form of handball as sport as early as possible. In this way, the primary selection would be moved a couple of years earlier as is situation with many other sports, which children start playing at the age of 5 or 6, whereas in classic handball the children would start at the age of 10 or 11. Reducing the size of the court compared to the classic handball court, as well as "relaxing" or adjusting the rules to the age category can be helpful when children are later to decide whether to continue playing the classic handball. Dynamics of the game and its adaptability later influence its application in all age categories. Another factor that contributes to this is that virtually no aggressive contact and behaviour are allowed.

Resources

Resources available in Serbia are practically ideal for mini handball implementation. Large number of outdoor and indoor sports venues which have smaller size courts than for the classic handball are not a limiting factor given that court for mini handball is significantly smaller in size and it is not strictly defined in length and width. In addition to the courts in schools and sports and recreational venues, there are courts available in parks or around buildings, as well as on beaches and picnic sites. All these areas can be used as a mini handball court.

Infrastructure

Infrastructure required for practice or matches is minimal. It takes two goals designed for mini handball or pre-existing goals for classic handball reduced to the required dimensions by using elastic strips or indoors by drawing goals on the walls if there are no standard goals available. Outside lines of the court, as well as the goal area should be distinctly marked. Pre-drawn lines can be used for this purpose, or the lines can be drawn to be either permanent or temporary by using self-adhesive tape or chalk. In addition to this, depending on the age, a ball size 0 or 1 is required.

Advantages

If we consider that Claudius Galen, one of the greatest medical experts of the Old Age (doctor of the gladiators and the Emperor Marcus Aurelius) claimed that "games played with a small ball" represent the most perfect physical exercise, we have already established the main advantage of this game. Walking, running, jumping, catching and passing the ball, and kicking are primary human movements and at the same time form the basis of mini handball. Also, it can be played by all age groups with no exceptions. It is important for both teams to be equal, i.e., for players to be of approximately the same age. Teams can be made up of the same sex players, but they can be mixed, as well. Dynamics of the game is determined by the players themselves, and therefore it cannot happen that the purpose of the competition is brought to question. Of course, it is important for teams to be formed according to the current predispositions, both in age and physical fitness.

Benefits

Benefits of introducing mini handball in tourism offer are multiple. Primarily, no great investments are required for the game nor training longer than couple of minutes. Engagement of the whole body, as well as socialization and psychological relief that any game can bring without any need for prior knowledge or great preparations make it possible for anyone to be motivated to participate. Benefits depend on the age of participants. Therefore, when it comes to pre-schoolers (aged 5-6) as well as younger school children (aged 7-10), the direct benefit is to adopt primary movement techniques as well as to socialize. For older elementary school children (aged 11-14), mini handball, when organised as a competition, can be used to develop competitive spirit. It can also be used as an integral part of a training regardless of the sport they play for it can be played as a basic game that can be organised at the beginning or at the end of the

practice. Benefits for older elementary school and high school children, as well as university students can be in the form of motor skills development and as a form of animation and competition at various tourist destinations. For older people, who are either employed or retired, this can be a recreational sport that can be adjusted to their current abilities, as well as a reason to socialize and connect with people when travelling, both during the summer and winter seasons, but especially during off-season when sun or snow are not primary motivation.

CONCLUSION

The contemporary lifestyle, which implies minimal movement, constant stress, accelerated pace of life, noise pollution, and environment issues, leads to a large percentage of tourists associating their motive for vacation with the activities that include sports or recreation. Primary motive is still health, both when it comes to prevention or to improve and maintain the best possible physical and mental condition. It is obvious that sport is an integral part of tourism offer that makes it possible for the tourists to meet their needs for play and movements. Mini handball is a game that enables modern man to fulfil this much needed space in a quality way. All age groups can be included and achieved through this game without any restrictions. Mini handball can be played both outdoors and indoors and therefore is not limited to the high season in tourism, be those summer or winter. It can be included in tourism offer throughout the year.

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STUDY REGARDING THE IMPACT OF THE COVID-19 PANDEMIC ON THE CHILDREN'S TRACK AND FIELD TRAINING

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ABSTRACT

The COVID-19 pandemic has led to a world halt of sports. From the highest level of performance to the lowest, all athletes have been affected to various degrees. This study aims to analyze the impact of the Covid-19 pandemic on the children's track and field training. It is important to identify some of the biggest challenges confronted by children during this time and understand their physical and mental state. In order to identify some of these challenges, a questionnaire was created. The questionnaire data were gathered from the coaches, children, and parents of the children involved in track and field. The answers have shown similarities between the means used by coaches to train children during this period, when training sessions have been conducted also online due to pandemic restrictions. The conclusions show the importance of the coaches' ability to remain constantly connected to children during the pandemic, in order to maintain their motivation to keep practicing track and field. The most important abilities of the coaches include an improved communication (because it was easier to connect with children), and an effective way of transmitting the information.

Keywords: track and field training, children, Covid-19 pandemic

INTRODUCTION

The Coronavirus pandemic is an epidemic currently happening across Romania caused by the novel coronavirus 2019-nCoV (SARS-CoV-2), a virus that causes an infection called COVID-19, which can be asymptomatic, mild, moderate or severe. The severe infection includes an atypical severe respiratory problems (Yeo, 2020) combined with a variety of cardiovascular problems (Guzik, Mohiddin, Dimarco, Patel, Savvatis et al., 2020). The first infection with the SARS-CoV-2 virus was recorded in December 2019 in Wuhan, China, from where it spread in most Chinese provinces and most countries in the world, causing a pandemic (Guzik et al., 2020)

The COVID-19 pandemic had a significant impact also on the lives of children around the world. According to the (Xiang, Zhang, & Kuwahara, 2020) more than 150 million children and adolescents have faced with closed schools as a result of the pandemic. Children and adolescent's lifestyle behaviors, such as physical activity (PA) and sedentary behavior (SB) may have been drastically impacted due to the prolonged school closures and home confinement during the COVID-19 pandemic (Xiang et al., 2020). Canceling sports events can negatively impact the children. This negative impact can include a loss of positive mental, physical and social benefits (Nearchou, Flinn, Niland, Subramaniam, & Hennessy, 2020) that are associated to sports.

Even before the lockdown, the sports world had begun to take measures to protect the athletes, the coaches, the fans, and the staff against the virus by canceling and postponing all sports events. The thought was that sports, regardless of competition level, would presume physical contact between athletes, coaches and audience, thus making sports a factor of easily transmitting the disease. Thus, the Romanian Athletics Federation (FRA) has also canceled all its indoors competitions in 2020, starting with the National Junior III Championship, on March 14-15, 2020. During the next week the National Children's Championship was supposed to take place in Bucharest, but it was also canceled. All of the other children's and juniors' competitions were canceled up to September 2020, when the National Cross

Country Running Championship took place in Botoşani, and in the next week, in October, the National Children's Championship took place in Bucharest. It is important to identify some of the biggest challenges confronted by children during this time and understand their physical and mental state. This is important in order to ensure the children's needs are satisfied and their health and wellbeing are protected. *The problem from which this study was designed and carried out asks the following question: "Can the identification of the main challenges of the children during the pandemic lead to an assessment of the impact the pandemic had on the children's track and field training?" Accordingly, this study aims to analyze the impact of the Covid-19 pandemic on the children's track and field training.*

METHODS

This study was conducted over the course of five months (April-September, 2020). The purpose of this study was to assess the impact of the COVID-19 pandemic on the children practicing track and field.

The methods used during this research were: a) the literature documentation method, b) the observation method, c) the statistical-mathematical method, d) the questionnaire method.

Subjects

The subjects were 20 coaches, 360 children, and 338 parents of children that are involved in track and field in the Northern area of Moldavia. The children were between 10 and 13 years old.

Procedure

The questionnaire contained a set of questions through which the authors studied the impact of the COVID-19 pandemic on the children's track and field training.

Question 1. What was the impact of the COVID-19 pandemic on the track and field competition season? (The impact on the current season and training)

Were some competitions canceled or postponed?	Yes	
	No	
	Maybe	
What is the current state of training?	I train face to face	
	I do not train face to face (online training)	
	I do not train at all	
How many hours of training per week were you able to perform during the COVID-19 pandemic?	Less than 3 hours	
	3-5 hours	
	5-8 hours	
	More than 8 hours	
Do you perform any other physical activities beside the mandatory training?	Yes	Exhausting activities
		Moderate activities
		Light activities
	Not at all	

Question 2. What was the training program used by the coaches during the COVID-19 pandemic?

Training session	Duration	Drills used	Intensity	Number of repetitions	Break
Warm-up					
Main part					
Cool-down					

Question 3. What is the psychological impact of the COVID-19 pandemic on the studied athletes?

Did you feel isolated/disconnected?	Yes
	No
	Sometimes
Were you afraid of getting infected with COVID-19?	Yes
	No
	Sometimes
Did you feel a lack of motivation in completing your tasks?	Yes
	No
	Sometimes
Are you worried of losing your initial fitness or that you will not be ready for the next competition?	Yes
	No
	Sometimes
Was your decision to go back to training affected because of the COVID-19 pandemic?	Yes
	No
	Sometimes

RESULTS

The analysis shows that 92% of the subjects said that they have experienced at least once the canceling or postponing of an important competition. Most coaches gave their athletes a training plan to perform at home, in order to help them keep their fitness, but they have conducted also online training sessions. It was noticed that 80% of the athletes now train face to face, 14% continue to receive a form of online training (Internet programs, online sessions, etc.) from their coaches, while 6% do not perform any kind of training. Between March and September 2020, 74% of the children have trained less than 5 hours a day, compared to 92% of the children who used to perform 8-10 hours of training before the pandemic. In addition to the mandatory training given by the coach, 20% of the children take part in other demanding activities, while 44% perform moderate activities on a regular basis.

Question 2. What was the training program used by the coaches during the COVID-19 pandemic?

In regards to the warm-up part, 96% of the coaches said that this took between 5-10 minutes of children walking in place, running in place, and performing stretching exercises, at an intensity of 40-50%.

Regarding the main part, 98% of the coaches answered that they used running drills, jumping drills, and general physical development drills, the duration of this part being between 25 and 35 minutes.

In regards to the cool-down part, 98% of the coaches said that the means used here are the same as for the warm-up, but the intensity of the drills is reduced, and the duration is longer.

To question 3, "What is the psychological impact of the COVID-19 pandemic on the studied athletes?", a significant percentage of children athletes (90% said "yes" and 8% said "sometimes") feel isolated and disconnected all the time or sometimes.

44% of the athletes expressed their feelings of anxiety and frustration in regards to a possible Covid-19 infection, while 24% of the athletes were not sure of their feelings.

In addition, 90% of the athletes face a lack of initiative in completing their tasks.

Regarding the answers to the question "Are you worried of losing your initial fitness or that you will not be ready for the next competition?'' 84% of the children were at one point worried of losing their fitness because they lagged behind their physical training, especially the aerobic part.

It can be noticed that to the question "Was your decision to go back to training affected because of the COVID-19 pandemic?" 84% of the athletes started training again once the national and local situation allowed them, while 10% gave up training. The decision to come back to sport seems not to be affected too much by the COVID-19 pandemic. Considering the benefits of track and field training, it is advised to continue it, in order to help the athletes through these difficult times.

DISCUSSION AND CONCLUSION

The lockdown brought on by the COVID-19 pandemic has significantly affected the performances of the child athletes. The great majority of the subjects has had at least one canceling or postponing of certain important competitions because of COVID-19. Despite the lockdown and uncertainty about the future, in regards to their training and the next competition season, most children have continued to train daily, either through online sessions with their coach, or by performing cardio sessions, based on their coach's plan and supervised by their parents. However, most children have now trained less than 5 hours

per week. The drastic reduction in the training time and the change of the drills used during it influence the athletes' ability to maintain a high fitness level. Individual training or lack of track and field training can be seen also as another challenge that the children had to face during this pandemic. Besides the guided training, children took part in regular physical exercises or other moderate activities.

A significant number of children experienced feelings of isolation and disconnection during the lockdown. Hence the importance of the social side of sports. A large majority of the subjects felt a lack of initiative and of motivation in regards to their training. This can be related to the impact of the COVID-19 pandemic on the competition season, the athletes having their competitions cancelled, and the incertitude about their participation in future competitions could have generated a lack of motivation. It is obvious that in the case of athletes, a complete training season, full of sacrifices, has to end in a competition. The competitions being cancelled, the children felt that they wasted a big part of their lives. Here is where coaches have intervened to motivate them, offering moral support to athletes so that they could reprise their athletic activity, and are motivated to continue their training.

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DIFFERENCES IN COORDINATION AND BALANCE BETWEEN MALE AND FEMALE ELITE SPORT CLIMBERS

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ABSTRACT

A very small number of authors studied coordination and balance as important motor skills responsible for success in sport climbing. Also, a small number of studies have been conducted on the differences between male and female sport climbers. The aim of this study was to determine the differences in coordination and balance between mele and female elite sport climbers. The research was conducted on 21 elite sport climbers (10 males aged 17.3±1.57 years and 11 females aged 16.0±1.55 years), Youth World Cup participants held in Arco, Italy. Study was carried out using six variables (three for the evaluation of the coordination and three for balance). The results indicate that globally there are no significant differences in coordination between male and female elite sport climbers, except in the coordination with a baton test in which men were statistically significantly more successful. However, there are statistically significant differences in balance at the multivariate level in favor of men, as well as in the Flamingo test, while the crosswise standing test on a balance bench was at the very limit of significance. These results probably point out at two more possible components in the specification equation that make male elite sport climbers still climb harder routes than female elite sport climbers.

Keywords: balance, coordination, differences, elite sport climbers

INTRODUCTION

Sport climbing has increased in popularity in the last decades both as a recreational physical activity and as a competitive sport (Creasey et al., 1999; Davis, 2004; Sheel, 2004; Woollings, McKay, & Emery, 2015; Saul et al., 2019). With 1000 people trying to climb for the first time every single day in the U.S., 25 million people are climbing regularly worldwide according to the International Federation of Sport Climbing (IFSC, 2019). Sport climbing had its Olympic debut at Tokyo 2020 (2021), where speed climbing, bouldering and lead climbing were featured (International Olympic Committee, 2016).

A very small number of authors studied coordination as one of very important motor skill responsible for success in sport climbing (Magiera & Ryguła, 2007; Sterkowicz, Jaworski, & Rokowski, 2014; Orth, Davids, & Seifert, 2016; Stanković et al., 2019). Good coordination has always been taken for granted and trained through mental visualization of the direction of the climb (Stanković et al., 2011). This motor ability appears as an essential part of the six-component model of successful climbing performance (Goddard & Neumann, 1993; Draper & Hodgson, 2008). Skilled climbing has been broadly characterised as rapidly and fluently transitioning between holds (Orth, Davids, & Seifert, 2016), and experienced rock climbers perceive information from the environment to coordinate climbing actions (Seifert et al., 2013). Higher scores in the coordination were found in the athletes involved in climbing compared to the group of untrained subjects, and analysis of a coordination profile of the best athlete suggests that coordination motor abilities should be considered during selection, recruitment and training of climbers (Sterkowicz, Jaworski, & Rokowski, 2014).

A small number of researchers have dealt with the issue of balance in sport climbers, as well as its impact on the result in sport climbing. Only four studies have dealt with balance assessment in sport climbers (Testa et al., 1999; Quaine & Martin, 1999; Ignjatović, Stanković, & Pavlović, 2016; Игњатовић,

2017). Testa et al. (1999) concluded that the horizontal impulse participates in balance control, while the vertical impulse contributes to movement initiation, and Quaine & Martin (1999) came to a scheme for establishing static balance. The research done by Ignjatović et al. (2016) pointed out the existence of statistically significant relations between the balance assessment set and the overall ranking in sport climbing, especially in the boulder discipline in women sport climbers, and in 2017, Игњатовић determined a significant influence of balance in lead climbing in female sport climbers.

Also, a small number of studies have been conducted with the aim of evaluating the differences between male and female sport climbers. The researchers investigated differences in strength and cardiorespiratory fitness (Binney & Cochrane, 2003; Padrenoso et al., 2008), in body composition and performance (Stanković et al., 2009; Mitchell, Bowhay, & Pitts, 2011), as well as in time needed to complete the climbing route (Arbulu, Usabiaga, & Castellano, 2015).

It can be stated that so far there have been relatively few studies that have studied the balance and coordination in the population of sport climbers, despite the relatively significant influence of these abilities, while studies of differences between male and female sport climbers in these two motor skills have not been conducted. The aim of this study is to determine the differences in coordination and balance between male and female elite sport climbers.

METHODS

Subjects

The sample of the examinees was extracted from the population of male (aged 17.3±1.57 years) and female (aged 16.0±1.55 years) elite sport climbers, participants at the Youth World Cup in Sport Climbing in Arco (Italy), held from August 28 to September 6, 2015. The research was conducted in 10 male and 11 female participants, and the sample involved each participant, provided that they were healthy at the time of testing and voluntarily agreed to participate in the research.

Procedure

In this study, six tests were applied to estimate the coordination and balance of the sport climbers. Tests for assessment of coordination were: the polygon backwards in seconds (POLB), coordination with a baton (COOB) and 20 steps with a baton (20SB). Balance assessment tests were: Flamingo test (FLAM), one leg standing along on a balance bench (OLSB) and crosswise standing on a balance beam (SCBB).

The applied set of tests of coordination and balance was taken from the research of Kurelić et al. (1975). It has been used numerous times in basic experimental research and has an appropriate level of metric characteristics in explaining the tested motor dimensions.

Statistical analysis

The statistical methods of analyses included descriptive statistics, MANOVA and ANOVA. Descriptive statistics comprised: number of participants (N), mean value (Mean), standard deviation (SD), minimum (Min) and maximum (Max) numerical results, range (Range) and standard error of the mean value (Error). Discriminative measurements were performed by two procedures: Skewness (Skew) pointing to the symmetry of substance layout around the arithmetic mean and Kurtosis (Kurt) designating peakedness or flatness of distribution. Multivariable MANOVA and univariable ANOVA analysis were used in order to show the differences between these two gender groups. Statistical significance was determined at the level of $p<0.05$. Raw data were processed by means of Statistica 10.0 software package.

RESULTS AND DISCUSSION

An analysing of Table 1 which shows the results of the central and dispersion parameters of the applied variables, it can be stated that discrimination of the tests is good because in the intervals of the minimal (Min) and maximal (Max) results comprise always about 3 to 5 standard deviations (SD), which enables us to state significant sensibility of all applied tests. By reviewing the data responsible for the symmetry of the distribution around the arithmetic mean (Skew) we can notice that the distribution is slightly curved to the left for variables POLB and COOB in male, and strongly curved to the left in the variable 20SB in female sport climbers. Also, there is a slightly curved distribution to the right in variable OLSB in male and strongly curved to the right in the same variable in female sport climbers. By analyzing the kurtosis we can notice that the results in variables 20SB and OLSB in female are quite compressed,

and slightly compressed in variable POLB in men, whereas in FLAM in men and SCBB in females distribution is slightly stretched.

Table 1. Descriptive statistics for the estimation of coordination and balance in male and female elite sport climbers

Variables	Group	N	Mean	Min	Max	Range	SD	Error	Skew	Kurt
POLB	Male	10	7.87	6.37	12.43	6.060	1.960	0.620	1.8392	2.7786
	Female	11	8.30	7.04	9.36	2.32	0.693	0.209	-0.1983	-0.1560
COOB	Male	10	3.45	2.68	4.72	2.040	0.696	0.220	1.0968	0.4084
	Female	11	4.07	3.39	4.92	1.530	0.411	0.124	0.5542	0.9846
20SB	Male	10	13.06	9.22	18.16	8.940	2.827	0.894	0.4912	-0.6207
	Female	11	12.55	10.49	19.33	8.84	2.643	0.797	2.1248	4.2640
FLAM	Male	10	4.57	3.25	6.22	2.970	1.005	0.318	0.1293	-1.0976
	Female	11	2.94	1.66	4.00	2.340	0.630	0.190	-0.2776	0.9828
OLSB	Male	10	18.06	12.44	20.00	7.560	2.728	0.863	-1.1125	0.1950
	Female	11	18.25	9.25	20.00	10.750	3.266	0.985	-2.4830	6.5532
SCBB	Male	10	14.31	4.14	20.00	15.860	5.650	1.787	-0.8733	-0.1478
	Female	11	10.34	6.15	14.29	8.140	2.682	0.809	-0.1900	-1.2594

Table 2. Differences in coordination between male and female elite sport climbers: MANOVA

Test	Value	F	Effect - df	Error - df	p
Wilks	0.715578	2.2523	3	17	0.119244

By analyzing Table 2 it can be noticed that there are no statistically significant differences in coordination between men and women elite sport climbers at the multivariate level (p=0.119244).

Table 3. Differences in coordination between male and female elite sport climbers: ANOVA

Variables	Group	N	Mean	SD	F	p
POLB	Male	10	7.87	1.960	0.463709	0.504111
	Female	11	8.30	0.693		
COOB	Male	10	3.45	0.696	6.325345	**0.021062**
	Female	11	4.07	0.411		
20SB	Male	10	13.06	2.827	0.179265	0.676760
	Female	11	12.55	2.643		

Table 3 shows the differences in coordination between male and female sport climbers at univariate level. By this analysis it can be noticed that there are statistically significant differences only in the variable coordination with a baton (COOB, p=0.021062) in favor of men, while there were no statistical differences in the other two variables (the polygon backwards in seconds- POLB and 20 steps with a baton- 20SB).

Table 4. Differences in balance between male and female elite sport climbers: MANOVA

Test	Value	F	Effect - df	Error - df	p
Wilks	0.443018	7.1244	3	17	**0.002632**

Table 4 indicates the existence of statistically significant differences in balance of male and female elite sport climbers (p=0.002632) in favor of men.

By analyzing Table 5, which shows the differences in balance between male and female elite sport climbers at univariate level, it can be noticed that there are statistically significant differences in the Flamingo test (p=0.000256) in favor of men, while the crosswise standing test on a balance beam was at the very limit of significance.

Table 5. Differences in balance between male and female elite sport climbers: ANOVA

Variables	Group	N	Mean	SD	F	p
FLAM	Male	10	4.57	1.005	20.08582	**0.000256**
	Female	11	2.94	0.630		
OLSB	Male	10	18.06	2.728	0.02127	0.885582
	Female	11	18.25	3.266		
SCBB	Male	10	14.31	5.650	4.35596	0.050590
	Female	11	10.34	2.682		

CONCLUSION

Based on the obtained results it can be concluded that globally there are no significant differences in coordination between male and female elite sport climbers, except in the coordination with a baton test in which men were statistically significantly more successful. However, there are statistically significant differences in balance at the multivariate level in favor of men, as well as in the Flamingo test, while the crosswise standing test on a balance beam was at the very limit of significance. These results probably point out at two more possible components in the specification equation that make men elite sport climbers still climb harder routes than women elite sport climbers. Therefore, we should pay attention to these two motor abilities when selecting young sport climbers.

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INFLUENCE OF UPPER EXTREMITIES STRENGTH OF YOUNG GYMNASTS ON SUCCESS IN PERFORMING EXERCISES ON RINGS

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ABSTRACT

Artistic gymnastics is the most famous and widespread gymnastics sport discipline, and rings are one of the six apparatus of men's gymnastics all-around. The aim of the study was to determine the influence of the upper extremities' strength on success in performing exercises on rings of young gymnasts. The sample consisted of 13 male gymnasts, aged 14 to 16, who practice gymnastics from 8 to 13 years. The Japanese digital dynamometer IMADAZ2H-1100 with WinWedge 3.4 software was used to estimate the absolute strength of the upper extremities muscles. The values displayed on the digital meter represent the absolute value of the maximum strength. When the absolute value of the strength was divided by the body mass of the participant, relative values were obtained. Based on the obtained results, it can be concluded that absolute and relative strength of the upper extremities do not have a decisive statistically significant influence on success in performing exercises on rings of young gymnasts. The obtained results represents a good starting point for further research in which the influence of other muscle regions that are responsible for the successful performing of exercises on other gymnastic apparatus in all-around, on a larger sample and different ages, could be examined.

Keywords: artistic gymnastics, rings, strength

INTRODUCTION

Under the generic name "Gymnastics" Fédération International de Gymnastique (FIG) regulates a large part of activities based on training, education and activities that will emphasize the physical and mental characteristics of the athlete regardless of race, religion, age, his or her social status. Due to the existence of large number of types of gymnastics, today gymnastics must be used with a prefix in order for the term to be clearly defined (Petković, 2011). Artistic gymnastics is the most famous and widespread gymnastics sport discipline. Under artistic gymnastics the widest audience perceives sport as a competitive discipline, of polystructural content (exercises are performed in three planes of movement and all three axes of rotation), of the acyclic type and defined rules as a convention in practice (Petković, Veličković, Petković, Hadži Ilić, & Mekić, 2013). Rings are one of the six apparatus of men's artistic gymnastic all-around. As apparatus, they are firstly practiced in rocking, and then in swinging, that is, in place. Women competed on rings in rocking until the 1950s. In 1903, rings in triangular and round shapes appeared in competitions for the first time (Petković, Veličković, Petković, Hadži Ilić, & Mekić, 2013). Specificity in exercise on rings in relation to other gymnastics apparatus are caused by the construction of rings. Unlike other apparatus rings are apparatus that move. The mobility of the apparatus can make it easier (swinging in hang) or difficult (swinging in support) to perform the exercise (Ilić, 1980).

Motor abilities are named differently by various authors (anthropomotor abilities, biomotor dimensions, kinesiological abilities, motor habits, motor dimensions, etc.). Everyone agrees that these are the qualities of a man that express his physical readiness for work, as well as the creative expression of his own personality (Paspalj, 2008). Specific motor abilities are acquired conditioned reflexes that occur in certain sports as a result of specific training work on the development of those motor abilities that are characteristics of that sport (Stojiljković, 2003). Many authors have tried to define strength in the best way using different starting points. Pavle Opavski (1971, 169) identifies strength and force and says

"force is the ability to transform muscular tension in the composition of motor units into a kinetic or potential form of mechanical energy". On the other hand, Fratrić (2006) defines strength as the ability of an athlete which is manifested in overcoming various resistances. Similar to the previous definition, Herodek (2006) and Zaciorski (1975) say that strength is a person's ability to overcome or resist external resistance with the help of muscular tension.

The most important for this research are the topological division and the division into absolute and relative strength. Absolute strength is the maximum muscle strength that a person can develop with his overall muscle mass (Stojiljković, 2003). Relative strength is the amount of strength that a person can develop per kilogram of their weight and is important for gymnasts, body manipulation exercises, exercise on apparatus, etc. In other words, relative strength is the strength that an athlete develops depending on his body mass (ideally would be if the athlete's strength is 1 kg of force per 1 kg of body mass) (Stojiljković, 2003). Topologically, strength can be divided into torso strength, upper extremity strength, and lower extremity strength (Herodek, 2006).

Due to the assumption that the upper extremities strength is significant, the contribution of this research is reflected in determining the significance of the influence of the upper extremities strength on success in performing exercises on rings among gymnasts, which is the aim of this study.

METHODS

Subjects

The sample consisted of 13 gymnasts (Table 1), aged 14 to 16 years (15.38±0.77 years), engaged in artistic gymnastics from 8 to 13 years (10.07±1.5 years of sports experience), and with a body mass of 42 to 78 kg (57.77±9.1 kg). All subjects were clinically healthy at the time of measurement. The research was approved by the Ethics Committee of the Faculty of Sports and Physical Education of University of Niš and in accordance with the Declaration of Helsinki (WMA, 2013).

Procedure

The sample of variables consisted of: **FSCOR**- final score on rings, **BICAP**- absolute strength of the flexor muscles of the upper arm, **BICRE**- relative strength of the flexor muscles of the upper arm, **SHOAP**- absolute strength of the shoulder anteflexor muscles, **SHORE-** relative strength of the shoulder anteflexor muscles.

The Japanese digital dynamometer IMADAZ2H-1100 with WinWedge 3.4 software was used to estimate the absolute strength of the upper extremities muscles. The values displayed on the digital meter represent the absolute value of the maximum strength. When absolute value of strength is divided by the body mass of the participant, a relative value is obtained. An electronic scale of the "TEFAL" brand with a measurement accuracy of 0.1 kg was used to measure body mass and the results are written in kilograms.

All procedures were performed in one day, just before the competition at the international tournament "Laza Krstić and Marica Dželatović" held in Novi Sad (Serbia). For the assessment of absolute strength, the following was measured: absolute upper arm flexor muscle strength (BICAP) and absolute shoulder anteflexor muscle strength (RAMAP). The sum of "D" and "E" scores (FSCOR) was used to assess the success of performing exercises on rings. Body mass measurement was performed according to the recommendations of the international Biological Program (IBP) (Đurašković, 2001).

Description of tests and method of measurement (Dopsaj, 2010):

a) To measure the maximum force of the flexor muscles of the upper arm, the subject holds a dynamometer in front of him with flexion in the elbow joint of 90 degrees. The feet are hip-width apart, and the chain connecting the stand to the digital force gauge is fully tightened. The subject pulls the dynamometer from the initial position evenly with both hands with the strength of the flexor muscles of the upper arm, during which he performs the movement of flexion in the elbow joint. The result is read in Newtons (N).

b) To measure the maximum force of the shoulder anteflexor muscles, the subject holds a dynamometer in front of him, arms outstretched with a 90-degree angle between the arms and torso. The feet are hip-width apart, and the chain connecting the stand to the digital force gauge is fully tightened. The subject pulls the dynamometer from the initial position evenly with both hands with the strength of the shoulder girdle muscles, during which he performs the ante-flexion movement in the shoulder joint. The result is read in Newtons (N).

Statistical analysis

For the data processing methods, statistical procedures were used that correspond to the problem of the research. For each variable the results of descriptive statistics were presented: average value (**Mean**), standard deviation (**SD**), minimum value (**Min**), maximum value (**Max**), skewness (**Skew**), kurtosis (**Kurt**), as well as the results of Kolomogorov-Smirnov Z test in order to examine the normality of data distribution. Regression analysis was used to determine the influence of absolute and relative strength of the upper extremities and shoulder girdle muscles on success in performing exercises on rings. The statistical program SPSS 20.0 was used for statistical data processing.

RESULTS

Based on the obtained measurement results, statistical data processing was performed. Table 1 shows the basic statistical parameters of descriptive statistics.

Table 1. Basic statistical parameters of descriptive statistics

Variables	Mean±SD	Min	Max	Skew	Kurt	KS - Z	
						KS - Z	p
FSCOR	10.89±1.84	5.80	13.00	-1.85	4.57	0.69	0.73
BICAP	322.77±80.92	214.00	470.00	0.11	-0.94	0.56	0.91
BICRE	5.56±0.96	3.79	7.70	0.49	1.30	0.54	0.93
SHOAP	140.62±51.66	41.00	231.00	-0.46	0.32	0.57	0.91
SHORE	2.41±0.77	0.98	3.79	-0.59	0.84	0.70	0.71

Legend: **Mean-** average value, **SD-** standard deviation, **Min-** minimum value, **Max-** maximum value, **Skew-** skewness, **Kurt-** kurtosis, **KS-Z-** Kolmogorov Smirnov Z test, **p-** statistical significance of the KS-Z test, **FSCOR-** final score on rings, **BICAP-** absolute strength of the flexor muscles of the upper arm, **BICRE-** relative strength of the flexor muscles of the upper arm, **SHOAP-** absolute strength of the shoulder anteflexor muscles, **SHORE-** relative strength of the shoulder anteflexor muscles

The results of the Kolmogorov-Smirnov Z test (p), which are greater than 0.05 for all of applied variables, indicate that there is no significant deviation from the normal distribution. These results are supported by the values of skewness and kurtosis and indicate the normal distribution of data.

Table 2. Regression analysis

Variables	Beta	t	p	R	R^2_{adjust}	Std. Err. Est.	F	p
BICAP	-.019	-.304	.769	.691	.216	1.627	1.829	.217
BICRE	3.042	1.140	.287					
SHOAP	.044	.283	.784					
SHORE	-4.509	-.600	.565					

Legend: **Beta- s**tandardized values of the regression coefficient, **t-** standardized regression coefficient significance tests, **p-** the level of significance of the standardized regression coefficient, **R-** the level of significance of the multiple correlation coefficient, R^2_{adjust}**-** adjusted coefficient of determination, **Std. Err. Est.-** standard error estimate, **F-** significance test of multiple regression analysis, **p-** significance level of multiple correlation, **BICAP-** absolute strength of the flexor muscles of the upper arm, **BICRE-** relative strength of the flexor muscles of the upper arm, **SHOAP-** absolute strength of the shoulder anteflexor muscles, **SHORE-** relative strength of the shoulder anteflexor muscles

Table 2 shows the results of regression analysis for the whole set of variables, as well as for each variable separately. The results indicates that although there is an influence of absolute and relative strength of the upper arm muscles (BICAP 0.769) and (BICRE 0.287) on the performance of exercises on rings, it is not statistically significant. The results of absolute and relative strength of the shoulder girdle muscles (SHOAP 0.784) and (SHORE 0.565) indicate the same. This is shown by the results of the standardized value of the ***Beta*** regression coefficient and the coefficient of significance of the regression ***t***. For the set of variables the obtained results are at the level of p=0.217. As with each variable separately, although there is an influence, it is not statistically significant, which is indicated by the values of the significance level of the multiple correlation coefficient ***R*** (0.691) and the adjusted coefficient R^2_{adjust} (0.216). ***Std. Err. Est.*** the standard error estimate (1.627) and the significance test of multiple regression analysis ***F*** (1.829) also indicate that there is no statistically significant effect of upper extremity strength

on the performance of the exercises on rings. Table 2 shows that the influence of shoulder girdle muscles and upper arm muscles on the success of performing exercises on rings is approximately equal, although these results have no statistical significance.

DISCUSSION AND CONCLUSION

The aim of this study was to examine the influence of relative and absolute strength of the upper extremities (upper arm muscles and shoulder girdle muscles) on success in performing exercises on rings among gymnasts aged 14 to 16 years. The results showed that there is no statistically significant effect of upper extremity muscle strength of gymnasts on the success in performing exercises on rings. There are only two studies that dealt specifically with the topic that is the subject of this study and their results are consistent with the results obtained in this study. In the first research, Paunović et al. (2018) examined the influence of the strength of different muscle groups on the result in all-around with young gymnasts. On a sample of respondents aged 14 to 16 years, they obtained results that are consistent with the results in this study. The influence of the relative strength of the upper arm muscles (BICMAX 0.926) and the shoulder girdle muscles (SHOMAX 0.149) is as in this study without statistical significance. For the set of applied variables, the results are also very similar and without statistical significance (p=0.653). In another study, Paunović et al. (2019) examined the influence of lower extremity strength on the success of performing exercises on the floor. On similar sample of respondents aged 14 to 16, the authors found that, although there is an influence of absolute and relative strength of the lower extremities on the success in performing exercises on the floor, it was not statistically significant. In this study, the authors examined separately the influence of the absolute strength of the lower extremities on the "D" score (p=0.631), on the "E" score (p=0.284) and on the final score (p=0.295), and applied the same procedure to the relative strength ("D" score: p=0.631, "E" score: p=0.284, final score: p=0.291). From the previous researches' results it can be seen that they are consistent with the results obtained in this research.

Based on the obtained results, it can be concluded that although there is an influence of absolute and relative strength on the success in performing exercises on rings among gymnasts, it is not statistically significant. The results indicate that, with relative strength, the level of significance of the correlation coefficient ***p*** is lower, but gives slight differences between them. Probably at this age the performance of the elements on rings, beside upper extremities strength, requires greater coordination, flexibility, balance and other motor skills. When performing exercises on rings, there are other factors that are important for achieving results, among which should be noted the good technical preparation of gymnasts, their level of training and mental stability, as well as the number of competitions during their careers. It is logical that a larger number of competitions affects the success of achieving better results (Bokan, 2009).

The above mentioned does not mean that the upper extremities strength is not extremely important for success in men's artistic gymnastics, but that this study found that it is not a decisive factor. The obtained results represent a good starting point for further researches in which the influence of other muscle regions that are responsible for the success of performing exercises on other gymnastic apparatus in all-around can be examined on a larger sample and different ages. Further research in this direction should be continued in order to determine the factor that is decisive for success in artistic gymnastics. Based on this, the right guidelines can be given for the further development of certain muscle groups that have a primary impact on the success of training and thus help trainers to achieve better competitive results. Based on this research, the fact is that relative strength is important in artistic gymnastics, but in addition, special attention should be given to the influence of other motor skills.

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MANIFESTATION OF LATERALITY ON LOWER EXTREMITIES IN ATHLETES

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ABSTRACT

In humans, laterality is manifested by the dominance of one hand, foot, eye, ear. Presence of laterality, caused by the specificity of one sport, can contribute to the development of asymmetry in muscular strength within the muscular system. The aim of this systematic review is to collect and analyse recent studies of the manifestation of laterality on lower extremities in athletes. The final analysis included 22 studies, namely between 2017 to July 2021. Most of the included studies followed differences between lower extremities in athletes by determining kinetics and kinematics parameters, and one part by determining strength. In almost each group of sports assymmetries between extremities are found. Recommendations for future research are to focus on finding causes of the prevalence of one side of the body and possibilities of neutralizing it.

Keywords: bilateral difference, leg dominance, preferred leg, unilateral and bilateral sports, asymmetry

INTRODUCTION

In humans, lateral dominancy (LD) is manifested by the dominance of one hand, foot, eye, ear. Giving an advantage to one side of the body is explained as an increased use of one leg or arm that has developed necessary motor skills to perform a specific task (Serrien, Ivry, & Swinnen, 2006). Most research state that the cortex of the brain of both hemispheres control the most voluntary movements in the contralateral side of the body where the dominant hemisphere is the one that controls the given function (Hebbal & Mysorekar, 2006). In the human population 80% to 90% is right-handed, and 60% to 82% have dominancy of right leg (Sommer, 2006). The prevalence of extremity on the same side of the body is explained as a consequence of cerebral efficacy to reduce double simulation of neural activation of both hemispheres (Ghirlanda, Frasnelli, & Vallortigara, 2008).

To achieve success in sports, athletes are often expected to neutralize the existence of LD in lower extremities by training because the presence of dominance on one side of the body can contribute to the development of asymmetry in muscular strength within the muscular system. Previous research showed that differences between extremities can achieve up to 66% (Bini, Jacques, Carpes, & Vaz, 2017; Carpes, Rossato, Faria, & Mota, 2007). According to authors, 10% and 15% of differences in strength between extremities is considered normal in order to avoid the possibilities of getting injured (Bennell et al., 1998). Based on the above mentioned, the aim of this paper is to analyse recent researches that examined the manifestation of laterality on lower extremities in athletes.

METHODS

For the collection of relevant research papers, the following electronic databases were used: DOAJ, PEDro and PubMed. For the purpose of closer search and selection of research papers, the search was limited by using key words that are related to the problem of this research: bilateral difference, leg dominance, preferred leg, unilateral and bilateral sports, asymmetry.

The final analysis included all available studies published during the last five years, namely between 2017 to July 2021, which were determining the differences between the lower extremities in athletes. Table 1 provides an overview of close analyses of 22 studies that met the set criteria. Following the conventions for systematic reviews, the table presents the following parameters: reference, research subject, sample of participants (sport, number, sex, age), description of applied instruments, and results.

Table 1. Summary of main characteristics of the included studies

Reference	Research subject	Sample of participants	Instruments	Results
Bini et al. (2017)	Assessing the possibility of reducing the asymmetry by a specific training.	Cycling/triathlon N: 20 G: M Y: 30 ± 7	Bike connected to a trainer, power	Statistically significant asymmetry was observed in asymmetric subjects. By applying specific training, the asymmetry was neutralized.
Girard et al. (2017)	Determining the differences in the symmetry between lower extremities during repeated sprints.	Running N: 13 G: M Y: 31.2±4.8	Treadmill, kinematic analysis	Repeated running on tridmill shows asymmetry in the extremities in many kinematic parameters.
Ludwig et al. (2017)	Determining the differences in the dominant and non-dominant limb in younger elite and amateur football players after a one-sided landing.	Football N: 114 G: M Y: 14.6±1.1	The task of the participants was to make a landing on one leg from the box. Valgus angles in the knee joint were compared.	Statistically significant differences were identified for valgus angles between the dominant and non - dominant leg in both groups of subjects, showing a larger angle in the dominant leg.
Marchini et al. (2017)	Determining the influence of age differences in motor variability during the performance of dorsal flexion coordination tasks in the ankle and the possibility of reducing asymmetry with training.	Young and older non-athletes, older in the training process 1 year N: 32 G: M (10)/F (22) Y: 30–60	EMG, isometric force	The removal of visual monitoring statistically significant increased the variability of force and decreased synergy in all groups of subjects.
Meyers et al. (2017)	Monitoring the impact of ageing on asymmetry during maximal sprint performance.	Recreational N: 344 G: M Y: 13.2±1.4	Ground-level optical measurement system	No strong relationships exist between the magnitude of asymmetry and maximal sprint velocity.
Sinsurin et al. (2017)	Determining the influence of lower limb dominance and landing direction in volleyball players.	Volleyball N: 19 G: F Y: 19.7±0.01	Force platform and kinamotogram	Statistically significant difference in limbs in landing strategies in different directions.
Bishop et al. (2018)	Quantification of inter-limb asymmetries from unilateral jump tests and examine their effects on speed and jump performance.	Football N: 19 G: F Y: 10±1.1	Electronic timing gates, “My Jump” iPhone application	Larger asymmetries are associated with reduced jump performance and would apear to be direction-specific.
Boccia et al. (2018)	Determination of asymmetry between extremities at the rate of torque development in ballistic contraction at submaximal moment.	Football N: 20 G: M Y: 17±1	Concentric isokinetic contractions and isometric contractions, Dynamometer	40% - 60% of the subjects showed asymmetry in the isometry of the rate of torque development at the force level of 50% MVC.
Nasirzade & Zonouzi (2018)	Determination of joints local and global symmetry during jogging in young male athletes.	Physical education students N: 15 G: M Y: 27.14±3.67	Kinematic and kinetics	Despite having asymmetric movements in the ankle, knee, and hip joints (local asymmetry), show symmetric behaviour in the lower limbs (global symmetry).
Read et al. (2018)	Effects of maturation on measures of asymmetry during neuromuscular control tests in elite male youth soccer players.	Football (Post-; Circa-; Pre-MHV) N: 347 G: M Y: 16.1±1.1; 14.4±0.9; 11.9±1.1	Force plate	Stage of maturation did not have a profound effect on asymmetry.
Zouhal et al. (2018)	The impact of the laterality on agility among elite football players.	Football: elite, amateur N: 80 G: M Y: 18.2±2.2 / 19.6±2.1	Accelerometer and cameras	A statistically significant difference was observed between the extremities and the time of rotation movement in elite football players..
Hashizume et al. (2019)	Determination of between-limb differences in negative work and associated mechanical parameters during the contact phase of running.	Recreational N: 22 G: M Y: 25.8±4.6	Kinetics and kinematics analyses, cameras, force platforms	Asymmetric negative work was generated in each lower extremity joint during the contact phase of running.
Madruga-Parera et	Efects of maturation on lower limb	Tennis (Post-; Circa-; Pre-MHV)	Infrared beams from photocells,	Inter-limb differences may be heightened during MHV.

al. (2019)	neuromuscularasymmetries in elite youth tennis players.	N: 41 G: M Y: 14.6±2.7	contact mat system	
Wang & Fu (2019)	Determination the effects of asymmetry on kinematics, kinetics, and changes in the center of pressure of legs during single-leg landings in female athletes.	Football N: 15 G: F Y: 20±1	Three-dimensional kinematics and kinetics	Asymmetry between the two legs during the single-leg landing impact were indicated.
Mo et al. (2020)	Influence of running speed and training experience on bilateral symmetry during running.	Running: elite, recreational, amateurs N: 31 G: M (18)/F (13) Y: 31.7±4.1 / 35.2±7.4 / 29.1±4.3	Temporal and kinematic parameters Treadmill	Elite runners exhibited a linear reduction in the symmetry index with increasing speed.
Tucker & Hanley (2020)	Analysis of increasing walk variability and symmetry at different speeds in world-class fast walkers.	Fast walking: elite N: 18 G: M (11)/F (7) Y: 25.7±4.1/25.9 ± 4.1	Treadmill	Each athlete showed asymmetry in at least one parameter, but none in more than half of the monitored parameters.
Satas et al. (2020)	Determining the influence of knee extensor fatigue on bilateral force, variability and coordination with and without visual monitoring.	Fast walking: recreational N: 22 G: M (18)/F (4) Y: 22.6±2.0 / 22.2±1.3	EMG, muscle stimulation, isometric force	Greater bilateral accuracy of force control was observed during the performance of the asymmetric task.
DeAdder (2020)	Determination of asymmetry between extremities in subjects with > 10%, athletes	Top athletes: pre/post puberty N: 122 G: M (57)/F (65) Y: 8 - 11/17+	EMG, force platform	Prebertal athletes exhibited greater asymmetry than athletes after puberty.
Elkins (2020)	Determination of asymmetry in production is greatest during isometric contractions	Football N: 21 G: M (10)/F (11) Y: 20.5±1.7 / 19.5±1.4	Dual force plates, isometric force	Both groups of participants (men and women) showed asymmetry in performing the task.
Bishop, Brashill et al. (2021)	Determining asymmetry between limbs in different age groups of subjects	Football: over 23, 18 and 16 years N: 51 G: M Y: 19.8±1.1 / 17.5±0.5 / 15.1±0.7	Force platforme	Differences between extremities were manifested in the repeated jump on one leg.
Bishop, Berney et al. (2021)	Determining the bilateral deficit and the relationship in linear velocity and change of direction.	Students, physically active N: 18 G: M Y: 19.8±1.1 / 17.5±0.5 / 15.1±0.7	Force plate, Kynematics	Bilateral deficit was manifested in repetitive jumps, drop jumps, and long jumps and correlated with the 505 velocity test.
Kons et al. (2021)	Determining the influence of consecutive judo matches on the asymmetry between the extremities and the bilateral deficit	Judo N: 14 G: M Y: -	Four simulated matches of 4 min each, force plate, hand grip	Participants showed statistically significant asymmetry only in the test of repeated jumps, which increased after 2nd match.

Legend: N- number of participants, **G-** gender, **M-** male, **F-** female, **Y-** years (age), **EMG-** electromyogram, **MHV–** maturational stages, **MVC-** maximum voluntary contraction

RESULTS

Database searches returned 71 studies. After eliminating all duplicate papers and analysing titles and abstracts, 55 studies entered the next stage of analysis. Only studies that had included relevant outcomes were considered. By examining the research abstracts, six more articles were included for further analysis. The final number of studies in the final analysis was 22.

First study in this group was published in 2017 (Bini et al., 2017), while the last were published in July 2021 (Bishop, Berney, Lake, Loturco, Blagrove, & Read, 2021; Bishop, Brashill, Cabbott, Wread, Lake, & Turner, 2021). The total number of subjects in all research was 1398. In six studies participants were both male and female (DeAdder, 2020; Elkins, 2020; Marchini, Pereira, Pedroso, Christou, & Neto, 2017; Mo et al., 2020; Satas, Jurgelaitiene, Brazaitis, Eimantas, & Skurvydas, 2020; Tucker, & Hanley, 2020), three studies had only female participants (Bishop, Read, McCubbine, & Turner, 2018; Sinsurin, Srisangboriboon, & Vachalathiti, 2017; Wang & Fu, 2019), and in 13 studies participants were male.

DISCUSSION

Previous researches that examined lower extremity dominance in sports have mostly focused on maximal contractions or dynamic performance of movements in tasks such as kicking a ball (Ball, 2011), different types of jumps (Bishop, Berney et al., 2021; Bishop, Brashill et al., 2021; Kons et al., 2021; Sinsurin et al., 2017), cycling, rowing and running (Bini et al., 2017; DeAdder, 2020; Girard et al., 2017; Mo et al., 2020; Tucker & Hanley, 2020). In the kinematic and strength parameters, the dominant leg showed statistically higher values in the measured parameters in relation to the non-dominant leg (Sinsurin et al., 2017; Tucker, & Hanley, 2020). For example, asymmetries between two legs were observed during single-leg landing in football players (Wang & Fu, 2019), and reaction and movement time during turns (Zouhal et al., 2018). Also, in volleyball players, the greater risk of injuries was identified more in right leg during the two landing techniques- bilateral landing and stepping back from a net after lending (Zahradnik, Jandacka, Uchytil, Farana, & Hamill, 2015), what is confirmed by Sinsurin et al. (2017) who found different strategies in landings between extremities in favour to non-dominant leg. Furthermore, researches confirmed the existence of asymmetries in kinetics characteristics of lower extremities also in cyclic sports, during run and cycling (Girard et al., 2017; Hashizume, Hobara, & Kobayashi, 2019). On the other hand, it has been found that in some tasks a non-dominant leg has better control over the dominant. For example, in the study Ludwig et al. (2017) the dominant foot showed less stability than the non-dominant during kicks in football players. Authors relate these phenomena to a better motor control over supporting leg (Hewett, Paterno, & Myer, 2002; Valdez, 2003). It is believed that repeated performance during various tasks with one limb, as consisted in sports with greater activation of one limb, can cause neuromuscular adaptations (Challis, 1998). Unfortunately, there is no recent research following nerve control with athletes to confirm this point of view.

Some research concluded that prevalence of one side of the body can cause asymmetries in lower limbs that could affect further performance (Carpes et al., 2007; Carpes, Mota, & Faria, 2010; Zouhal et al., 2018), but that demands of sports can reduce or exceed the manifestation of one limb dominancy. This is in agreement with previous researches where runners did not show asymmetry in force between legs, but the difference was statistically significant in non-athletes (Siqueira, Pelegrini, Fontana, & Greve, 2002), and also that symmetry in trained runners were better (Smak, Neptune, & Hull, 1999). Bini et al. (2017) found that is possible to reduce asymmetry by following specific trainings.

One more phenomena was noticed. Nasirzade & Zonouzi (2018) found the compensation in the movements' chain during slow running, where participants, despite having asymmetric movements in the ankle, knee, and hip joints, showed symmetric behaviour in the lower limbs. The literature explains this as ability of central nervous system (CNS) to regulate movements by multiple joint movements to compensate the asymmetry (Carpes et al., 2010; Nasirzade, & Zonouzi, 2018; Salem, Salinas, & Harding, 2003).

To our knowledge there are no studies that have monitored the variability of force in the muscle and the characteristics of neural control between lower extremities, which has been shown as a good evidence of existence of difference in the motor units' discharge rate between upper extremities when performing isometric contractions (Adam et al., 1998), as well as difference in the number of activated motor units among trained and untrained participants (Semmler & Nordstrom, 1998). Based on the above mentioned additional researches are needed.

CONCLUSION

According to the analysis it can be concluded that most of the researches followed differences between lower extremities in athletes by determining kinetics and kinematics parameters, and one part by determining strength. In almost each group of sports (sports with greater activation of one limb, cyclic sports and sports that requires the support of both legs) between-extremity asymmetries were found. Tests that include cyclic tasks, dominancy of one side, can be identified in faster and prolonged performances, while in tests that follow static and dynamic tasks, dominancy is more expressed at lower and slower intensity performances. In athletes muscle strength imbalance between extremities might be reduced by performing sports for many years or by following special created trainings. Also, there is a drift of CNS to improve performance in bilateral tasks by compensation of movements through kinetics chain which reduce existent of asymmetries, which is not well explained. Future researches should focus on finding causes of a prevalence of one side of the body and possibilities of neutralizing it.

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DIFFERENCES IN EXPLOSIVE STRENGTH IN ATHLETICS AND VARIOUS SPORTS: A SYSTEMATIC REVIEW

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ABSTRACT

Explosive power is defined as an ability of short-term maximum muscular force to accelerate the movement of a body or it's parts. In most disciplines of Athletics, the basic criterion of success is the development of the greatest possible reactive force in the shortest possible time of contact with the ground. The aim of this review is to determine the differences in the explosive strength of the lower extremities of athletes who train Athletics and athletes from other sports. For analyzing the adequate literature the following electronic databases were searched for papers published between 2002 and 2020: PubMed, MEDLINE, Google Scholar, ScienceDirect, and Embase. The following terms were combined to design the search strategy: explosive strength of lower extremities, athletics, countermovement jump, tensiometer platform and vertical jump. Included studies were uncontrolled randomized and non-randomized transversal and longitudinal studies that examined the explosive power of the lower extremities in athletes (Athletics) and other athletes using a variety of tests. The included respondents are top athletes of both gender, aged 15 to 35. Of the 578 studies, through elimination and selection based on inclusion and exclusion criteria, 20 studies were selected. Athletes generate greater strength and power than all other subjects of other analyzed sports, for the values of drop jump from the height (60 cm, p=.01). Athletes need less time at the moment of impulse than other groups of athletes, as well as less time for amortisation. Drop jump (60 cm) parameters show that there is a negative correlation for force, reaction time, strength and jump height (-0.4 up to -0.81, p=.001). In sports that are explosively demanding, with the help of various tests, it has been established that athletes have the best values of contact parameters in relation to other sports.

Keywords: explosive strength, athletics, countermovement jump, tensiometer platform, vertical jump

INTRODUCTION

Athletics is one of the most widespread sports, which includes running, throwing and jumping disciplines. In most disciplines of Athletics, except long-distance and walking disciplines, the basic criterion of success is the development of the greatest possible reactive force in the shortest possible time of contact with the ground or contact phase (Михајловић, 2010).

Explosive strength is defined as the ability of short-term maximum muscle force used to accelerate the movement of a body or part of a body. Explosive muscle force is determined by the external resistance that needs to be overcome (Rippetoe & Kilgore, 2007; Verkhoshansky & Siff, 2009). The explosive strength of the lower extremities is one of the most important motor characteristics in athletes, therefore, its assessment is important for further progress in the training process and for the positive results of athletes (Стефановић, 1992). Beside Athletics, sports which abound in great forces of load and transmission of impulses through the lower extremities are so called team sports (volleyball, basketball, football...), and other individual sports (diving, weightlifting, skiing...) (Verkhoshansky & Siff, 2009). A variety of tests that originated from the training and development of the jumping and throwing training

process in Athletics are used for assessment. Through ordinary long jumps and vertical jumps where a meter is used for estimation, technical innovations have produced a tensiometer plate (Markström & Olsson, 2013). The most common type of analysis on the tensiometer plate is the semi-squat jump, both with and without arm swing, countermovement jump, and jumps with a certain percentage of loading weight to body weight ratio (Fuchs, Menzel, Guidotti, Bell, von Duvillard et al., 2019).

The aim of this paper is to determine the differences and the current status of explosive strength of the lower extremities (evaluated by tensiometer platform) in Athletics and various sports. Also, aim is to collect the studies which had the same aims and problem of research, to generate and analyze their results through systematic method.

METHODS

Data sources and search strategy

The following electronic databases were used to search for the literature used in this document: PubMed, MEDLINE, Google Scholar, ScienceDirect, ERIC from 2000 to 2021. The search was executed by using the following terminological determinants: explosive strength of lower extremities, athletics, countermovement jump, differences, tensiometer platform and vertical jump. The search strategy was modified for each electronic database, where possible, in order to increase sensitivity. All titles and abstracts have been reviewed for potential papers to be included in the systematic review. The lists of references of previous review and original research were reviewed as well. Relevant studies were selected after a detailed review, but only if they met the inclusion criteria.

Inclusion and exclusion criteria

Type of study

The paper is comprised of uncontrolled randomized and nonrandomized transversal and longitudinal studies on the assessment and determination of explosive strength of the lower extremities in athletes and other sportsmen and sportswomen using a tensiometer platform. The search was limited to research papers written in English.

Subjects

Subjects included were of both gender, aged 15 to 30 and experienced and top sportsmen/women (participants in competitions at the international and national level). Included study subjects were healthy, without deformities and artificial aids that affect the normal performance of jumping and movement.

Type of intervention

Selected research had to contain the assessment and impact of sports training on the development of explosive strength of the lower extremities of the subjects, i.e. sportsmen/women.

Type of output results

The included studies were those studies that showed the assessment, impact, and current state of the explosive strength of the lower extremities of the subjects.

The exclusion criteria

Exclusion criteria were: 1) research that used tests and apparatus to assess explosive strength other than the tensiometer platform; 2) subjects younger than 15 and older than 30, and 3) research performed on sportsmen/women, excluding athletes.

RESULTS

The search identified 578 potentially relevant studies and another 11 by reviewing references. After removing the duplicates and reviewing the titles and abstracts, 77 papers remained. After reviewing the full texts according to the inclusion criteria, 20 papers remained. Diagram 1 shows the schematic procedure of collecting, analyzing and eliminating papers.

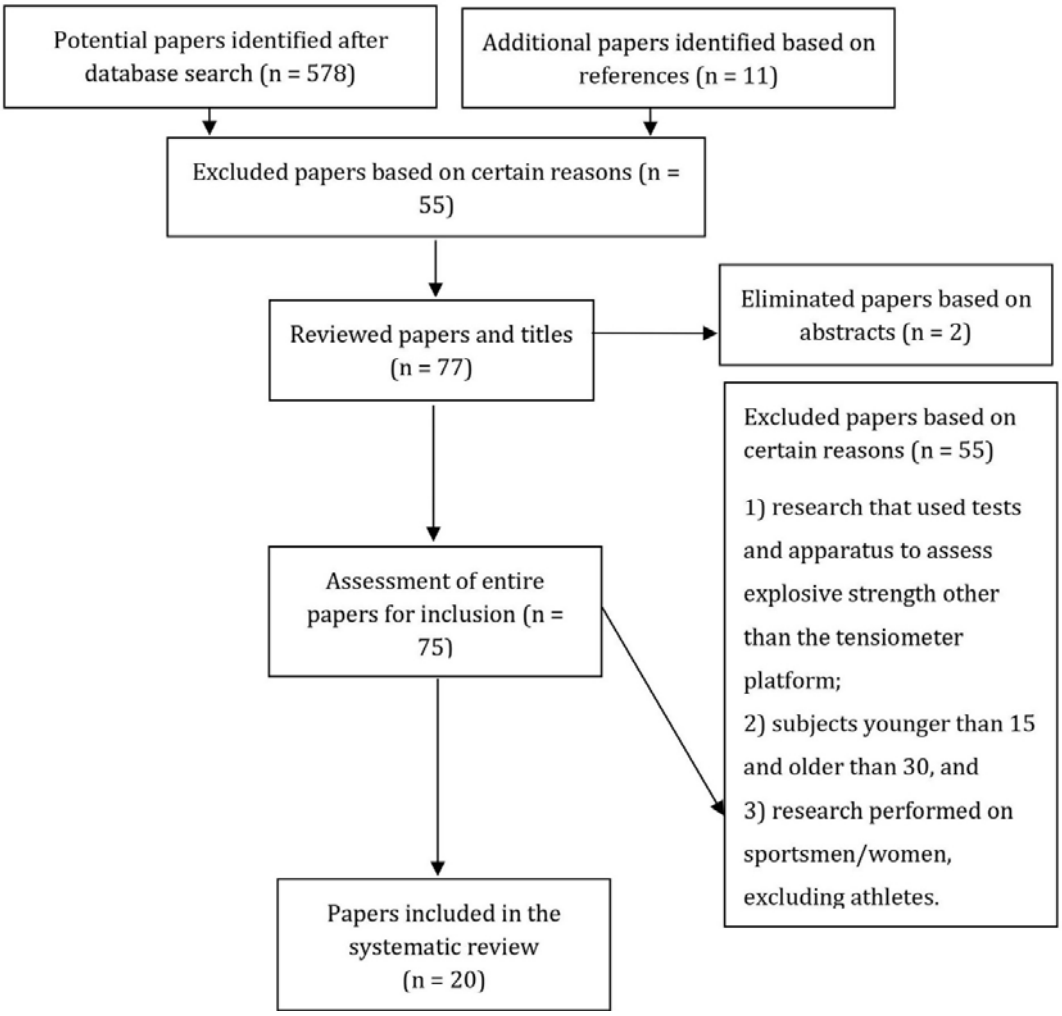

Diagram 1. Schematic representation of the studies search strategy

Author and a year of publication		Subjects				Methods	Results
		n	Gender	Age	Sport	Test	
1	***Kozinc et al. (2021)***	770	M=526 F=186	19.6	Athletics 77, Football 18, Volleyball 40, Dance 75, Basketball 170, Tennis 109, Speed skating, 164, Karate 59 and Students 58	3 attempts CMJ, SJ	Highest Mean CMJ for men-Athletics- 43.57±5.93 cm, Dance 36.96±5.41 cm and Volleyball 35.73±8.36 cm; for women- Athletics- 31.65±3.52 cm, Karate 28.11±4.23 cm and Speed skating 26.85±3.00 cm, p=0.003; η2= 0.03 (interaction gender and sport). Highest Mean SJ for men-Athletics- 39.51±5.09 cm, Volleyball 33.07±7.79 cm and Dance 33.03±5.49 cm; for women- Athletics- 29.94±5.00 cm, Karate 26.08±4.08 cm and Speed skating 24.50±2.48 cm, p=0.007; η2=0.03 (interaction gender and sport).
2	***Haugen et al. (2020)***	1577	M=989 F=588	23±5	44 different sports	6 attempts CMJ	CMJ-Strength & power sport athletes- (51.9±6.9 cm and 39.6±5.1 cm for men and women, respectively), team sports (mean diff, ±90%CL for men and women: 9.7±1.2 cm and 8.5±1.0 cm), downhill winter sports (9.8±1.4 cm and 6.7±1.3 cm), combat sports (12.3±1.3 cm and 11.2±1.3 cm), endurance sports (15.8±1.4 cm and 11.6±1.3 cm) and precision sports (16.9±1.8 cm and 15.2±2.1 cm). Mean gender diff- 8 cm to 12 cm across sport man 33% higher than females. Highest CMJ for men: 62.7±4.8 cm (athletics sprint and jumping disciplines), for women: 48.4±6.0 cm, and lowest CMJ for men: 30.4±3.8 cm (Orienteering), for women: 22.8±5.7 cm, respectively.
3	***Sole et al.***	150	M=75	20.5±1.	Athletics 26,	2 attempts (3	3 sport range level mixed groups show Mean CMJ: a) for

	(2018)		F=75	4	Football 41, Volleyball 19, Basketball 11, Baseball 47 and Tennis 6	groups-30) CMJ, Fm, P (for each phase)	man- first group: 47.4±4.4 cm, second group: 36.4±1.5 cm and third group: 28.4±2.4 cm; b) for women- first group: 36.0±2.1 cm, second group: 27.5±0.9 cm and third group: 19.7±2.3 cm.
4	***Douglas et al. (2017)***	24	M=14 F=10	24±6	Athletics (sprint disciplines)	3 attempts (2 groups-12) DJ(25, 50 and 75cm), Fm, P, V (for each phase)	Diff in reaction strength index ($s \cdot s^{-1}$) For first group: DJ(25 cm)-2.11±0.25, DJ(50 cm)- 2.07±0.36, and DJ(75 cm) 1.88±0.37, ES(50 cm vs. 25 cm)= -0.18(-0.56; 0.21), ES(75cm vs. 50cm)- 0.71(-1.16; -0.26), (moderate, r=0.5-0.7). For second group (athletes): DJ(25 cm)- 3.08±0.4, DJ(50 cm)- 3.08±0.50, and DJ(75 cm)- 2.90±0.53, ES(50 cm vs. 25 cm)= 0.00, (-0.28; 0.29), ES(75 cm vs. 50 cm)= -0.43 (-0.60; -0.27), moderate, r=0.5-0.7. DJ(25 cm), r=-0,87, DJ(50cm), r=-0,92, and DJ(75cm), r=-0,93.
5	***Čoh & Smajlović (2015)***	12	M=12	22.4±3.4	Athletics (sprint disciplines)	2 attempts (2 groups by level-6), DJ(45cm), Fm, V	First group show for DJ (45 cm) heigh of 54.76±5.34 cm compare to 46.02±5.95 cm, diff 8.7 cm, $p<0.05$, for V=3.18±0.15 m/s, compare to 2.87±0.24 m/s, $p<0.05$, and eccentric V=3.05±0.11 m/s, compare to 2.81±0.07 m/s, $p<0.05$.
6	***Loturco et al. (2015)***	22	M=13 F=9	18-28	Athletics (sprint disciplines)	6 attempts, CMJ, XS, sprint 50m, t, Fm, V	r between XS and CMJ for 50 m sprint (R^2 = 0.81), r between P and ↑XS and ↑CMJ is 40% from body weight and ↓t sprint.
7	***Coh & Mackala (2013)***	12	M=12	19-26	Athletics (sprint disciplines 12)	5 attempts (2 groups), CMJ, AS, VJ (45 cm), sprint 60 m and 100 m, Fm, V, t (for each leg)	CMJ diff between groups (p=0.05), in V (elite: 3.23 m/s, national: 2.94 m/s), H, vertical V, Fm during concentric phase (elite: 123.91 Ns; national: 108.06 Ns). Differences SJ between groups for V for eccentric and concentric phase (concentric-elite: 3.18 m/s, national: 2.87 m/s; eccentric-elite: 3.05 m/s, national: 2.81 m/s).
8	***Markstrom & Olsson (2013)***	22	M=16 F=6	20	Athletics (sprint, throwing and jumping disciplines)	3-4 attempts CMJ, SJ, DJ, DJ (one leg), 60 m sprint, Fm, V, P	↕ diff between sprinters and throwers SJ: 41.73±1.79 cm and 32.85±2.02 cm, and CMJ: 44.70±1.77 cm and 35.17±2.38 cm. ↕ Sprinters and jumpers, V=0.98, F(1, 8)=5.19, p=0.05. DJ PF/body weight-sprinters ↑ in DJ PF/body weight than jumpers (M=96.65, SE=7.91; M=77.65, SE=5.89, respectively), t(8)=1.93, p=0.05 (0.09), with a large effect size r=0.56. ↕ between sprinters and throwers V= 0.87, F(4, 7)=3.69, p=0.112.
9	***Petrović et al. (2012)***	60	M=60	15	Athletics 20, Football 20, Basketball 20	2 groups, CMJ, SJ, Fm, P	Diff in SJ between Athletics: 69.4±4.8 cm, Basketball: 58.6±4.7 cm and Football: 44.6±5.5 cm (p=0.00), and in CMJ: 61.9±5.3 cm, 55.6±8.5 cm, and 40.7±5.2 cm (p=0.00), respectively.
10	***Lima et al. (2011)***	10	M=10	18-23	Athletics (sprint disciplines)	2 attempts, CMJ, VJ, DJ(75 cm), sprint 50 m	Diff between groups for ↓sprint 50 m –1.4% to –2.4% ($p<0.05$), for ↑CMJ +5.5% (45.8 cm and 43.4 cm; $p<0.01$).
11	***González-Badillo & Marques (2010)***	48	M=48	18-28	Athletics (sprint and jump disciplines)	3 attempts, CMJ, V, Fm, and P (in each phase)	In all athletes CMJ height presented significant relations with both eccentric and concentric r between CMJ and Pmax during concentric (r=0.812–0.851) and Mean P (r=0.829–0.870). V with CMJ (r=0.57–0.65).
12	***Cormie et al. (2009)***	30	M=30	18-23	Athletics 18 and American football 12	2 attempts (2 groups), CMJ, 1RSq, V and Fm, a, P	Athletics ↑ in all parameters in relation to football players, for P=90.6% and 99.8, Fm 95.0% and 98.0% and, a=77.0% and 78.0% in relation with t (p=0.05). Diff for CMJ for max P from 29.2% to 54.6% and 60.4% to 97.4%, max Fm to 16.6%, 32.2% to 62.0%, and 70.8% to 81.4%; a from 15.2% to 39.6% and 57.2% to 78.8% in relation t.
13	***Ebben et al. (2009)***	23	M=13 F=10	19-28	Athletics (sprint, jumping and throwing disciplines)	3 attempts. CMJ (one leg) V, t, Fm, P	H diff between two and one leg jumps ($p<0.01$). ↑ Fm and P in right in relation to left leg ($p<0.01$). P in right 45.3%, in left leg 46.7% during CMJ. Diff H in all jumps by gender ($p<0.01$).
14	***Kyriazis et al. (2009)***	9	M=9	22-30	Athletics (throwing disciplines)	9 attempts CMJ (2 different load weights), 1RSq, t, Fm, P	↑1RSq 6.5±6% (p=0.025) P and t for CMJ without load ↑ for 9.0±9% and 7.0±8%. Sport performances ↑ and r with P for CMJ no load (r=0.66, p=0.05), with 20 kg (r=0.67, p=0.05) and with load 30% from 1RSq (r=0.70, p=0.05).
15	***Nuzzo et al. (2008)***	13	M=13	18-21	Athletics 7 Football 6	2 attempts (2 groups), CMJ, V, Fm, P, 1RSq and clean	ISO and Fm for 1RSq, 1RSq and clean are connected (p=0.05) with CMJ and Fm (r=0.639, 0.791 and 0.840). r for 1RSq and CMJ Fm, V and H are positive (r=0.676, 0.731, 0.690). Same for max clean (r=0.706, 0.698 and 0.642). r for mean load clean and H CMJ is (r=0.588). r for CMJ V and Fm for H in CMJ are also positive (r=0.826 and 0.726).
16	***Rousanoglo***	41	F=41	15-19	Athletics (jump	3 attempts	DP in 9 diff knee angles in r with H and P from SJ and CMJ

	u et al. (2008)				disciplines 20) Volleyball 21	CMJ, SJ, DP	(p=0.05) r>0.80). Volley r in knee angle 40˚ to 90˚ for CMJ, H and SJ for P. Athletics, diff between P and H CMJ and SJ.
17	***Vescovi & Mcguigan (2008)***	214	M=F	15-22	Football 134, lacrosse 79 and Athletics 1	2 attempts (3 groups), CMJ, sprint 30m, agility	↕ between sports for CMJ, sprint and agility r between H, CMJ and t sprint (r=-0.532 to -0.778). r for longer sprint tests (20 m and 30 m) in relation to short ones (10 m and 20 m) (r=-0.658 to -0.788). Agility r with t sprint (r=0.6).
18	***Weber et al. (2008)***	12	M=12	18-22	Athletics (sprint 7 and jumping disciplines 5)	5 attempts SJ, Fm, 1RSq	↑Mean H for 1RSq (before 41.6±5.3 cm; after: 43.9±5.1 cm) ↓ SJ (before: 42.7±5.8 cm; after: 41.4±5.1 cm). ↑ Mean Fm (before: 1867.6±259.7 N; after: 1942.2±316.1 N).
19	***Ebben et al. (2007)***	45	M=24 F=21	18-22	Athletics (sprint and jump disciplines)	3 attempts CMJ, T, Fm	Mean H 52.78±9.87 cm and 38.61±6.74 cm for M and F. Mean t 413.91±84.71 ms and 468.14±114.59 ms, for M and F. Mean Fm 5038.39±1592.13 Ns and 4118.89±2184.03 Ns, for M and F. r between Fm CMJ and CMJ H (r=0.19, p=0.22), and Tm (r=-0.33, p=0.03).
20	***Kollias et al. (2004)***	138	M=138	18-29	Athletics 37, Football 18, Volleyball 24, Handball 29, Basketball 20 and Rowing 10	3 attempts (6 groups), CMJ, Drop jump (60cm), t, Fm, P	Diff between sports in CMJ (p=0.001) for H and Fm, P. ↑Athletics Fm and P in relation of all others and for drop jump are mixed (60 cm), p=0.01. Athletics ↓t and impulse. For drop jump (60 cm) negative r for Fm, t, P, H (r=-0.400 to -0.813, p=0.001). P and t (r=0.593, p=0.001), P (r=-0.430, p=0.001). Volleyball players have highest H (p=0.001) in relation to all others sports.

Legend: n– Subject number, **M-** Male, **F-** Female,**CMJ-** Countermovement Jump, **SJ–** Squat jump, **VJ–** Vertical jump, **XS–** Standing long jump, **1RSq–** One rep squat, **r–** Correlation, **V-** Velocity, **Fm–** Muscle force, **P–** Power, **H–** Jump height, **AS–** Asymmetry, **ES-** Effect size, **ISO–** Isokinetic muscle strength, **Diff–** Differences, **DP–** Dynamic power, **a–** Acceleration, **EMG–** Electromyography, **CI–** Confidence interval, **OR-** Odds; **f–** Factor; **p–** Statistical significance, **↑-** Statistical significant increase, **↓-** Statistical significant decrease, **↕-** No differences.

DISCUSSION

Of the 578 studies, through elimination and selection based on inclusion and exclusion criteria, 20 studies were selected. From all 20 studies there is 3232 subjects in total and the range of number of study subjects goes from 6 to 1577, while all studies examined athletes using tensiometer platforms. Nine studies (Kollias, Panoutsakopoulos, & Papaiakovou, 2004; Nuzzo, McBride, Cormie, & McCaulley, 2008; Rousanoglou, Georgiadis, & Boudolos, 2008; Vescovi, & Mcguigan, 2008; Cormie, McBride, & McCaulley, 2009; Petrović, Mihajlović, Smajić, & Đinić, 2012; Sole, Mizuguchi, Sato, Moir, & Stone, 2018; Haugen, Breitschädel, Wiig, & Seiler, 2020; Kozinc, Žitnik, Smajla, & Šarabon, 2021) compared the explosive state in relation to 45 different sports. Ten studies analyzed only athletics (Ebben, Flanagan, & Jensen, 2007; Weber, Brown, Coburn, & Zinder, 2008; Ebben, Flanagan, & Jensen, 2009; Kyriazis, Terzis, Boudolos, & Georgiadis, 2009; Lima, Marin, Barquilha, Da Silva, Puggina, Pithon-Curi, & Hirabara, 2011; Coh & Mackala 2013; Markstrom & Olsson 2013; Čoh & Smajlović, 2015; Loturco, D'Angelo, Fernandes, Gil, Kobal, Abad, & Nakamura, 2015; Douglas, Pearson, Ross, & McGuigan, 2018;). Four studies investigated gender differences in explosive strength (Ebben et al., 2007; Sole et al., 2018; Haugen et al., 2020; Kozinc et al., 2021), and two studies investigated changes after training program (González-Badillo & Marques 2010; Lima et al., 2011).

A study by Coh & Mackala (2013) analysed 12 sprinters with CMJ on a tensiometer platform and their impact on the 100 m sprint performance between the two groups of subjects. In the first group were elite sprinters, while in the test group of the athletes were of national rank. The results showed detailed data on the explosive strength of the lower extremities in both groups, the difference between the groups was found (p=0.05). At the reaction speed during CMJ, the elite sprinters had 3.23 m/s, while the test group had a lower value of 2.94 m/s. Also, the results in the high jump showed the difference between the groups (3.18 m/s and 2.87 m/s, respectively). Predictive parameters that reflect the possibility of the sprinter's progress at 100 m were obtained by estimating the difference in the explosive strength of the muscles of the lower extremities from the tests that were analyzed. Slightly different study that used same subjects and only different test for assessment (DJ of 45 cm) is that done by Čoh & Smajlović (2015). Authors investigated kinetic parameters and differences between two level of sprinters and presented significant results for DJ (45mcm) height of 54.76±5.34 cm compare to 46.02±5.95 cm, difference of 8.7 cm, $p<0.05$, for takeoff velocity 3.18±0.15 m/s, compared to 2.87±0.24 m/s, $p<0.05$, and eccentric velocity 3.05±0.11 m/s, compared to 2.81±0.07 m/s, $p<0.05$. González-Badillo & Marques (2010) investigated relation between kinetic factors during each phase in CMJ in Athletics. They found high correlation values between the force produced during the concentric and eccentric phases with the height of all CMJ tests. According to the obtained results, there is a tendency of suggesting that the higher the velocity in the

eccentric phase, the higher jump height will be, provided that the velocity is within the specified range (−0.8 m/s and −2.2 m/s). Namely, the maximum negative velocity can also be a good predictor of CMJ performance. Positive correlation (r=0.54-0.65, p=0.000), indicates that those subjects who achieve a higher negative velocity will tend to jump higher.

Differences between sports and the relationship of different tests for the assessment of explosive power on sports performance was performed in the research work of the authors Vescovi & Mcguigan (2008). The subjects were from lacrosse, athletics and football. By means of tensiometer platform the authors investigated the values of CMJ and SJ in addition the values of the 30 m sprint test and the agility test. The results show that there is no statistical difference in the values of the test results analyzed in the study between sports for CMJ, sprint and agility. The correlation between CMJ jump height and sprint test time in all subjects has statistical significance (r=-0.53 to -0.78). Also, this correlation increases with increasing of sprint distance (20 m and 30 m) than with shorter ones (10 m and 20 m): r=-0.66 to -0.79. Agility test results are related to sprint test time (r=0.60).

The testing of the difference between the correlation of explosive power and the jump height between female volleyball players and female athletes was performed through the analysis of dynamic power assessment tests in nine different knee angles (Rousanoglou et al., 2008). A total of 20 female jumpers and 21 female volleyball players performed CMJ and SJ where muscle strength was measured on a tensiometer platform. The results showed that there was no difference in the correlation coefficients: r=.44 and r=.433, p=0.05. Volleyball players show strong correlation (r=0.80) with muscle strength in knee angle 40˚ to 90˚ for CMJ and SJ.

One study (Kollias, Panoutsakopoulos, & Papaiakovou, 2004) compared the explosive strength of lower extremities in Athletics to other sports, such as football, volleyball, handball, basketball, and rowing. Authors found that there is a statistically significant difference between groups of athletes in the value of the CMJ test results (p=0.001) for jump height, maximum force and strength during the jump. Athletes create greater strength and power while jumping, than all other subjects that were analyzed. However, these parameters differ from the values of the DJ (60 cm): p=0.01. Athletes need less time at the moment of impulse and less amortization time compared to others. When performing DJ (60 cm) there is a negative correlation for force, reaction time, strength and jump height (r=-0.40 to -0.81, p=0.001). Power and time for jump height are also correlated (r=0.59, p=0.001), as well as power (r=-0.43, p=0.001). Volleyball players, in fact, have highest values for jump height from CMJ and DJ (60 cm) (p=0.001) compared to all groups. Similar finding was noticed between athletes (n=20), basketball players (n=20) and football players (n=20) in explosive strength measured with SJ and CMJ (p=0.00), (Petrović, Mihajlović, Smajić, & Đinić, 2012). Results for SJ were: 44.6±5.5 cm (football players), 58.6±4.7 cm (basketball players) to 69.4±4.8 cm (athletes). For CMJ: 40.7±5.2 cm (football players), 55.6±8.5 cm (basketball players), to 61.9±5.3 cm (athletes). Study that had most of subjects (n=1577), from 44 different sports was study realized by Haugen et al. (2020). From six attempts of CMJ they obtained results that clearly show differences in explosive strength by sport in favor of athletics disciplines. Largest range of the subjects are from national level up to World and Olympic Games finalists. Gender differences by CMJ are for strength and power sport athletes (51.9±6.9 cm and 39.6±5.1 cm for men and women, respectively), team sports (mean diff, ±90%CL for men and women: 9.7±1.2 cm and 8.5±1.0 cm), downhill winter sports (9.8±1.4 cm and 6.7±1.3 cm), combat sports (12.3±1.3 cm and 11.2±1.3 cm), endurance sports (15.8±1.4 cm and 11.6±1.3 cm) and precision sports (16.9±1.8 cm and 15.2±2.1 cm). The highest value of CMJ was in sprinters and jumpers (men: 62.7±4.8 cm, women: 48.4±6.0 cm), and lowest in orienteering (men: 30.4±3.8 cm, women: 22.8±5.7 cm). Similar findings for CMJ values were noted in study of Haugen et al. (2020): for men in Athletics (43.57±5.93 cm), in dance (36.96±5.41 cm) and volleyball (35.73±8.36 cm), and for women in Athletics also (31.65±3.52 cm), karate (28.11±4.23 cm) and speed skating (26.85±3.00 cm), p=0.003, η^2=0.03, interaction gender and sport. The highest mean value of SJ were in the following sports when speaking about men: Athletics- 39.51±5.09 cm, volleyball-33.07±7.79 cm and dance 33.03±5.49 cm, and in case of women: Athletics- 29.94±5.00 cm, karate 26.08±4.08 cm and speed skating 24.50±2.48 cm (p=0.007, η^2=0.03, interaction gender and sport). Most of the movements in Athletics are actually different variations in the development of (explosive) power, which explains why athletes showed the best results in all variables, not only in terms of absolute values, but also in relative values of different jump tests, taking into account that these activities are performed daily during the training process (Petrović et al., 2012).

Differences between athletes and American football players in explosive power values before and after the training cycle were made in the study of Cormie et al. (2009). The authors analyzed 18 male athletes and 12 male football players. Athletes show an increase in all measured kinetic parameters in relation to American football players, for strength 90.6% and 99.8, force 95.0% and 98.0% and, a=77.0% and 78.0% in relation to normalized time during CMJ (p=0.05). The differences in CMJ for maximum

strength ranged from 29.2% to 54.6% and 60.4% to 97.4%; for maximum force from 16.6%, 32.2% to 62.0%, and 70.8% to 81.4%; from 15.2% to 39.6% and 57.2% to 78.8% in relation to normalized time. A similar study of training load and DJ from a height of 75 cm, between 10 sprinters, was conducted (Lima et al., 2011). Differences between muscle performance and jump height after training between groups for sprint time on 50 m show significant decrease (from –1.4% to –2.4%, $p<0.05$), and for CMJ height significant increase of +5.5% (45.8 cm and 43.4 cm, $p<0.01$). In study of Weber et al. (2008), authors examined effects of pre- and post-workout load on the explosive power of athletes and sports performance. Seven sprinters and five jumpers participated in this study. Results show an increase in mean jump height for squat load program (before program: 41.6±5.3cm, after program: 43.9±5.1 cm). Contradictory results are found only in case of SJ: before program 42.7±5.8 cm and after 41.4±5.1cm. The increase in mean muscle force before the program was 1867.6±259.7 N and after the program 1942.2±316.1 N, for all subjects.

One study (Ebben et al., 2007) analyzed gender differences, in the rate of force development and time to takeoff during CMJ, and was conducted by calculating the percentage of progress before and after the training cycle. Male athletes (24) and female athletes (21) performed CMJ jumps on the tensiometer platform. No statistically significant differences were found between men and women for the time to takeoff ($p=0.08$) or for the rate of force development ($p=0.11$). Mean time to takeoff values were 413.91±84.71 ms (men) and 468.14±114.59 ms (women). The mean rate of force development values was 5038.39±1592.13 Ns (men) and 4118.89±2184.03 Ns (women). The rate of force development was not correlated to CMJ ($r=0.19$, $p=0.22$), although time to takeoff was ($r=-0.33$, $p=0.03$). Results indicate that women can jump just as quickly as men and develop force at a rate that is similar to men. Similar study that compared phase characteristics, force-time between different athletes was Sole, Mizuguchi, Sato, Moir, & Stone (2018). Three mixed groups show mean results for CMJ in case of men: 47.4±4.4 cm (first group), 36.4±1.5 cm (second group), and 28.4±2.4 cm (third group); and for women: 36.0±2.1 cm (first group), 27.5±0.9 cm (second group), and 19.7±2.3 cm (third group). It was found that better jumping is associated with higher phase pulse and magnitude. In addition to the larger phase magnitude, the better jumpers also maintained a higher relative force during the first phase of the net pulse/propulsion acceleration, which in turn produced a higher total pulse. The primary difference between men and women was related to the rate and magnitude of relative force production during the phases involving peak eccentric and concentric force production. Gender differences have been observed and are assumed to be the result of differences in relative strength and capacity to produce force. Interestingly, the duration of the phase was similar between groups as well as between men and women, suggesting that this characteristic is of little importance for jump height.

CONCLUSION

It can be concluded that athletes from sprint and jumping disciplines have a highest explosive strength value measured during CMJ jumping, while among team sports dominance belongs to volleyball (beach volleyball) players. Each type of training has a positive effect on contact performance in the form of a vertical test jump- CMJ, while load training negatively affects the jump height in the squat jump. There are no gender differences in athletes when reaching the maximum value of kinetic parameters.

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ANALYSIS OF SHOT SUCCESS INDICATORS AMONG FEMALE BASKETBALL PLAYERS

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ABSTRACT

More complex methods in the indicators of success analysis in the game bring a larger number of data whose systematization and analysis is a necessary prerequisite for a successful team scouting. Thus, conditions are created for gaining an advantage in terms of adequate technical and tactical preparation of opposing teams. The aim of the research is to analyze the indicators of shot success in the most efficient basketball players and determine the difference between them. A total of 2838 shot indicators were analyzed with the use of non-parametric and parametric statistics. The type of movement before the shot, the type of shot, the period of the game when shooting, the distance from which the shot is performed and the outcome of the shot were analyzed. Chi-square test and ANOVA method was used for determining the differences in shot success indicators between top ten female basketball players. Also, the post hoc and z-test analysis for comparing the differences among specific pairs of players were conducted. With the use of Chi-square test and ANOVA method, the results showed statistically significant differences among the players with the p-level of ($p \leq 0.05$). The players differentiated in the type of movement before the shot ($p=0.00$), the type of shot ($p=0.00$), the period of the game when shooting ($p=0.01$), the distance from which the shot is performed ($p=0.00$), except in the outcome of the shot ($p=0.29$). It was found that the players statistically differed in all shot variables except in the shot outcome variable. In variables where statistical difference was found, post hoc and z-tests showed that players who played on center and power forward positions mainly differed from players on guard positions in most of the indicators.

Keywords: scouting, shot variables, position, team sport

INTRODUCTION

The analysis of data related to the basketball game is becoming more popular with the appearance of sites that offer this data (Lorenzo et al., 2019; Lamas et al., 2020). As far as the female population is concerned, there is a small number of papers available compared to the research of the male population of basketball players. However, there are studies that have sought differences not only in the level of competition, but also in gender (Sampaio et al., 2004; Alfonso et al., 2009). Increasingly complex methods in the analysis of indicators of success in the game bring a larger amount of data whose systematization and analysis is a necessary prerequisite for successful scouting of a team. Thus, conditions are created for gaining an advantage in terms of adequate technical and tactical preparation of opposing teams. A number of studies have examined the differences between winning and losing teams (Gomez et al., 2006; Ruano et al., 2007; Conte & Lukonaitiene, 2018), the differences between starting players and bench players (Gomez et al., 2009), differences between successful and unsuccessful teams (Teck et al., 2012), the relationship between physical characteristics and statistics (Fort-Vanmeerhaeghe et al., 2016), and others. Some authors (Cui et al., 2019) sought key anthropometric and physical determinants for different positions in the game. The behavior of young winning teams (Veleirinho & Tavares, 2013), in terms of increasing the line distance by three points, was also analyzed based on game statistics. The effectiveness of ball possession was assessed depending on the period of play (Gomez et al., 2013), while the efficiency of free throws proved to be significant with the position and experience of the players (Ibanez et al., 2015). Competitive experience in seniors made a better difference compared to juniors (Kalen et al., 2017). Other authors have concluded that there is a large association between sleep and the efficiency of players (EFF) (Staunton et al., 2017). The high probability of winning and losing matches is justified by game-related indicators (Leicht et al., 2017). Championships in Asia and Europe have similar game

profiles for seniors (Madarame, 2018b) as for juniors (Madarame, 2018a). In a study of Gasperi et al. (2020), the results showed that foreign players performed better in line with team ability and playing position for the majority of performance indicators. The effect of age has been examined in relation to the physical and technical performance of NBA players (Kalen et al., 2021). The explanation of the difference in the technical performance of the players in relation to the playing position was given by the authors based on 471 matches (Zhai et al., 2021). Furthermore, the aim of this research is to analyze the indicators of shot success in the most efficient basketball players and determine the differences between them. The subject of this research are statistical indicators of the success of basketball shots among female basketball players in the highest quality basketball league in the world. The problem of the research is gaining adequate conclusions about the differences in the parameters of the performance indicators in a shot in relation to the most efficient basketball players.

METHODS

Subjects

The sample of respondents are the ten most efficient female basketball players ranked according to the total number of points scored in the 2020 season (the official website of the Women's National Basketball Association - WNBA). Data from the previous season (Body Mass: 76.6±8.7 kg, Body Height: 183.8±7.9 cm) were used in the analysis of shots of the ten most efficient basketball players.

Procedure

Data from the official website of the WNBA (*https://stats.wnba.com/*) were extracted and used in this research. The following shot success indicators were used for the variable sample: type of movement before the shot (layup, driving layup, jump shot, turnaround jump shot, pull up jump shot); shot outcome (hit, miss); type of shot (for two points, for three points); game period when shooting (1^{st}, 2^{nd}, 3^{rd}, 4^{th}); shot distance (meters).

Statistical analysis

Differences in shot success indicators were examined by an ANOVA method and the Chi-square test, also a z-test for comparing columns and post-hoc analysis. The statistical package SPSS, version 24.0, was used for statistical analysis.

RESULTS

This chapter presents the results of the research in relation to shot success indicators. For each indicator and its category, the realized value of the Chi-square test and the significance of the test are shown. In situations where a significant difference was registered, the results of the z-test were also presented, in which the differences of individual pairs of players were examined.

Based on the Chi-square test whose value is 356.1, it can be concluded that the p value is less than the significance threshold ($p \leq 0.05$) and that the most efficient basketball players differ statistically significant by the type of movement before the shot.

Within the chi-square test, z-test was performed in order to compare individual pairs of players as an additional statistical analysis, that clarifies between which basketball players there is a statistically significant difference in a certain type of movement before the shot.

Table 1. Crosstabulation data of type of movement before shot

Crosstab

			PLAYER										Total
			Wilson	Ogunbowale	Laney	Stewart	Bonner	Taurasi	Mitchell	Hines-Allen	Collier	Diggins-Smith	
TYPE OF MOVEMENT BEFORE THE SHOT	layup	Count	73a, b	52c	57a, b, d, e, f	86c, e, f	73a, b	7g	45c, d, f	82h	59b, h	48a, d, e, f	582
		% within PLAYER	26,0%	14,0%	21,8%	18,1%	24,3%	3,2%	16,5%	37,1%	29,4%	20,5%	20,5%
	driving layup	Count	14a, b	44c	23b, c	16a	40c	9a	32c	12a, b	8a	28c	226
		% within PLAYER	5,0%	11,9%	8,8%	3,4%	13,3%	4,1%	11,8%	5,4%	4,0%	12,0%	8,0%
	jump shot	Count	139a	184a	155b, c	310c, d	156a, b, e	157d	160b, c, e	106a	109a, b, e	118a, e	1594
		% within PLAYER	49,5%	49,6%	59,4%	65,1%	51,8%	71,4%	58,8%	48,0%	54,2%	50,4%	56,2%
	turnaround jump shot	Count	30a	2b, c	4c, d	22e, f	8d, f	3b, c, d	0b	16a, e	15a, e	2b, c, d	102
		% within PLAYER	10,7%	0,5%	1,5%	4,6%	2,7%	1,4%	0,0%	7,2%	7,5%	0,9%	3,6%
	pull up jump shot	Count	25a, b	89c	22a, b	42a, b	24a, b	44c, d	35b, e	5f	10a, f	38d, e	334
		% within PLAYER	8,9%	24,0%	8,4%	8,8%	8,0%	20,0%	12,9%	2,3%	5,0%	16,2%	11,8%
Total		Count	281	371	261	476	301	220	272	221	201	234	2838
		% within PLAYER	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Each subscript letter denotes a subset of PLAYER categories whose column proportions do not differ significantly from each other at the ,05 level.

The obtained Chi-square test result for the shot type variable is 371.6. In addition, the obtained p value of 0.000 which indicates that there is a statistically significant difference between the most efficient basketball players by the type of shot.

Table 2. Crosstabulation data of type of shot

Crosstab

			PLAYER										Total
			Wilson	Ogunbowale	Laney	Stewart	Bonner	Taurasi	Mitchell	Hines-Allen	Collier	Diggins-Smith	
TYPE OF SHOT	two point shot	Count	281a	233b	189c, d	294b	198b, d	59e	131f	164c	154c	119f	1822
		% within PLAYER	100,0%	62,8%	72,4%	61,8%	65,8%	26,8%	48,2%	74,2%	76,6%	50,9%	64,2%
	three point shot	Count	0a	138b	72c, d	182b	103b, d	161e	141f	57c	47c	115f	1016
		% within PLAYER	0,0%	37,2%	27,6%	38,2%	34,2%	73,2%	51,8%	25,8%	23,4%	49,1%	35,8%
Total		Count	281	371	261	476	301	220	272	221	201	234	2838
		% within PLAYER	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Each subscript letter denotes a subset of PLAYER categories whose column proportions do not differ significantly from each other at the ,05 level.

The result of the Chi-square test for the variable period of the game when shooting shows a value of 46.5. Results also shows a significance at the level of 0.011, which is less than the significance threshold ($p \leq 0.05$), thus indicating a statistically significant difference in which period of the game basketball players decide to shoot at the basket.

Table 3. Crosstabulation data of game period when shooting

Crosstab

			PLAYER										Total
			Wilson	Ogunbowale	Laney	Stewart	Bonner	Taurasi	Mitchell	Hines-Allen	Collier	Diggins-Smith	
GAME PERIOD WHEN SHOOTING	first quarter	Count	90a	92b, c, d, e	83a, d, e	144a, c, e	72b, c	60a, b, c, d, e	64b	52b, c	56a, b, c, d, e	77a	790
		% within PLAYER	32,0%	24,8%	31,8%	30,3%	23,9%	27,3%	23,5%	23,5%	27,9%	32,9%	27,8%
	second quarter	Count	60a	75a	60a	116a	64a	52a	60a	56a	47a	44a	634
		% within PLAYER	21,4%	20,2%	23,0%	24,4%	21,3%	23,6%	22,1%	25,3%	23,4%	18,8%	22,3%
	third quarter	Count	64a, b	85b	59a, b	136a, b	90a	53a, b	75a, b	61a, b	52a, b	60a, b	735
		% within PLAYER	22,8%	22,9%	22,6%	28,6%	29,9%	24,1%	27,6%	27,6%	25,9%	25,6%	25,9%
	forth quarter	Count	67a	119b	59a, c	80c	75a	55a, b	73a, b	52a	46a, c	53a, c	679
		% within PLAYER	23,8%	32,1%	22,6%	16,8%	24,9%	25,0%	26,8%	23,5%	22,9%	22,6%	23,9%
Total		Count	281	371	261	476	301	220	272	221	201	234	2838
		% within PLAYER	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Each subscript letter denotes a subset of PLAYER categories whose column proportions do not differ significantly from each other at the ,05 level.

Regarding the shot outcome, there has been no statistically significant difference among the basketball players, the result of the chi-square test being 10.697, which gave a significant value of 0.297.

DISCUSSION

Basketball element layup indicates that the two basketball players (M.H.-A., D.T.) statistically significant differ from the rest of the basketball players, as well as that there is a significant difference between these two basketball players, as shown in Table 1. M.H.-A. plays in the position of power forward (PF) and her total of shots from the layup is 82, while D.T. has the role of a playmaker and her shots from the layup make only seven attempts. From this pair of basketball players it can be concluded that the player who plays in the position of PF mostly decides to realize their shots under the basket by layup without dribbling. The element of driving layup indicates a statistically significant difference between the group of basketball players consisting of A.W., B.S., D.T. and N.C., and the group consisting of A.O., B.L., D.B., K.M. and S.D.-S. The first group of basketball players has a significantly lower number of shots by driving layups, which is expected since each basketball player in this group is a tall player, in the positions of PFs. The exception in this group is D.T. who has the role of point guard (PG) and shooting guard (SG), and the reason why she decides for a different realization of the game is probably her age (39). On the

other hand, the second group of basketball players has a significantly higher number of driving layups, since all players from this group play in the positions of PGs and SGs. In Table 1 of the contingency, the element of jump shot shows that the basketball players A.W., A.O., D.B., M.H.-A., N.C., S.D.-S. do not differ statistically significant, i.e. they have an approximately similar percentage of realizations at the basket with a jump shot in relation to the total attempt. A statistically significant difference between the basketball players is attributed to D.T., where 71.4% of her shots at the basket ended with the element of a jump shot. In Table 1 we can also see a significant difference in a few of the basketball players when it comes to the turnaround jump shot. Players A.W., M.H.-A. and N.C. have had statistically significant more attempts to realize this technique than other basketball players, which is expected since they are characterized by playing in low post positions, where jump shot after turn is one of the more dominant elements. In the last row of Table 1, the element of realization at the basket with pull up jump shot indicates that basketball players who play center positions do not differ statistically significant, as well as that they are statistically significant different from basketball players who play in positions of guards, and have a smaller percentage of attempts of pull up jump shots. These results confirm the theoretical expectations, assuming that high players due to their anthropometric characteristics, lack of self-confidence in dribbling a ball, and lack of dribbling practice, do not decide to finish on the basket using pull up jump shot technique.

The type of shot variable indicates that there are statistically significant differences for the two-point shot, as well as for the three-point shot. Table 2 displays the players that differentiate from other players and the pairs of players that differentiate among each other. D.T. is the basketball player with the highest number of attempts for three points, as many as 161 shots for three points, i.e. 73.2% of the total number of shots for two and three points. Therefore, D.T. statistically significant differs from the rest of the basketball players in the table. The assumption for the obtained results regarding D.T. in the analysis of contingencies for the most efficient basketball players and the type of shot she decides on is her age. She is the oldest player and probably, due to her age and experience, she decides to shoot outside the line for three points and to play a game that is based on a greater distance from the paint. On the other hand, basketball players K.M. and S.D.-S. do not differ statistically significant. Their attempts for two and three points are almost indistinguishable, with K.M.'s 48.2% for two and 51.8% for three points, and S.D.-S.'s 50.9% for two and 49.1% for three points. The results obtained by contingency analysis indicate that players K.M. and S.D.-S. are versatile players in terms of the type of shot and that they both equally decide on shots for two and three points. In Table 2, another unique example can be noticed regarding player A.W. Namely, there has not been recorded a single three-point shot attempt out of A.W.'s total number of shots (281).

The fourth quarter indicates a statistically significant difference between one basketball player and the other basketball players. Namely, A.O. marked with the index letter 'c' in Table 3, significantly differs from other basketball players and has the most attempts in shooting towards the basket in the last quarter. In this sample of respondents, there are players who are older than A.O. and have a statistically significant lower number of attempts in shooting at the basket in the last quarter, which denies the theory that older basketball players have a significantly higher number of shots in the last quarter as the most experienced players in the team.

CONCLUSION

Based on the conducted research, by using the specific data collected from the official website of WNBA, it can be concluded that most efficient female basketball players during season 2020 statistically differ in the majority of shot success indicators, such as the type of movement before shot, type of shot, period of game when shooting and shooting distance. However, there were not found statistically significant differences in shot outcome. The obtained results can be mainly attributed to anthropometric characteristics and age of the players. Thus, the finding may use as a guideline for basketball coaches to improve their players' skills on the court in difference game situations.

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BODY COMPOSITION AND MOTOR ABILITIES OF BASKETBALL PLAYERS

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ABSTRACT

Basketball is a popular sport, and the fundament of that popularity is based on pronounced attractiveness, game dynamics, and unpredictability. Often the game itself requires a lot of short sprints and a lot of changes in the movement direction in a small space. In addition to good motor skills, for players to satisfy all the requirements of a modern game, it is necessary to have a particular body composition that can contribute to the game one-on-one. This study aimed to determine the relationes of body composition and certain motor abilities of basketball players. A total of 25 basketball players participated in the research. Agility assessment was carried out by the following tests: T-test, Zig-zag test, and Slalom test. For speed assessment, running speed was measured at 5, 10, and 20 meters. Body height, body mass, Body Mass Index, percentage of muscle tissue, and percentage of adipose tissue were measured (calculated) for the body composition assessment. The Kolmogorov-Smirnov test was conducted to confirm the data's distribution normality. The relationship between body composition and motor abilities was assessed using Pearson's coefficient of correlation. We can conclude from the results obtained, that there is a statistically significant correlation between body composition and motor abilities. Statistically significant negative correlation was achieved between percentage of muscle tissue and following tests: Zig-zag (p=0.008), Slalom test (p=0.000) and running speed tests at 5m (p=0.000) and 10m (p=0.000). The percentage of adipose tissue was positively related to T-test (p=0.007) and Slalom test (p=0.018). A positive correlation was also found between the percentage of adipose tissue and the running speed tests at 5m (p=0.003) and 20m (p=0.005). BMI achieved a statistically significant positive correlation only with the T-test (p=0.006). The percentage of body fat and body mass index adversely affects the results of agility. Consequently, we can improve the player's skills by improving body composition. The results emphasize the importance of muscle development because the percentage of muscle mass improves agility and speed results in basketball players.

Keywords: muscles, correlation, strength, speed, agility

INTRODUCTION

Certain sports have their specific morphological characteristics on which success in competition often depends (Malina et al., 2004). Basketball represents a very popular team sport and its popularity is based on expressed attractiveness, game dynamics, and unpredictability. Often the game itself requires a lot of short sprints and numerous changes in the direction of movement in a small space (Castagna et al., 2009). Nowadays, science strives to improve the motor abilities of players and achieve an ideal body composition. This process is complex due to the different requirements that basketball has. Anthropometry has a significant place in the selection of basketball players in addition to these characteristics- other factors that affect the selection of basketball players (Carter et al., 2005).

Due to all the above, basketball training is full of exercises during which players change the direction and speed of movement (Young & Farrow, 2006). In order for players to satisfy all the requirements of a modern game, in addition to good motor skills, they need to have a certain body composition that can contribute to the game one-on-one, without compromising the level of certain motor skills. In addition to good running performances and agility, body height and weight also play an important role and advantage over other players. In addition to the benefits of body composition, it is necessary to determine the best proportion of muscle mass and the amount of fat in the body. Previous research has included respondents of various ages, fitness, and sports status. One of the crucial things in determining the position of players is the height (Dežman, Trninić, & Dizdar 2001). Positions of center and small forward

are usually reserved for higher players, while the position of point guard is reserved for the players who are lower in growth compared to center (Ostojic, Mazic, & Dikic, 2006). Gryko, et al. (2018) determined that the assessment of body composition can be one of the key factors for success in the basketball game. From all the above, it can be concluded that body composition and motor abilities are interrelated. The importance of research is reflected in the fact that it provides information on the body composition and motor skills of basketball players. The similarities in the body composition of basketball players were determined and the motor abilities related to basketball were investigated. The aim of this study was to determine the influence of body composition on the motor abilities of basketball players.

METHODS

Subjects

The research involved 25 basketball players with an average age of 13 years, and average sports experience of four years. All subjects were clinically healthy prior the testing and voluntarily agreed to it (a parental consent was obtained for each of the 13 respondent).

Procedure

Testing was done in the afternoon in bright and spacious basketball hall, with an average temperature of 21°C: firstly anthropometric measurements, and then motor skills testing. After 20-minute warmup, which included different runs with a change of direction, exercises with an increasing range of motion and strengthening the locomotor system, the basketball players were tested. Body height (BH) was measured with Martin's anthropometer GPM 101 (GPM GmbH Switzerland), with an accuracy of 0.1 cm. Respondents' Body composition, i.e. body mass (BM), body mass index (BMI), percentage of body fat (BF), and percentage of muscle mass (MM), were measured using the bioelectric impedance device- Omron BF511 (Kyoto, Japan) with an accuracy of 0.1 kg, 0.1 kg/m^2, 0.1% and 0.1%, respectively. The reliability and validity of the Omron BF511 bioelectric impedance have been confirmed by Dehghan & Merchant (2008). The running speed (sprint) was estimated on the basis of a straight run of 20 m with passing times of 5, 10, and 20 m on the floor, by using Witty photocell gates (Microgate, Italy) with gates positioned at the starting line, at 5, 10, and 20 m from the starting line with an accuracy of 0.01 s (Madić et al., 2015). Agility was assessed by a T-test, and time, as in straight-line running, is measured with the help of Witty photocell gates (Microgate, Italy) placed at a height of 0.75 cm at the starting line. The test was conducted with an accuracy of 0.01 s (Madić et al., 2015). In the slalom test, the flags are placed at a distance of 2 meters, so that the total distance between the first and last stand is 12 meters. The task is to run for as short a time as possible between the stands, around the last one, and back (slalom running). Task execution time is measured in 0.01 s (Madić et al., 2015). Another measuring instruments applied for measuring players agility was the zig-zag test (Madić et al., 2015).

Statistical analysis

In addition to descriptive statistics (average value- Mean, and standard deviation- SD), the Kolmogorov-Smirnov test was used to test a normality of data distribution. The relationship between body composition and motor abilities was assessed by using Pearson's correlation.

RESULTS AND DISCUSSION

The results of descriptive statistics of body composition and motor abilities are shown in Tables 1 and 2, and values of coefficient of correlation in Table 3.

Table 1. Descriptive statistics of body composition parameters

Variables	Mean±SD
BH(cm)	148.156±13.749
BM (kg)	43.819±10.065
BMI (kg/m²)	19.127±2.765
BF (%)	19.471±7.529
MM (%)	36.212±3.213

Legend: Mean- average value, **SD-** standard deviation, **BH-** body height, **BM-** body mass, **BMI-** body mass index, **BF-** percentage of body fat, **MM-** percentage of muscle mass.

Table 2. Descriptive statistic of applied motor tests

Speed tests	***Mean±SD***
5m	1.270±0.135
10m	2.297±0.332
20m	4.063±0.557
Agility tests	***Mean±SD***
T-test	12.190±2.145
Zig-zag	9.757±2.255
Slalom	8.251±1.168

Legend: Mean- average value, **SD-** standard deviation.

Table 3. Correlation between body composition and motor abilities

		5m	**10m**	**20m**	**T-test**	**Zig-zag**	**Slalom**
BH	*r*	-.678**	-.696**	-.780**	-.373	-.650**	-.659**
	Sig.	0.000*	0.000*	4.180	0.066	0.000*	0.000*
BM	*r*	-.310	-.443*	-.399*	.045	-.519**	-.286
	Sig.	0.130	0.026*	0.047*	0.828	0.007*	0.166
BMI	*r*	.310	.028	.258	.575**	-.112	.205
	Sig.	0.171	0.900	0.257	0.006*	0.630	0.370
BF	*r*	.607**	.356	.581**	.566**	.193	.508*
	Sig.	0.003*	0.112	0.005*	0.007*	0.403	0.018*
MM	*r*	-.688**	-.725**	-.795**	-.341	-.557**	-.733**
	Sig.	0.000*	0.000*	1.640	0.130	0.008*	0.000*

Legend: Mean- average value, **SD-** standard deviation, **BH-** body height, **BM-** body mass, **BMI-** body mass index, **BF-** percentage of body fat, **MM-** percentage of muscle mass.

*p<0.005, **p<0.001

The aim of this study was to determine the correlation of body composition parameters on selected motor abilities (i.e. speed and agility) of basketball players. BH had the highest correlation with two speed tests (5m and 10m), while not statistically significantly correlated with test 20m (Sig.=4.180). Regarding agility tests, the only statistically significant correlation was found with Zig-zag and Slalom test (r= -.650 and r=-.659, respectively). BM was statistically significant correlated with tests 10m and 20m (r=-.443 and r=-.399, respectively), while correlation is missing in the case of running speed at 5m. The zig-zag test was associated with BM (r=-.519, Sig.=0.007), and no statistically significant correlation was found with other agility tests. Similar results were obtained in the study of Köklü, Alemdaroğlu, & Koçak (2010). BMI had a statistically significant correlation only with the ziz-zag test (r=.575, Sig.=0.006), while no statistically significant correlation was found with the other agility tests as well as with the speed tests. On the other hand, a study of Frey & Chow (2006) found a statistically significant association between BMI and running speed (p=0.04).

The amount of fat in the body was statistically significantly related to motor tests, in terms of agility: with T-test and slalom test (p=0.007 and p=0.018, respectively), and in terms of speed: 5m and 20m (p=0.003 and p=0.005, respectively). There was no statistically significant correlation between the zig-zag test and the running speed at 10m. While in the study of Scanlan, Humphries, Tucker, & Dalbo, (2014) the amount of fat was not statistically significant associated with running speeds at 5m, 10m and 20m (p=0.594, p=0.813 and p=0.855, respectively). Statistically significant correlations of MM and ziz-zag (p=0.008), slalom test (p=0.000), so as 5m (p=0.000) and 10m (p=0.000) were noted. No statistically significant correlation was achieved between MM and T-test and 20m test. These results in terms of speed were confirmed in the study of Apostolidis, Nassis, Bolatoglou, & Geladas (2004).

CONCLUSION

From the results obtained in this research it can be concluded that there is a statistically significant correlation of body composition and selected motor abilities in basketball players. Therefore, the percentage of body fat and body mass index adversely affects the results of agility, and by reducing them we can improve the results. The results of this study indicate the importance of muscle development, because the percentage of muscle mass means better results in agility and speed of basketball players. These results have practical importance for physical education teachers and coaches who can use speed and agility tests to monitor progress and determine the physical fitness of students and athletes. These tests are easy to apply and can be used to select athletes. The study limitation is the small sample of young respondents (13-14 years of age), and the fact that these results cannot be generalized to the entire population.

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TEAM ASSOCIATION AND EFFECTIVE COMMUNICATION IN KORFBALL

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ABSTRACT

While there were a certain number of sports branches in the world in previous years and the number of people playing was limited, today there are various sports branches in the world. As the number of sports branches increases, the statistics of being played and watched for each also increase. Thus, every new sport branch finds itself in competition with others and tries to increases its visibility in order to be one of those sports. In this study, korfball, which is one of the developing sports branches, is evaluated in terms of sports management elements. The definition of the branch, its history, the way korfball is played, the field and material knowledge, its social impact, the economy of korfball in the Netherlands, which is the homeland of korfball, were examined. It is seen that korfball is a very popular branch in the Netherlands, where it emerged. In Turkey, korfball is a sport branch in the Emerging Sports Federation and its activities are being carried out. The main purpose of this study is to examine whether there is a gender difference in terms of "effective communication in team sports" and "team unity" in korfball, which is the only sport in which male and female athletes play together. In addition, descriptive analyses were made in terms of age groups, education levels and duration of involvement in korfball. Finally, the effect of "acceptance and positive conflict in effective communication" on team unity was examined with regression analysis. All 250 athletes from 12 korfball clubs in Turkey were reached. Statistical analyses were made with the data set of 133 athletes who responded. As a result, a significant difference was found in terms of gender and duration of interest in korfball sport. In addition, a weak relationship was found in the cause-effect relationship of the association and communication of the korfball players within the team. In this study, which was applied for the first time to korfball players in Turkey, high average values were obtained in terms of team unity and effective communication. In korfball, which is a versatile sport, the gains of the athletes are quite high. According to the results of this study, considering that women's effective communication skills are high, it can be recommended to increase the number of women in sports organizations and teams.

Keywords: korfball, effective communication, team unity, team sports

INTRODUCTION

Korfball was designed by Dutch physical education teacher Nico Brockhuysen in Sweden in 1902. Playing this game in physical education classes has increased the speed of its spread. The Dutch Korfball Association was founded in 1903. In 1933, the International Korfball Federation was established, making it an official branch. Korfball is currently played in 69 countries on five continents. There are more than 100,000 korfball players in about 580 sports clubs in the Netherlands. These figures show that korfball has a place in the country's sports economy. The Netherlands is followed by China and Belgium. Korfball started in Turkey in 1995 at Marmara University and Işık Schools and recognized by the Turkish University Sports Federation in 2002. In 2008, it was included in the Federation of Emerging Sports Branches. People who love this sport formed a union and established the Turkish Korfball Committee in 1997 and was accepted as a member at a meeting held by International Korfball Federation (IKF) in the Netherlands in the same year.

Korfball is a branch that emphasizes gender equality and encourages women to play on the same court as men, and it is the first and only branch in the world where men and women can play together. It is a sport where two teams play in a rectangular field and try to throw the ball into each other's basket with

the help of their hands. Korfball is played in 30 minutes and two halves (35 minutes in the open field); the break is 10 minutes; teams consist of eight people (four men and four women). This creates a social impact. Equal representation of men and women on the field in korfball where physical contact is less, and skill is at the forefront shows that Korfball was developed to prevent violence in sports (Gubby & Welard, 2016). Although there are gender understandings based on social norms in korfball, which represents gender equality unlike traditional sports, there are very positive findings on equality (Gubby & Wellard, 2016).

Communication is the transfer of information between individuals. Team cohesion is the togetherness and commitment that holds together a team or a group working for a certain goal. Cohesion and communication are very important concepts in terms of team sports. Teamwork, cooperation and effective communication improve the coordination of the athletes and support their psychological structures well.

Individuals expect to meet some of their needs in groups. For example, while some look for task-related results such as winning and development, some expect friendship and commitment. Therefore, communication affects the development and maintenance of a group. Communication mediates individuals to provide information about both the task (e.g. team strategy, suggestions for individual development) and social issues (e.g. who your friends are, your role in the team) (Sullivan & Gee, 2007). As a result, intra-team communication plays an important role in ensuring team unity to get efficient results. The main purpose of this study is to examine whether there is a gender difference in terms of "effective communication in team sports" and "team cohesion" in korfball, which is the only sport in which male and female athletes play together. The research questions for the purpose of the study are as follows.

1. Is there a difference between genders in terms of "effective communication in team sports" and "team cohesion" elements?
2. Is there a difference between age groups in terms of "effective communication in team sports" and "team cohesion" elements?
3. Is there a difference between education levels in terms of "effective communication in team sports" and "team cohesion" elements?
4. Is there a difference in terms of "effective communication in team sports" and "team cohesion" according to the duration of the athletes' interest in korfball?
5. How much does "effective communication in team sports" explain team cohesion?

METHODS

Subjects

The research involved 150 korfball players in total, all members of 12 sports clubs actively operating in Turkey in the 2020-2021 season.

Procedure

In this study, a Personal Information Form consisting of 11 questions, a 15-item “Effective Communication Scale in Team Sports” consisting of 2 sub-dimensions, and an 18-item “Team Cohesion Scale” consisting of 4 sub-dimensions were used (Alkan, 2009; Unutmaz, Kiremitci, & Gençer, 2011). The answer options for the items in the scales are a 5-point likert type.

Statistical analysis

Descriptive analyses were made in terms of age groups, education levels and duration of involvement in korfball. In addition, it was examined how much "effective communication" explains team cohesion. For answering the research problems independent sample t-test was used, so as on-way ANOVA, Factor analysis, and Regression analysis.

RESULTS

Table 1. Demographic findings

Variables	Sub variables	f	%
Gender	Woman	70	52,6
	Man	63	47,4
	Total	133	100,0
Age	16-20	50	37,6
	21-25	61	45,9
	26-30	13	9,8
	31 and above	9	6,8
	Total	133	100,0
Education	High school	23	18,1
	Bachelor's	99	74,4
	Master's degree and above	10	7,5
	Total	133	100,0
How many years has he/she played	less than 1 year	5	3,8
	1-3	66	49,6
	4-7	37	27,8
	8 and above	25	18,8
	Total	133	100,0
through whom he/she met Korfball	Social media	2	1,5
	Friends	47	35,3
	School	83	62,4
	Other	1	,8
	Total	133	100,0
Playing a sport other than Korfball	Yes	123	92,5
	No	10	7,5
	Total	133	100,0

Gender, age, educational status of the research group, how they met Korfball, the duration of their interest in Korfball and their interest in another sport are shown in Table 1. In addition, it has been observed that athletes are also interested in basketball besides Korfball (n=61, 45.9%). Volleyball is in the 2nd place and Athletics is in the 3rd place. Other 12 branches are football, fitness, rowing, artistic gymnastics, karate, tennis, windsurf, softball, cross country, taekwondo, wing chun, futsal.

Table 2. Internal consistency of scales

		Cronbach α	X	SS
Scale (15 item)	**Effective Communication in Team Sports**	**0.680**		
Sub-scale (9 item)	Acceptance and positive conflict	0.951	4,04	,93
Sub-scale (6 item)	Distinctiveness and negative conflict	0.873	2,68	1,03
Scale (17 item)	**Team Cohesion**	**0,810**		
Sub-scale (6 item)	Individual attraction to group-social	0,880	3,98	,84
Sub-scale (4 item)	Group integration- social	0,788	4,06	,83
Sub-scale (4 item)	Individual attraction to group-task	0,754	4,23	,79
Sub-scale (3 item)	Group integration-task	0,487	3,87	,97

In factor analysis, the cut-off point for the factor explanation load of the items was determined as 0.4. For this reason, item 14, which explains the "Group integration-task" factor at a rate of 0.392 in the team cohesion scale, was removed and the analysis was continued.

Table 3. Factor analysis - Effective communication in Team Sports

	Effective Communication in Team Sports (variance explained %69)	
	Acceptance and positive conflict (42, 929)	Distinctiveness and negative conflict (26,071)
Item 3	,830	
Item4	,870	
Item5	,866	
Item6	,890	
Item8	,748	
Item11	,853	
Item13	,738	
Item14	,763	
Item15	,837	
Item1		,573
Item2		,684
Item7		,820
Item9		,790
Item10		,825
Item12		,821

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 3 iterations.

Table 4. Factor analysis - Team Cohesion

	Team Cohesion (variance explained %63,740)			
	Individual attraction to group-social (23,114)	Group integration-social (17,726)	Individual attraction to group-task (14,499)	Group integration-task (8,401)
Item1				,725
Item3				,491
Item5	,705			
Item7				,581
Item9	,736			
Item2			,672	
Item4			,684	
Item6			,698	
Item8			,697	
Item11		,741		
Item13		,799		
Item15	,790			
Item17		,754		
Item10	,804			
Item12	,798			
Item16	,836			
Item18		,526		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 9 iterations.

Testing of research questions

1. Is there a difference between genders in terms of "effective communication in team sports" and "team cohesion" elements?

As a result of the independent sample t-test, a difference of 0.037 significance level was found between men and women in the sub-dimension of individual attraction to group-task (p<0.05). Women's averages are higher than men's.

Table 5. Independent sample t-test for gender

t-test for Equality of Means	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Acceptance and positive conflict	-,104	131	,917	-,01693	,16256
Distinctiveness and negative conflict	,368	131	,714	,06640	,18050
Individual attraction to group-social	,560	131	,576	,08201	,14639
Individual attraction to group-task	2,108	131	**,037**	,28849	,13682
Group integration-social	1,319	131	,189	,18968	,14380
Group integration-task	1,092	131	,277	,18413	,16855

	Gender	N	Mean
Individual attraction to group-task	Woman	70	**4,3679**
	Man	63	4,0794

2. Is there a difference between age groups in terms of "effective communication in team sports" and "team cohesion" elements?

There was no difference. One-Way ANOVA test was applied.

3. Is there a difference between education levels in terms of "effective communication in team sports" and "team cohesion" elements?

There was no difference. One-Way ANOVA test was applied.

4. Is there a difference in terms of "effective communication in team sports" and "team cohesion" according to the duration of the athletes' interest in korfball?

There was no difference. One-Way ANOVA test was applied.

5. How much does "effective communication in team sports" explain team cohesion?

Table 6. Regression model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,482(a)	,233	,221	,50861

a Predictors: (Constant), ayirt_ngtf_cat, kabul_poztf_cat

It can be said that team cohesion is explained by effective communication (accepting-positive conflict and distinctiveness -negative conflict) at a rate of 23% (p<0.01).

DISCUSSION AND CONCLUSION

Communication is required for coordination in teams. Team coordination and communication relationships play a role in achieving team expertise (Eccles & Tenenbaum, 2004). In this study, which was applied for the first time in the field of korfball in Turkey, high average values were obtained in terms of team unity and effective communication. In addition, it was concluded that effective communication explains team unity to a certain extent. Therefore, it can be said that it is important to popularize korfball, which is almost not common in Turkey yet.

Compared to traditional sports, korfball offers great opportunities for boys and girls to play sports together. Especially in physical education classes, it is important that both boys and girls can play in harmony with mixed gender in an educational setting (Gubby & Welard, 2016). In this study, it is seen that women have higher effective communication skills. Based on this, it is suggested that more women should be included in teams in Turkey, where women managers and employees are less than men.

Korfball is currently only included in a few university teams and clubs in Turkey. Athletes also stated that they met korfball through school and friends. To become korfball widespread, it is necessary to include korfball in sports training programs, to train korfball trainers and volunteers to work in this field.

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EFFECTS OF EXERCISE PROGRAM ON DEVELOPMENT OF LOWER LIMBS' EXPLOSIVE STRENGTH IN TENNIS PLAYERS: A SYSTEMATIC REVIEW

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ABSTRACT

The aim of the research was to determine the effects of exercise programs on lower limbs' explosive strength in junior tennis players. For collecting of appropriate scientific researches from 2010 till 2021 the following keywords were used: tennis, eplosive strength, training and exercise program, motor ability- in three electronic databases (Google Scholar, KobSon, SCI index). Based on the keywords, the existing scientific researches have gone through three levels of selection in order to enter the final analysis. These analyzed researches are presented through five groups of parameters: authors of the research, sample description (sex, age and number), experimental treatment (description, frequency), measuring instruments and results. Only 10 researches have met the criteria, and the analysis shown that the exercise programs lasted from 6 to 8 weeks, with weekly training frequency between two and three times of 30 minutes, that is, as an addition to the training. Exercise programs that have been used for the development of lower limbs' explosive strength in tennis players were of plyometric type, with and without equipment. The tests, by which the assessment of the lower limb' explosive strength was determined, were: CMJ, CMJ (bilateral/unilateral), SJ, DJ and OLH. The results of the applied exercise programs have shown, in all of the analyzed researches, statistically significant progress ($p<0.05$). A lower-limb explosive strength represents a very significant segment within the basic motor skills of tennis players in the junior category due to the latent period of development period, but also to the pretensions of the increasing dynamism of the tennis game. In accordance with this, the research can help trainers to use the information for planning the development of the explosive strength of their tennis players, and for athletes to advance and manifest the maximum potential of this part of this basic motor space.

Keywords: plyometric training, training, basic motor skills, tennis players, jumps

INTRODUCTION

Tennis is one of the most popular sports of the 21st century, classified as a poly-structural acyclic sports activity that can be performed individually (singles) or in pairs (doubles), and includes techniques which require an implement (Milenković & Ilić, 2012). It is characterized by a high level of dynamism, physical, technical and tactical conditioning and mental stability (Filipčič, 2000; Smajić, Savić, Korać, Kuljanin, Vasić, & Tomić, 2015). Tennis players are consequently presented with exceptionally high criteria regarding the development of their biological performance from the earliest stages of doing this sport. Accordingly, motor abilities and their full developmental potential constitute one of the most significant factors when it comes to achieving top results in tennis (Neljak, Antekolović, Krističević, &Višković, 2003).

The most important fundamental motor skills for tennis players are power, speed, agility, coordination and precision. Power, or explosive strength, is one of the most important fundamental motor components for tennis players since it has a direct impact on the performance of certain technical elements of the game itself (Cohen, Mont, Campbell, Vogelstein, & Loewy, 1994; Sannicandro, Cofano, Rosa, & Piccinno, 2014). Explosive strength is a function of genetic predisposition to a large extent;

however, it can fulfil its maximum potential through practice, that is, through influencing its development (Stojiljković, 2003). A prerequisite for reaching one's maximum potential is the impact of dedicated practice during the formative stages of strength development. One of such formative periods in the development of tennis players' strength is the junior age group period. During this period, it is necessary for coaches to include in their training plans and programs, as part of basic motor skills, exercises for developing explosive strength. Explosive strength in tennis manifests both in the activation of the entire body and in a segmentary manner. Explosive strength of the lower limbs constitutes an extremely important element, primarily regarding power but also regarding fundamental motor skills, which has a direct impact on the performance of technical elements of the game of tennis (Cohen et al., 1994; Girard & Millet, 2009).

In view of the above, tennis coaches can face dilemmas regarding the manner and extent of the physiological and anatomical training loads they can present their players with in order for exercise to exert an appropriate effect on developing their genetic potential. Another issue concerns the type of practice or exercise that should be applied, with what specific training loads and durations. In addition, tennis coaches may face dilemmas regarding methods for monitoring the development of this fundamental motor skill as well as the tests used for diagnostics regarding lower limb explosive strength in tennis players. Based on the aforementioned dilemmas, the objective of this paper is to identify the effects of exercise programs on lower limb explosive strength in junior tennis players.

METHODS

The following electronic databases were searched in order to collect data for our research into the effects of exercise programs on developing lower limb explosive strength among tennis players in the junior age group: Google Scholar, SCIndeks, KoBson. The search included studies published in the period between 2010 and 2020. The following keywords were used when searching the databases: 'tennis', 'explosive strength', 'training program', 'exercise program', 'motor ability'. Next, the retrieved study titles, abstracts and full texts were analyzed. In order for a study to be included in the final analysis, it had to meet the following three criteria: the study had to include an experimental treatment, study participants belonged in the junior age group, and the study conducted an assessment of the explosive strength of lower limbs in tennis players. Those studies that met the set criteria were then analyzed and presented according to the following parameters: reference (first author's surname and year of publication), participant sample (age, total number of participants, participant subgroups), physical exercise program, program duration, instruments used for assessing the parameters of explosive strength of lower limbs, study results.

RESULTS

The procedure for collecting, analyzing and eliminating the retrieved studies is presented in Figure 1. Keyword search identified 719 papers. The number of studies excluded immediately based on title, repetition of the same paper, as well as the time when they were published (before 2010) was 511, while 208 papers were included in further analysis. Further analysis of those 208 papers then excluded another 198 papers, based on multiple criteria: abstract, as this identified them as systematic reviews, the absence of an experimental treatment, as well as not meeting the age criterion for study participants (tennis players from other than junior age group).

The remaining 10 papers met the criteria. These were papers published between 2010 and 2020, including participants in the junior age group, assessed for lower limb explosive strength.

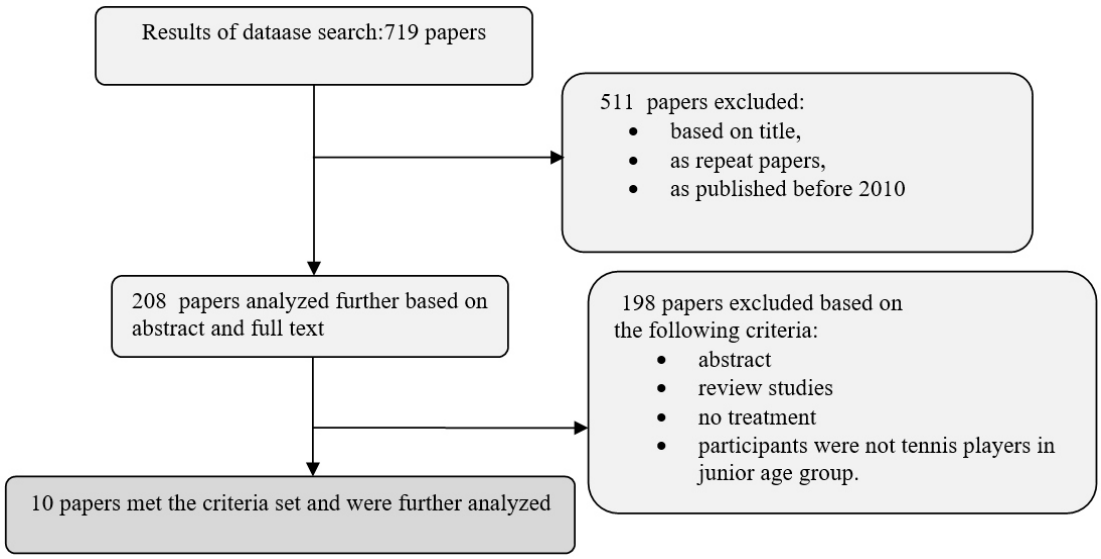

Figure 1. A statistical presentation of papers retrieved

This review study included a total of ten studies that dealt with determining the effects of various trainings on the development of the explosive strength of young tennis players. All papers were published in the period from 2010 to 2021. The largest number of participants (n=256) was found in the study of Kramer et al. (2016), while the smallest number of participants (n=15) was in the oldest study (Barber-Westin et al., 2010). In four papers, the participants were both, males and females (Barber-Westin et al., 2010; Sannicandro et al., 2014; Barber-Westin et al., 2015; Pardos-Mainer et al., 2017), five researches dealt only with male participants (Fernandez-Fernandez et al., 2015; Sarabia et al., 2015; Kramer et al., 2016; Kilit et al., 2019), while in one study participants were only females (Kramer et al., 2021). All papers included in this review dealt with tennis players under the age of 18. In only two studies there was one experimental group (Barber-Westin et al., 2010, 2015). In four papers the total number of subjects was divided into experimental and control groups (Sannicandro et al., 2014; Fernandez-Fernandez et al., 2015; Sarabia et al., 2015; Pardos-Mainer et al., 2017), while in the four remaining studies the total number of subjects were divided into two experimental groups (Kramer et al., 2016; Kilit et al., 2019; Fernandez-Fernandez et al., 2020; Kramer et al., 2021). This review paper included two longitudinal studies (Kramer et al., 2016, 2021), one that lasted 11 weeks (Sarabia et al., 2015), three that were conducted within eight weeks (Fernandez-Fernandez et al., 2015; Pardos-Mainer et al., 2017; Fernandez-Fernandez et al., 2020), while in the remaining five studies experimental treatments lasted six weeks (Barber-Westin et al. , 2010; Sannicandro et al., 2014; Barber-Westin et al., 2015; Kramer et al., 2016; Kilit et al., 2019). In all ten collected studies as one of the main criteria, the researchers dealt with the effects of various training programs on the explosive strength of young tennis players. In all ten studies, the authors found statistically significant changes in the monitored parameters**.**

Table 1. A summary of studies conducted to date

FIRST AUTHOR AND YEAR	METHODS				PROGRAM	TESTS	MONITORED PARAMETERS	RESULTS
	Number of participants	Sex	Age	Number of Groups				
Barber-Westin et al., 2010	15	F=10 M=5	13.0±1.5 years	1	6 weeks - 3 times a week (dynamic warmup, plyometric and jump training, strength training (lower extremity, upper extremity, core).	Single-Leg Hop for Distance, Single-Leg Triple Crossover Hop for Distance.	**Explosive strength**.	Statistically significant improvements and large-to-moderate effect sizes were found in the single-leg triple crossover hop for both legs ($p < 0.05$).

Sannicandro et al., 2014	23	F=8 M=15	13.2±0.9 years	2 An Experimental (EG) (n=11, F=4, M=7) Comparison Group (CG) (n=12, F=4, M=7)	6 weeks (total of 12 training sessions directed at balance training: two 30-minute sessions/week)	One-leg hop test (OLH), side-hop test (SH) and side steps and forward 4.115-m test (4m-SSF),	Explosive strength of lower limbs	Significant differences between pre- and post-training tests in the EG only: the degree of lower-limb asymmetry was decreased in the EG, as assessed using the OLH test ($p< 0.001$), SH test ($p < 0.001$) and 4m-SSF test ($p < 0.05$). Significant reduction in the percent of asymmetry in lower-limb strength, as measured using the SH ($p < 0.01$), 4m-SSF ($p < 0.01$) and OLH ($p< 0.05$) tests.
Barber-Westin et al., 2015	42	F=31 M=11	14±2 years	1	6 weeks (dynamic warm-up, jump training, strength training, and tennis specific agility and hitting drills	Two single leg hop tests.	**Explosive strength.**	Statistically significant improvements and large-moderate effect sizes were measured, dynamic single-leg balance. No differences between genders.
Fernandez-Fernandez et al., 2015	16	M=16	16.9±0.5 years	2 An experimental group (EG) and a control group (CG)	8-week training intervention (explosive strength-ExpS)	Vertical Jumping, Maximal Graded	**Explosive strength**	Except for percentage of decrement in the RS test ($p=0.72$) and maximal aerobic performance ($p = 1.0$), all performance variables (i.e., sprint, countermovement jump, and RSA) were significantly improved ($p<0.05$; effect sizes ranging from 0.56 to 1.12).
Sarabia et al., 2015	20	M=20	15.0±1 years	2 An experimental group (EG, n=11) and a control group (C, n=9).	11 weeks divided into four weeks for an anatomical adaptation period (AAP); six weeks for a main training program (MTP), and a tapering week (TW)	half squats, bench press, squat jumps, countermovement jumps and side-ball throws	Strength, **explosive strength**	The experimental group significantly improved ($p<0.05$) in mean and peak power output and in the total number of repetitions during the half-squat endurance test; mean force, power and velocity in the half-squat power output test; Profile of Mood States; in squat-jump and countermovement-jump height. Significant differences were found between the groups at the post-tests in the total number of repetitions, mean and peak power during the half-squat endurance test, mean velocity in the half-squat power output test, salivary cortisol concentration and in the Profile of Mood.

Kramer et al, 2016	256	M=256	10–15 years	2 Elite and sub-elite	5 years	Countermovement jump.	**Lower limb explosive strength** (LLES).	Sprint performance improved with age at each additional 1 year of age, thus predicting .016 sec improvement in five-meter sprint time by all variables of the model. Sprint performance differences between elite and sub-elite players was related to longitudinal changes in body size and lower limb strength up until age 13.
Pardos-Mainer et al., 2017	21	F=10 M=11	14.33± 1.77 years	2(An experimental group (EG and a control group (CG)	8 weeks (biweekly plyometric training instead of the habitual fitness training)	Bilateral (CMJ) and unilateral countermovement jump test and bilateral (SH) and unilateral (SHU) standing broad jump test	**Explosive strength**	All performance variables were improved in both groups compared to the pre-test. Greater enhancements were obtained in SH, SHU, CMJ and BM in the experimental group in comparison to the control group
Kilit & Arslan, 2019	29	M=29	13.8±0.4 years	2 HIIT: High-intensity interval group (n=14) and OTT: on-court tennis training group (n=15)	6 weeks of high-intensity interval training (HIIT) vs. 6 weeks of on-court tennis training (OTT)	Countermovement jump, Squat jump, Drop jump	**Explosive strength**	Both training protocols increased jumping performances significantly ($p<0.05$).
Fernandez-Fernandez et al, 2020	28	M=28	15.09± 1.16 years	2 Training group performing neuromuscular warmup (NWU; n =14), and the group that followed Dynamic warmup (DWU; n =14)	8 weeks	bilateral/unilateral countermovement jump (CMJ)	**Explosive strength**	Both groups, NWU and DWU, significantly improved their CMJ (bilateral and unilateral [dominant side] [$p<0.005$; $d=1.27–1.59$]),

Kramer et al., 2020	167	F=167	10–15 years	2 Elite (*n*=48) sub-elite (*n*=119)	Longitudinal study	lower limb explosive strength	**Explosive strength**	Significant different developmental patterns were found for elite and sub-elite players, with elite players aged 10–14 being faster. After age 14, no significant differences were found in sprint performance between elite and sub-elite players ($p >$. 05). Sprint performance is an important characteristic of young female tennis players and seemed to depend on growth and maturation in parallel to physical fitness.

DISCUSSION

Table 1 presents studies about the effects of exercise programs on the development of lower limb explosive strength in junior tennis players. Each of the papers analyzed is presented through five parameters: reference, participant age, number of participants, participant groups, characteristics of the treatment selected, measurement methods (assessment of condition and of the effects of the treatment), and results achieved following the treatment. Based on the papers analyzed, we can clearly distinguish the following tests for the assessment of lower limb explosive strength in tennis players: bilateral/unilateral countermovement jump (Fernandez, et al., 2015; Sarabia, et al., 2015; Kramer, et al., 2016; Pardos-Mainer, et al., 2017; Kilit, et al., 2019; Fernandez, et al., 2020; Kramer, et al., 2020), squat jump (Sarabia, et al., 2015; Kilit, et al., 2019), drop jump (Kilit, et al., 2019), two/one single leg hop tests (Barber-Westin, et al., 2010; Sannicandro, et al., 2014; Barber-Westin, et al., 2015). The column "treatment characteristics" lists applications of a certain exercise program whose objective was the strengthening of muscles or enhanced strength, speed and balance in the lower limbs, taking place in intervals ranging from a minimum of 30 minutes (in the studies by Sannicandro, et al., 2014; Kilit, et al., 2019) up to 90 minutes, which was the duration of a single practice session in the study by Barber-Westin et al. (2010) and Sarabia et al. (2015), with a weekly frequency of between two (Sannicandro, et al., 2014; Fernandez, et al., 2015; Pardos-Mainer, et al., 2017; Kilit, et al., 2019) and four times per week (Sarabia, et al., 2015), and study duration between six weeks (Barber-Westin, et al., 2010, 2015; Sannicandro, et al., 2014;; Sarabia, et al., 2015; Kilit, et al., 2019) and eight weeks (Fernandez, et al., 2015, 2020). Treatments included plyometric exercises with or without the use of sports implements, which were administered based on the number of repetitions in sets in nearly all the papers analyzed (9 papers) and on intervals in one (Kilit, et al., 2019). Application of the experimental programs was preceded by warm-up in the duration of 5-10 minutes, following which the principal portion of the programs comprised up to ten exercises and three to four sets with between 6 and 15 repetitions in each. The duration of breaks was 30 seconds between repetitions and up to 2 minutes between exercises.

The results of final measurements indicated that there was a statistically significant difference in results following the application of experimental programs aimed at developing explosive strength of lower limbs in tennis players. In all the papers analyzed, the level of statistical significance of differences between final measurements compared to initial ones was at $p<0.05$. Accordingly, we can conclude that the programs applied yielded positive effects for this age group, as well as that the development of explosive strength is necessary for this age group as it constitutes a very important parameter of tennis players' fundamental motor skills (Cohen et al., 1994; Sannicandro, et al., 2014), but also because this is a latency period for the development of this motor skill in particular (Stojiljković, 2003). Based on the exercise programs analyzed, it can be concluded that a program for the development of lower limb explosive strength for this age group should not last longer than eight weeks, with a weekly frequency of twice a week, and a duration of 30-60 minutes in order to achieve positive effects. In terms of exercise programs that included plyometric exercises or jumps with or without use of any additional implements in 3 to 6 sets, and where the number of sets exceeded four, the number of repetitions was between three and eight, while where the number of sets was under four, the number of repetitions in a set was between ten and fifteen. The results of the studies reviewed thus indicate certain temporal, organisational, and

professional guidelines to follow when planning for developing lower limb explosive strength in junior tennis players.

CONCLUSION

The analysis of papers included in the present study has indicated the required duration, method of application of different exercise programs, as well as the method of assessment or diagnostics concerning explosive strength of the lower limbs among tennis players in the junior age group. The review of results of the studies to date will offer coaches the opportunity to enhance their expertise with a cutting edge methodology for planning the development of lower limb explosive strength for this age group, as well as enabling athletes themselves to gain a better understanding of the importance of training loads, as well as the ways in which they fulfill their potential to the maximum, regarding power as a fundamental motor skill. The range of the papers analyzed also indicates that this field requires further study by researchers in this area. Additionally, more dedication is required when it comes to fundamental motor skills, which are of paramount importance when implementing technical and tactical elements in tennis. Accordingly, we hope this study will prove useful when planning future research in this area aimed at creating or enhancing exercise programs for developing lower limb explosive strength in tennis players.

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DIFFERENCE IN EXPLOSIVE POWER AND AGILITY BETWEEN FASTER AND SLOWER FOOTBALL PLAYERS AGED 15-18

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ABSTRACT

During the football match high-intensity activities occur approximately every 90 seconds, and the distance covered during the sprint (1.5 m up to 105 m) indicates that player is required both to accelerate and to develop a maximum speed. To the best of authors' knowledge, no study aimed to examine the explosive power (EP) and agility of football players when divided into groups of faster and slower players. In this regard the aim of this study was to determine the differences in explosive power and agility in faster and slower football players aged 15-18. The study involved 50 youth football players (16.4±0.9 yrs, 177.8±5.1 cm, 72.4±4.7 kg) competing in a top youth league. At the time of testing all respondents had training experience of 9±1.3 years and they were divided into two groups: faster players (n=25) and slower players (n=25). EP was determined by CMJ, CMJ free arm and SJ tests using Opto-jump (Microgate, Italy). Agility was assessed by T-test, Slalom, 4x5 m and 9-3-6-3-9, as well as running speed at 10 and 30 m using Witty photocell gates (Microgate, Italy). Significant difference on 10 m acceleration test have been observed in CMJ, SJ and T-test (p=.043, p=.041 and p=.022, respectively) and on a 30 m run test in CMJ, SJ, T-test, 4x5 m and 9-3-6-3-9 tests (p=.000, p=.002, p=.022, p=.000, and p=.019, respectively). Also percentage difference is biggest in EP tests (SJ=11.18%; CMJ=11.96%; CMJ free arm=8.86%). Statistically, the difference is much more visible when the classification of players is done on the basis of 30 m running than when it is done based on 10 m acceleration. It can be concluded that there is a difference between faster and slower players in all of the tested parameters when the maximum speed is taken as a criterion. When it comes to acceleration of 10 m there is a statistical difference between faster and slower players in certain segments of EP, while the difference in agility parameters is questionable because only T-test showed a statistically significant difference. The main limitations of this study are sub-elite subjects and big difference between youngest and oldest player. Therefore, future studies should consider these limitations and divide players by playing positions.

Keywords: adolescents, speed, power performance, vertical jump, sub-elite players

INTRODUCTION

During a football match, players make 30 to 40 sprints of different lengths and more than 700 turns (Bloomfield, Polman, O'Donoghue, & McNaughton, 2007) and this directly tells us what the character of this sport is. High-intensity activities occur approximately every 90 seconds during a match and last for two to four seconds. The distance a player travels during a sprint (1.5 to 105 m) indicates that the game requires both acceleration and maximum speed (Bangsbo, 1994).

High-intensity movements during football games can be classified into actions that require acceleration (10 m sprint), actions with maximum speed (30 m sprint), or actions that require agility (Little & Williams, 2003). Maximum speed and acceleration are important abilities in field sports, and the running speed over short distances is the basis for success (Taskin, 2008). It is reported that 96% of sprints during a football match are shorter than 30 m and 49% are shorter than 10 m (Stølen, Chamari, Castagna, & Wisløff, 2005). Agility, meanwhile, requires fast, repetitive decelerations and accelerations over short distances, apparently using a different running technique; it also includes perceptual skill (Brechue, Mayhew, & Piper, 2010). On the other hand explosive power is described as the ability of the neuromuscular system to produce the greatest possible impulse in a given period and has been identified as one of the factors contributing to soccer performance (Reilly, Bangsbo, & Franks, 2000). Despite its

wide use in soccer vertical jump (height jumped) testing requires specific testing setup and devices (i.e., force platform and switch mats) that may limit its use in field conditions (Stølen et al., 2005).

Based on previous research, it can be concluded that the authors are quite inconsistent when it comes to speed and agility in football players. Some papers (Chaleh, Fatemi, & Shahsavar, 2012; Köklü, Alemdaroğlu, Özkan, Koz, & Ersöz, 2015) concluded that these two abilities are connected and, on the other hand, some studies (Buttifant, Graham, & Cross, 1999, 2001; Salaj & Markovic, 2011) claim that there is no significant correlation between linear sprint running and agility. In contrast to these results, other studies (Little & Williams, 2003; Spaniol, Flores, Bonnette, Melrose, & Ocker, 2010) have confirmed that there is a statistically significant correlation between sprint running and agility. When it comes to explosive power, opinions are also divided, so some studies (Mero, 1981; Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004) argue that the vertical jump correlates with running speed, and in contrast to this, other studies (Cronin & Hansen, 2005; Vescovi & Mcguigan, 2008) found weak correlations between explosive power and time obtained on running tests.

Since the results of previous studies are quite different, it is necessary to conduct more studies that would determine what is true. Also, to the best of authors knowledge, no study aimed to examine the explosive power and agility of football players when they are divided into a groups of faster and slower players. In this regard, the aim of this study was to determine the differences in explosive power and agility in faster and slower football players aged 15-18.

METHODS

Subjects

The study involved 50 youth football players (16.4±0.9 yrs, 177.8±5.1 cm, 72.4±4.7 kg), members of the same team competing in a top youth league. At the time of testing, all respondents had training experience of 9±1.3 years. The criteria for inclusion in the study were that the players were healthy and had not had a major injury in the last six months. Participants who have already turned 18 years gave written consent to voluntarily participate in the testing, while parents did so on behalf of underage participants.

Procedures

All procedures were performed in accordance with the Declaration of Helsinki. Testing was conducted on the first day of the preparation period before the start of the season. The first part of the testing was conducted in the morning from 9 to 11 a.m., where the explosive power was measured and the participants were required to have sports equipment and sports shoes with flat soles. The second part of the testing (speed and agility) was conducted in the period from 1 to 3 p.m. on a football field with a synthetic grass surface where the participants were required to have football boots.

The following tests were used to determine the vertical jumping ability: Countermovement jump test (CMJ), Countermovement jump with free arms test (CMJ free arms) and Squat jump test (SJ). Measurements were performed using Optojump (Microgate, Bolzano, Italy) equipment. The participants performed a 15-minute warm-up before testing procedure, consisting of moderate jumping and dynamic stretching. Jump height was recorded to the nearest 0.1 cm and each respondent had three attempts on each test. The pause between each attempt is at least 15 seconds because it has been found that this is enough time to recover between 3-5 jumps at maximum effort (Read & Cisar, 2001).

Agility was assessed through the T-test, 9-3-6-3-9, Slalom and 4x5 m without the ball following the protocol outlined by Semenick (1990). Time was measured with Witty photocell gates (Microgate, Italy) mounted on a tripod with a height of 0.75 m at the starting line, with an accuracy of 0.01 sec. In every test for assessment of agility, participants are instructed to start from an erected position with one leg in front of the other, 30 cm behind the starting line so that they don't cut the light beam and thus negatively affect the result. Time recording begins when subjects pass through the gates and stops when they pass through them on return. Participants have two trials on each test with one minute recovery between each trial.

To estimate the speed, a test of straight running was used, with split times at 10 and 30 meters. The subject is in an erected position with one foot just behind the starting line. At the meter's signal, he starts and runs the marked distance at maximum speed. It is very important that the respondent does not slow down before passing the goal. The test was completed after the subject performed the correct sprint. Rest between attempts lasts at least for 2 minutes. The result record is automatically stored on the computer. Sprint and split times were measured with four Witty photocell gates (Microgate, Italy), positioned at the

starting line, 10 m, 30 m, and finish line, with an accuracy of 0.01 s. After running speed test, the subjects were divided into two groups: faster players (n=25) and slower players (n=25).

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). The results of this research will be processed and interpreted so as to obtain the central dispersion parameters for each measuring instrument, namely: mean value (Mean), standard deviation (SD). These statistics will be applied to all measuring instruments and will be presented in a table. Independent-Samples t-test will be used to determine the differences in explosive power and agility between groups of faster and slower football players. The significance level will be p<.05.

RESULTS

Table 1. Descriptive statistic for faster (n=25) and slower (n=25) players when it comes to 10m acceleration

Test	Faster (Mean±SD)	Slower (Mean±SD)	p
CMJ (cm)	34.34±4.04	32.07±3.68	.043*
CMJ free arms (cm)	40.35±3.61	38.28±4.78	.093
SJ (cm)	32.42±3.43	30.32±3.60	.040*
Slalom (s)	5.84±.397	5.90±.332	.580
4x5 m (s)	5.76±.188	5.89±.267	.062
T-test (s)	9.07±.318	9.28±.313	.022*
9-3-6-3-9 (s)	7.93±.657	8.07±.347	.319

Legend: CMJ– countermovement jump **; CMJ free arms–** countermovement jump with free arms swing ; **SJ–** squat jump ; **Slalom, 4 x 5 m, T test, 9-3-6-3-9 -** agility tests ; **p**- level of significance ; *****- statistical significance < 0.05

Parameters of descriptive statistics (Table 1) for 10 m acceleration shows practical difference between faster and slower players in all tests for the assessment of explosive power (CMJ, CMJ free arms, SJ), but a statistically significant difference was observed in the tests CMJ (p=.043) and SJ (p=.040). As expected, players who achieved better time when accelerating to 10 meters achieved better results, both in tests for assessing explosive power (CMJ, CMJ free arms, SJ), and in tests for assessing agility (Slalom, 4x5m, T-test, 9-3-6-3-9). However, the realized differences are not statistically significant except in the case of T-test (p=.022).

Table 2. Descriptive statistic for faster (n=25) and slower (n=25) players when it comes to 30m sprint speed

Test	Faster (Mean±SD)	Slower (Mean±SD)	p
CMJ (cm)	35.27±3.66	31.05±3.13	.000*
CMJ free arms (cm)	41.09±3.63	37.45±4.30	.093
SJ (cm)	33.18±3.20	29.47±3.12	.002*
Slalom (s)	5.75±.32	5.99±0.37	.580
4x5 m (s)	5.71±.15	5.95±0.26	.000*
T-test (s)	9.01±.268	9.36±0.29	.022*
9-3-6-3-9 (s)	7.77±.28	8.23±0.6	.019*

Legend: CMJ– countermovement jump **; CMJ free arms–** countermovement jump with free arms swing ; **SJ–** squat jump ; **Slalom, 4 x 5 m, T test, 9-3-6-3-9 -** agility tests ; **p**- level of significance ; *****- statistical significance < 0.05

The results obtained in the 30 m running test shows a significantly higher discriminatory value of the results when it comes to faster and slower players. The results indicate a significant difference in all tests applied in this study, where the groups differ statistically significant in the CMJ (p=.000), SJ (p=0.002), 4x5 m (p=.000), T-test (p=0.22) and 9-3-6-3-9 (p=.019).

DISCUSSION

This paper examined whether there is a difference in explosive power and agility in football players aged 15 to 18 when they are divided into a faster and slower group and the results showed that there is a statistically significant difference between groups. Statistically, it is bigger difference when the classification of players is done on the basis of maximum speed (sprint 30 m) in relation to the acceleration of players at 10 m.

Explosive power, in the form of the achieved vertical jump height, is considered a good indicator of success in football, so functional testing of football players in which explosive power is not assessed is almost unthinkable (Stølen et al., 2005). The height of the jump on the explosive power tests showed a connection with success, both in senior and junior categories (Arnason, Sigurdsson, Gudmundsson, Holme, Engebretsen, & Bahr, 2004; Mujika, Santisteban, Impellizzeri, & Castagna, 2009; Wisløff et al., 2004). Jump height is the most appropriate indicator due to its reliability, simplicity and the ability to track progress (Arnason et al., 2004; Stølen et al., 2005).

The findings of this study indicate a significant association between sprint ability and explosive power and slalom agility without the ball in young football players. One possible reason is that running, agility and explosive power involve dynamic movements that require great muscular strength and that these movements are therefore expected to be closely related. Another explanation for the great correlation between sprint, agility and explosive power may be the same energy systems that require this type of movement (Köklü et al., 2015). According to the obtained results, the CMJ test shows the difference between faster and slower players when they are classified based on the 10 m acceleration (p=.043) with a tendency to increase the difference with increasing sprint distance and transitioning to maximum player speed (p=.000) if we look at the results obtained on the 30-meter running test. These results are supported by research that has proven a significant correlation between the results obtained on the running and the explosive power tests (Popowczak, Rokita, Świerzko, Szczepan, Michalski, & Maćkała, 2019). Moreover, another study (López-Segovia, Marques, Van den Tillaar, & González-Badillo, 2011) showed a high level of correlation of results between vertical jumps and acceleration tests (10m) p<.001) and maximum speed (30m) (p<.01). On the other hand, Vescovi & Mcguigan (2008) showed a weak association between CMJ test results and running speed. As for the SJ test, based on the 10 m acceleration, the results indicate that there is statistically significant (p=.04) difference between faster and slower players. The results based on the 30 meters speed differ drastically in relation to those obtained on the 10 meters results and show great statistical significance (p=.000) in this research. Research conducted by Köklü, Özkan, Eyuboğlu, & Ersöz (2009) proved that the acceleration is weakly correlated with the results obtained on the SJ test (r=-0.353, p<0.05) in young football players and in contrast to this study Pandey & Chaubey (2015) found a strong correlation between these two parameters. Pandey & Chaubey (2015) conducted a study examining the correlation between explosive power and agility in football players aged 18 to 22 years and they came to the conclusion that there is a significant connection between explosive power and agility in football players. On the other hand, one study (Köklü et al., 2009) proved that agility is weakly correlated with SJ (r=-0.353, p<0.05) in young football players, and Chamari, Hachana, Ahmed, Galy, Sghaier, Chatard et al. (2004) found that CMJ also had weak correlation with 30 m running test. Different findings when testing explosive power, agility and sprint can occur due to differences between study participants. It is indicated that age or experience can have potential impact in testing these locomotor skills (Gil, Badiola, Bidaurrazaga-Letona, Zabala-Lili, Gravina et al., 2014). One study (Popowczak et al., 2019) found a significant correlation between the results on the 30-meter running test and those obtained on tests that assess explosive power. Another study found that the jump height was related to both the times obtained when accelerating to 10 meters (r=0.72, p<0.001) and the maximum speed (r=0.60, p<0.01) (Wisløff et al., 2004). Sporis, Jukic, Milanovic, & Vucetic (2010) found that slalom running without the ball moderately correlated with the 30-meter running test (r=0.560, p<0.05).

It is well known that maximal running speed, acceleration and agility are key factors in many field sports (Meir, Colla, & Milligan, 2001). Since players rarely run long enough to reach maximum speed, it is considered that, when it comes to success in football, the acceleration and agility plays the most important role (Reilly & Borrie, 1992). The results of the agility tests shows the lowest significance is in the Slalom test (p=.019), and the highest in the tests 4x5 meters (p=.000) and T-test (p=.000). Results also shows the lowest significance is in the Slalom test (p=.580), and the highest in the T-test (p=.022).

Regarding the obtained results of the T-test, based on the acceleration to 10 meters, it can be concluded that the difference between faster and slower players is large (p=.022). Similarly, the maximum speed shows the shares in the realized differences between faster and slower players, with the statistical significance being much higher compared to the acceleration (p=.000). Some studies found that acceleration, maximum speed and results on Slalom test highly correlate (Little & Williams, 2003; Reilly, Williams, Nevill, & Franks, 2000), and in contrast to this Vescovi & Mcguigan (2008) found a weak correlation between acceleration and agility test scores. The difference in the obtained results from different studies can be explained with the help of several facts. One of the possible reasons is the different level of physical fitness and skills (Jovanovic, Sporis, Omrcen, & Fiorentini, 2011). Another possible reason is the level of perception and the ability to make decisions of each player individually, i.e. the player can be averagely fast, but very agile due to high levels of perceptual factors (Young & Farrow, 2006). Furthermore, the reasons are the distances that are covered during the tests. During this research, acceleration (10m) and maximum speed (30m) were measured, while the running time at 20m was measured but not taken into account during data processing, and players crossed that distance in agility tests (4x5 m and Slalom test). Given this, different distances should be taken into account when examining differences in agility in relation to sprint running. This research also shows that the ability to jump vertically depends on the maximum speed and partly on the acceleration in football players youth age.

The main limitation of this study is that the level of subjects was not elite and at that of the differences may still vary too much. Future studies should divide participants, if working with youth categories, into several groups and analyze them separately. Also, there is a need to use more modern tests to assess ability, so it is recommended that agility is measured not only as the ability to quickly change direction but also a perceptual factor should be included when testing. Finally, more effort should be dedicated to the implementation of devices that would assess the explosive power of the lover limbs in real game conditions.

CONCLUSION

From all the above, it can be concluded that there is a difference between faster and slower football players in all of the conducted tests when the maximum speed is taken as a criterion. When it comes to the test of running, i.e., acceleration at 10 meters, there is a statistical difference between faster and slower players in certain segments of explosive power, while the difference in agility parameters is questionable because only the T-test showed a statistically significant difference. The significance of this research is that the mutual relationship between the explosive power of the lower extremities and agility with acceleration and maximum speed in football players aged 15 to 18 has been determined. The obtained results represent a good basis for some new research that would deal with the examination of some other tests and their connection with this and other motor abilities, as well as the possibility of reducing the number of tests needed to determine. The main limitations of this study are non-elite subjects and big difference between youngest and oldest player. Therefore, future studies should consider these limitations and in addition to this divide the players by playing positions.

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BODY COMPOSITION AND STRENGTH OF BASKETBALL PLAYERS

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ABSTRACT

Basketball, as a team sport, requires a developed physical readiness in order to play a game successfully. In addition, motor abilities, changes in body composition and the growth of the body with maturation greatly affect the basketball game. The aim of the study was to determine how body composition affects the strength of basketball players. Nineteen basketball players, aged 14.10±0.55 years, with a sports experience of 6.77±1.25 years, participated in the research. All subjects were clinically healthy and had no serious injury in the last six months until the day of testing. Body composition (body height, body mass, body fat percentage, muscle mass percentage and body mass index) was determined using Omron BF511 bioimpedance device (Omron Healthcare Co., Kyoto, Japan) and Martin's anthropometer GPM 101 (GPM GmbH Switzerland). Explosive, repetitive and static strength were tested, with the help of specific tests. The relationship between body composition and strength was assessed using Pearson's coefficient of correlation and the statistical significance was set at $p<0.05$. Statistical procedures and analyses were performed using the statistical program IBM SPSS Statistics 20.0. The results of this study show a high correlation of body composition with strength variables. The greatest responsibility for the relationship among the variables had the results of body mass index ($p<0.01$, $p<0.02$, $p<0.05$), body fat percentage ($p<0.02$, $p<0.05$), then, body weight ($p<0.02$, $p<0.03$) and the variable that has the lowest correlation with strength variables is the percentage of muscle mass ($p<0.05$). The results of this study show a negative correlation between body mass index, body mass and body fat percentage with all strength variables, which proves that higher parameters of the previously mentioned variables, have decrease the effect on strength performance. One static strength variable was positively correlated with the percentage of muscle mass and this proved that a higher percentage of muscle can improve a certain part of static strength.

Keywords: body fat, body muscles, explosive strength, repetitive strength, static strength

INTRODUCTION

Basketball is one of the most popular ball sports in the world. It is a game in which multiple actions take place in one second, which cannot be encountered in other ball sports (Kamble, Daulatabad, & Baji, 2012). Basketball, as a team sport, requires a developed physical readiness to play a game successfully (McInnes, Carlson, Jones, & McKenna, 1995). A successful basketball game requires the ability of players to generate good speed, agility, and tremendous strength throughout the game (Kamble et al., 2012). Skills such as dribbling, shooting and passing are of the utmost importance to the player at any level of play (Kamble et al., 2012; Santos & Janeira, 2012). In addition to skills and motor skills, changes in body composition and the growth of the body with maturation greatly affect the game of basketball (Malina, Bouchard, & Bar-Or, 2004; te Wierike, de Jong, Tromp, Vuijk, Lemmink, Malina et al., 2014).

Appropriate body composition and body mass, among other factors, contribute to exercise and performance (Massuça & Fragoso, 2011). It has been proven that body mass can negatively affect an athlete's speed and endurance (Massuça & Fragoso, 2011), while body composition can positively affect strength and agility (Chaouachi, Brughelli, Chamari, Levin, Abdelkrim, Laurencelle, & Castagna, 2009). In other words, success in basketball, in addition to a high level of technical and tactical skills, also requires from each athlete appropriate anthropometric characteristics and body composition (Popovic, Akpinar, Jaksic, Matic, & Bjelica, 2013). High body height will give a significant advantage in achieving success (Popovic et al., 2013), as lower body mass and lower growth of basketball players will affect the advantage in achieving success in long-term competition compared to basketball players with higher

body mass. Based on research conducted on preadolescent basketball players (Popovic et al., 2013; Perroni, Vetrano, Camolese, Guidetti, & Baldari, 2015; Gryko, Stastny, Kopiczko, Mikołajec, Pecha, & Perkowski, 2019), it can be seen that the average body height is 166.1±9.7 cm, average body mass 56.9±9.8 kg, average body mass index (BMI) 20.5±2.4 kg/m^2 (Toselli, Campa, Maietta Latessa, Greco, Loi, Grigoletto, & Zaccagni, 2021), average percentage of subcutaneous adipose tissue is 10.2±7.6% (Gryko et al., 2019), and average percentage of muscle mass 35.68±7.18% (Vigo & Viviani, 2020). Researches (Vaeyens, Lenoir, Williams, & Philippaerts, 2008; Gryko et al., 2019) have shown that body composition can be a good educator for selection in basketball, especially since body composition itself can affect strength (Ugarkovic & Kukolj, 2002). Strength is the most important motor ability on which basketball is based (Ziv & Lidor, 2010). Maximum intensity, in a short time, shows the relationship between the application of explosive power and speed (Alemdaroğlu, 2012), together with related abilities such as agility and change of direction (Sheppard & Young, 2006).

Success in basketball can be predicted if motor skills are tested, and the most influential are: explosive power, repetitive power and static power (Vukasevic, Bubanja, Zarkovic, Jabucanin, & Masanovic, 2021). By determining the optimal model of body composition, in order to better improve strength, there is a need to define models of body composition and strength, as well as a closer explanation of their relationship. According to previous research, it has been proven that body composition affects the strength of basketball players. Body mass adversely affects the results of explosive power of basketball players (Nikolaidis, Asadi, Santos, Calleja-González, Padulo, Chtourou, & Zemkova, 2015), which has been confirmed in other works on respondents from other sports (Cormie, McBride, & McCaulley, 2007; Thompson, Ryan, Sobolewski, Smith, Akehi, Conchola, & Buckminster, 2013). Also, it was confirmed that there is a negative relationship between increased body mass and strength in subjects (Folland, Mc Cauley, & Williams, 2008). The relationship between BMI and explosive power has not been previously studied in a large number of papers on basketball players (Nikolaidis et al., 2015). However, there is evidence of a negative impact on overall strength in female volleyball players (Nikolaidis, 2013), football players (Nikolaidis, 2012) and handball players (Nikolaidis & Ingebrigtsen, 2013) of different ages. Data on the influence of body fat on the strength of basketball players (Ostojic, Mazic, & Dikic, 2006) indicate a negative outcome on strength variables. Research conducted on handball players has also confirmed a negative impact on strength performance (Visnapuu & Jürimäe, 2009; Ciplak, Eler, Joksimović, & Eler, 2019; Hermassi, Chelly, Wagner, Fieseler, Schulze, Delank, Shepard, & Schwesig, 2019; Kale & Akdoğan, 2020). The relationship between the percentage of muscle mass and the strength of basketball players was investigated in the staudy of Torres-Unda, Zarrazquin, Gil, Ruiz, Irazusta, Kortajarena, Seco, & Irazusta (2013), where it was proven that a higher percentage of muscle mass has a positive effect on strength tests. The works, whose subjects were handball players of different ages, also proved that a higher percentage of muscle strength has a positive effect on explosive, repetitive and static strength (Debanne & Laffaye, 2011; Saavedra, Kristjánsdóttir, Einarsson, Guðmundsdóttir, Þorgeirsson, & Stefansson, 2018; Hammami, Hermassi, Gaamouri, Aloui, Comfort, Shephard, & Chelly, 2019; Molina-López, Barea Zarzuela, Sáez-Padilla, Tornero-Quiñones, & Planells, 2020).

According to our review, previous studies have included respondents of different ages, different sports, athletic fitness and sports status, and not a single study included semi-professional preadolescent basketball players. In this regard, the aim of the study was to determine how body composition affects the strength of basketball players of that age.

METHODS

Subjects

Nineteen basketball players aged 14.10±0.55 years, with a sports experience of 6.77±1.25 years participated in the research. The sample included only respondents who voluntarily agreed to participate. Prior to testing, parental consent was obtained for each underage respondent. All subjects were clinically healthy and had no serious injury in the last six months from the day of testing.

Procedure

The testing was performed in the lighted basketball hall, in the evening (19 h). Anthropometric measurements were made before strength testing. After the standard 15-minute warm-up, which included a different run with a change of direction (with and without the ball), and exercises for increasement of the range of movement, the basketball players were tested. Body height was measured with Martin's anthropometer GPM 101 *(GPM GmbH Switzerland)* with an accuracy of 0.1 cm. Body mass,

BMI, body fat percentage and percentage of muscle mass, were measured using Omron BF511 bioelectric impedance device (Kyoto, Japan*).* The reliability and validity of the Omron BF511 bioelectric impedance has been confirmed by Dehghan & Merchant (2008). All applied strength tests used in this study were conducted according to a standardized measurement procedure, and were selected because of their good metric characteristics. Measurement conditions and techniques were according to Metikoš, Prot, Hoffman, Pintar, & Oreb (1989), and the reliability and validity of tests were confirmed in scientific papers (Metikoš et al., 1989; Aragón, 2000; Baumgartner, Oh, Chung, & Hales, 2002; Larsson, Tegern, Monnier, Skoglund, Helander, et al., 2015; Kalach, Gontarev, Stardelova, & Tasevski, 2016). The Eurofit Physical Fitness Test Battery (1988) was used. Explosive strength: long jump, high jump, running 20 m high start; repetitive strength: V-ups on bench, Push-ups, hyperextension exercise; static strength: bent-arm hang, arm hang with legs forward, leg extension.

Statistical analysis

Arithmetic value (Mean) and standard deviation (SD) were calculated for each variable. The Kolmogorov-Smirnov test was used to confirm normality of data distribution. The relationship between body composition and strength was assessed using Pearson's coefficient (r): 0.10 to 0.30 should be interpreted as a weak correlation, 0.30 to 0.50 as a moderate correlation, and greater than 0.50 as a strong correlation (Cohen, 1988). Statistical significance was set at $p<0.05$. Statistical procedures and analyses were conducted using the statistical program IBM SPSS Statistics 20.

RESULTS

The results of descriptive statistics of body composition and strength are shown in Tables 1 and 2, respectively.

Table 1. Descriptive statistics of body composition parameters of 19 basketball players

Variables	Mean±SD
BH(cm)	162.35±10.93
BM (kg)	52.1±11.15
BMI (kg/m²)	19.63±2.51
BF (%)	13.94±4.09
MM (%)	37.86±4.3

Legend: Mean- average value, **SD-** standard deviation, **BH-** body height, **BM-** body mass, **BMI-** body mass index, **BF-** percentage of body fat, **MM-** percentage of muscle mass.

Table 2. Descriptive statistics of strength parameters of 19 basketball players

Variables	Mean±SD
Explosive strength	
LJUMP(cm)	173.4±18.3
M20M (s)	4.08±0.26
HJUMP(cm)	31.55±4.89
Repetitive strength	
V-UPS (rep)	23.9±15.03
P-UPS (rep)	8.05±6.3
HYPER (rep)	8.65±4.41
Static strength	
BAH (s)	7.54±6.99
AHL (s)	19.45±2.35
LEGE (s)	63.75±33.2

Legend: Mean- average value, **SD-** standard deviation, **LJUMP-** long jump, **M20M-** running 20m high start, **HJUMP-** high jump, **V-UPS-** V-ups on bench, **P-UPS-** push-ups, **HYPER-** hypertension exercise, **BAH-** bent-arm hang, **AHL-** arm hang with legs forward, **LEGE-** leg extension, **rep-** number of repetitions.

The relationship between body composition and strength is shown in detail using a matrix Pearson's coefficient correlations (r) in Table 3.

Table 3. Pearson's correlation matrix of all variables

Variables (n=19)		Explosive strength			Repetitive strength			Static strength		
		LJUMP	M20M	HJUMP	V-UPS	P-UPS	HYPER	BAH	AHL	LEGE
BM	r	-0.296*	-0.076	0.215*	-0.24	-0.349	-0.335	-0.362	-0.33	0.22
	p	0.02*	0.07	0.03*	0.32	0.14	0.16	0.12	0.16	0.36
BMI	r	-0.372	-.539*	-.519*	-0.452*	-.554*	-0.391	-.499*	-0.059	-0.426
	p	0.11	0.01*	0.02*	0.05*	0.01*	0.09	0.02*	0.80	0.07
BF%	r	-0.152	0.011	-0.306*	0.002	-0.269*	-0.434*	-0.238	0.194	-0.291
	p	0.53	0.96	0.02*	0.99	0.02*	0.05*	0.32	0.42	0.24
MM%	r	-0.078	-0.115	-0.336	0.036	-0.196	-0.239	-0.182	0.061*	-0.23
	p	0.75	0.64	0.16	0.88	0.42	0.32	0.45	0.05*	0.35

Legend: BM- body mass, **BMI-** body mass index, **BF-** percentage of body fat, **MM-** percentage of muscle mass, **LJUMP-** long jump, **M20M-** running 20m high start, **HJUMP-** high jump, **V-UPS-** V-ups on bench, **P-UPS-** push-ups, **HYPER-** hypertension exercise, **BAH-** bent-arm hang, **AHL-** arm hang with legs forward, **LEGE-** leg extension, p- p-value, r- Pearson's correlation cooefficient.

* statistically significant correlation: $p<0.05$

DISCUSSION

The aim of the study was to determine how body composition affects the strength of basketball players. The main results of this study show a high correlation of body composition with strength variables. The greatest responsibility for the association in the variables had the results of the BMI, BF%, then BM, and the variable that has the lowest correlation with the variables of strength is the MM%. Also, body mass results did not correlate with repetitive strength results, just as body fat percentage was not statistically significantly associated with static strength variables. The variables of explosive and repetitive power did not have a statistically significant correlation with the percentage of muscle mass.

BMI results showed the highest correlation with strength tests. The highest negative correlation was recorded with the variables of explosive strength M20M and HJUPM (-.539 and -.519, respectively; p=0.01), then slightly lower negative correlation was recorded with the results of explosive and static strength, i.e. HJUMP and BAH (p= 0.02), and the least statistically significant correlation was observed in the variable repetitive power V-UPS (r=-.452, p=0.05). In previous research, the results of body mass have shown a direct connection with the results of strength. Namely, it has been proven that higher results of BMI adversely affect the results of explosive power (Moncef, Said, Olfa, & Dagbaji, 2012; Hammami et al., 2019; Molina-López et al., 2020; Rinaldo, Toselli, Gualdi- Russo, Zedda, & Zaccagni, 2020), while a small number of papers (Nikolaidis & Ingebrigtsen, 2013; Nikolaidis, 2012; Nikolaidis et al., 2015) indicate a negative impact in static and repetitive strength performances.

The percentage of body fat (BF%) had a large negative correlation with the results of repetitive and explosive strength in the variables HJUMP(r=-.306, p=0.02) and P-UPS (r=-.269, p=0.02); a slightly lower negative correlation was observed in variable HYPER (r=-.434, p=0.05), while static strength variables did not show a statistically significant association with body fat percentage. It can be assumed that a higher level of body fat percentage decrease results in the mentioned variables. Studies that analysed the percentage of body fat in basketball players (Kamble et al., 2012; Ribeiro, Mota, Sampaio-Jorge, Morales, & Leite, 2015; Masanovic, 2018) showed that the statistical significance of the negative impact of body fat on strength was confirmed, which was also confirmed by research in other sports (Ciplak et al., 2019; Kale & Akdoğan, 2020).

Variables BM and MM% had the least correlation with strength variables. Namely, the largest negative correlation between body mass and explosive strength is in the variables LJUMP (r=-.296, p=0.02) and HJUPM (r=.215, p=0.03), while no statistically significant correlation was proven with the variables of repetitive and static strength. The percentage of muscle mass was positively correlated with only one strength variable- AHL (r=0.061, p=0.05). Other results of explosive, repetitive and static strength did not have a statistically significant correlation with the results of the percentage of muscle mass. In previous studies which examined the relationship between body mass and muscle mass percentage with strength, was proven the positive effect of muscle mass percentage on strength results (Erculj, Blas, & Bracic, 2010; Kamble et al., 2012; Santos, Matias, Rocha, Minderico, Allison, Sardinha, & Silva, 2014; Nikolaidis et al., 2015), as well as the negative impact of increased body mass on explosive power (Kale & Akdoğan, 2020; Visnapuu & Jürimäe, 2009).

CONCLUSION

From the obtained results of this research, it can be concluded that there is a statistically significant correlation of body composition and strength of basketball players. Therefore, a higher body mass index adversely affects the results of explosive, repetitive and static strength. Generally, it can be concluded that weight training has a negative effect on the explosive power of basketball players, and that the development of muscles contributes to an increase in the percentage of muscle mass that affects the better results of static strength of basketball players. The limitation of this study is that the results of the percentage of muscle mass did not correlate with the results of explosive and repetitive power, and thus a large part remained inexplicable.

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Physical Activity and Health

THE EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING PROGRAMMES WITH DIFFERENT FREQUENCIES ON BODY COMPOSITION AND BLOOD LIPIDE PROFILE IN PHYSICALLY ACTIVE MALES

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ABSTRACT

High intensity interval training (HIIT) is a time-efficient and enjoyable method of exercise improving both health and performance related parameters. Indeed, HIIT has been reported to result in more fat loss compared to traditional endurance training. Possible reasons for this effect are higher metabolic rate up to 48 hrs after training and higher fat oxidation due to increased total energy expenditure during HIIT. It is also well documented that HIIT leads to improvement in blood lipid profile. However, there is limited study comparing the frequency of HIIT sessions on health-related variables. Thus, this study aims to compare the effects of HIIT programme with different frequencies on body composition and blood lipid profile in physically active males. Twenty-six young physically active males (age 20.1±2 yrs; height 176.1±5.13 cm; weight 72.8±7.5 kg; body mass index (BMI) 23.5±2.0 kg/m2; body fat percentage (BFP) 19.0±4.4 %) were randomly divided into 3 groups (HIIT2, n=9; HIIT4, n=9; Control, n=8). HIIT2 and HIIT4 groups participated in a 6-week HIIT programme 2 or 4 times per week, respectively. HIIT consisted of standard Wingate protocol with 2 min recovery intervals, gradually increasing from 4 sets/session at week 1 to 9 sets/session at week 6. Control group did not change their routine exercise programme. DXA derived body composition (body weight, fat mass, soft lean mass, BF%) and blood lipid profile (total cholesterol, triglyceride, high-density lipoprotein, low density lipoprotein) were determined before and after the HIIT programme. A 5-day nutrition records were taken at the beginning, middle and end of the programme. Effects of the treatments were compared by Analysis of Covariance (ANCOVA) by inserting the pre-tests as the covariate. Repeated measure ANOVA was used to compare the nutrients and energy intakes throughout the study. No significant difference was found between the experimental groups either in body composition or blood lipid variables ($p>0.05$). Nutrients (protein, fat, carbohydrate) and energy intakes (kcal) were similar at three time points of the study for all three groups ($p>0.05$). Six weeks of HIIT either 2 or 4 times per week did not change body composition or blood lipid profile in physically active young males. Considering that the participants' body composition variables and blood lipid profile at baseline were within the normal ranges this finding is not surprising. On the other hand, considering possible increase in energy expenditure due to HIIT, and that energy intake did not change throughout the study we were expecting an energy deficit and thus weight loss. However, as we did not determine energy expenditure we do not know whether energy deficit occurred during the study or not. In conclusion, short term HIIT training either 2 or 4 times per week did not change body composition or blood lipid profile in physically active young males.

Keywords: blood lipid profile, cholesterol, triglycerides, frequencies, HIIT

INTRODUCTION

Physical inactivity is a major risk factor for many chronic diseases. Sedentary lifestyle may increase the risk of coronary heart disease (CHD), especially by impairing cardiovascular fitness and blood flow (Medicine, 2013). If physical inactivity can be changed, it helps reduce the risk of CH (Pearson, Maron,

Ridker, & Grundy, 2001). Exercise has a positive effect on lipid and carbohydrate metabolism, and moderate decreases in body weight, fat stores, total cholesterol (TC), serum triglycerides (TGs), low-density lipoprotein cholesterol (LDL-C) and an increase in antiatherogenic high-density lipoprotein cholesterol (HDL-C) (Tran & Weltman, 1985). Cholesterol can be produced by the body, and its level in the body can also change through nutrition. It has been reported that the amount of cholesterol and TGs in the blood is very important in terms of evaluating the risk of cardiovascular disease (CVD) (Libby, Bonow, & Mann, 2011). Although a certain amount of cholesterol is necessary for the body, it is emphasized that excess cholesterol accumulates in the vessels, leading to deterioration of elasticity (atherosclerosis) and blockages, leading to hypertension, cardiovascular diseases, infarction, stroke and paralysis (Genest, 2019). Sedentary lifestyle causes many health problems. The most important of these are known as TC, LDL-C and low levels of HDL-C, which are among the main risk factors for CVD (Conroy et al., 2003; NCEP, 2002). In the follow-up studies of healthcare professionals, they report that physical activity is significantly and positively associated with HDL-C (Fung et al., 2000). Unusual increases and decreases in blood lipid profile are known as dyslipidaemia (Mora, Cook, Buring, Ridker, & Lee, 2007; Yusuf et al., 2004) and constitute an important risk factor for cardiovascular diseases such as ischaemic stroke (Goldstein et al., 2001); non-alcoholic fatty liver disease (Cohen & Fisher, 2013); and chronic pancreatitis (Ewald, Hardt, & Kloer, 2009).

Physical inactivity may cause health problems such as weight gain, high blood pressure, hypercholesterolemia, insulin resistance (Wu, Gao, Chen, & Van Dam, 2009) as well as an important cause of morbidity and mortality (Löllgen, Böckenhoff, & Knapp, 2009). Current physical activity guidelines including those from the Canadian Society for Exercise Physiology (CSEP) recommend that adults should accumulate at least 150 min of moderate- to vigorous-intensity aerobic physical activity per week to achieve health benefits (Tremblay et al., 2011). The CSEP guidelines do not specifically define intensity ranges; however, guidelines from other agencies, including the American College of Sports Medicine, classify moderate intensity as 64%–76% of maximal heart rate (HR_{max}) (46%–63% of maximal oxygen uptake (VO_{2max}) and vigorous intensity as 77%–95% of HR_{max} (64%–90%VO_{2max}) (Garber et al., 2011). Researchers are seeking physical activity that provides sustainable behaviour and positive improvement in health-related parameters. Lack of sufficient time to exercise and exercise programs that take a long time are seen as the main causes of inactivity. In addition, the majority of exercise protocols that increase fat oxidation require regular and long-term exercises (Wu et al., 2009). High intensity interval training (HIIT) is an exercise trend that can be beneficial in this regard (Kilpatrick, Jung, & Little, 2014). HIIT (Tabata et al., 1996) appears to result in greater fat loss compared to traditional continuous running training (Tabata et al., 1996). It has been stated that metabolic rate remains high even 48 hours after training with HIIT studies (Hickson, Foster, Pollock, Galassi, & Rich, 1985).

This study aims to compare the effects of 6-weeks incremental HIIT programme with different frequencies on body composition, blood lipid profile, nutrients and energy intake of physically active males.

METHODS

Subjects

Twenty-six volunteer male who do sports for recreational purposes at least 2 days a week and have done team sports before [age 20.1±2 yrs; height 176.1±5.1 cm; body weight (BW) 72.8±7.5 kg; body mass index (BMI) 23.5±2.0 kg/m^2; body fat percentage (BFP) 19.0±4.4 %] were included and randomly divided into three groups (HIIT2, n=9; HIIT4, n=9; Control, n=8). Ethics committee approval was obtained for the study with the decision number 07-364-17. Exclusion criteria were determined as presence of a chronic disease, presence of diabetes, and presence of a drug that is used continuously.

Procedure

HIIT (30sec x 4reps/120sec rest) was performed with the MonarkPeak bicycle ergometer (Sweden), asking the participants to do their best against a load corresponding to 7.5% of their body weight. Participants participated in a HIIT programme that lasted 6 weeks (HIIT2 2d/wk and HIIT4 4d/wk). The sets of both groups were designed to be 9 sets at the end of 6 weeks by increasing 1 set per week. When the pedaling rate reached to 150 rpm the resistance was applied and the subjects continued to pedal as fast as possible for 30 seconds. The control group continued their routine exercises for at least 2 days and maximum 4 days a week. Anthropometric measurements, blood samples were taken from the

participants before and after the HIIT programme. In addition, 5-day nutrition records were taken at the beginning, middle and end of the programme.

Anthropometric Measurements

The height of the participants was measured before starting the HIIT program. BW and body composition were measured before and after the 6-week HIIT program. Height was measured with a stadiometer (Holtain UK) record as cm. BW, fat mass (FM), body fat percentages (BFP), total muscle mass (MM) and soft lean mass (SFM) were determined with dual energy x-ray absorptiometry (DEXA, Lunar Prodigy Pro narrow Fan Beam (4.5°), USA) in whole body scanning mode.

Blood Samples

The blood samples (cholesterol and triglycerides) of the participants were taken 48 hours before starting the HIIT program and 48 hours after the 6-week HIIT program was finished, between 09:00 am and 11:00 am in the morning, while the participants were at rest and on a full stomach. Blood samples were taken from the forearm (vena mediana cubiti or vena cephalica) by the medical doctor with a syringe by attaching a tourniquet to the arm, transferred to the relevant tubes and transferred to the laboratory within 2 hours after cooling. All tubes were centrifuged (1500-2000 cycle for 10-15 minutes) before analysis, and then studied by chemiluminescence method in Siemens Centaur XP immunoassay device.

Statistical analysis

After descriptive statistics (mean±SD) of all variables were made, the effects of HIIT training applied at two different frequencies on body composition, blood lipid profile, and food and energy intake of the participants were analyzed with repeated measures ANOVA. The significance value was accepted as $p<.05$.

RESULTS

Table 1 shows that there was a statistically significant difference within subjects in BW, TMM and SLM ($p_{BW}=.006$; $p_{SLM}<.001$, $p_{TMM}=.005$), however there was no statistically significant difference between subject and group by time interaction ($p>.05$). FM and BFP did not show statistically significant difference within subject, between subject and group by time interaction ($p>.05$).

Table 2 shows that there is no statistically significant difference in within subject, between subject and group by time interaction in any variables ($p>.05$).

Table 1. Antropometric measures outcome pre and post six weeks HIIT

n=26	Groups	Pre-test mean±SD	Post-test mean±SD	Within subjects			Between subjects			Group time		
Variables				F	p	η^2	F	p	η^2	F	p	η^2
BW (kg)	CG	71.37±4.63	72.61±5.91									
	HIIT2	71.84±7.35	72.75±7.36	9.20	.006*	.286	.636	.539	.052	.131	.878	.011
	HIIT4	75.27±9.66	76.12±9.43									
FM (kg)	CG	14.67±2.91	15.00±3.42									
	HIIT2	13.79±4.46	13.42±4.15	.353	.558	.015	.166	.848	.014	1.22	.313	.096
	HIIT4	14.32±5.63	14.00±5.07									
BFP (%)	CG	20.21±3.25	20.27±3.31									
	HIIT2	18.74±4.69	18.08±4.55	3.10	.092	.119	.554	.582	.046	1.03	.371	.083
	HIIT4	18.44±5.29	17.90±4.75									
SLM (kg)	CG	54.41±3.22	55.32±3.67									
	HIIT2	55.95±4.87	57.21±5.68	17.8	<.001*	.438	1.56	.230	.120	.173	.842	.015
	HIIT4	58.52±5.80	59.76±6.09									
TMM (kg)	CG	72.32±4.57	73.52±5.87									
	HIIT2	72.71±7.27	73.62±7.43	9.89	.005*	.301	.630	.542	.052	.091	.913	.008
	HIIT4	76.11±9.56	77.01±9.35									

Legend: BW- Body weight, **FM-** Fat Mass, **BFP-** Body Fat Percentage, **TMM-** Total muscle mass, **SLM-** Soft lean mass, **CG-** Control group

Table 2. Comparisons of blood lipid profile before and after six weeks of HIIT programme

Variables	Groups	Pre-test mean±SD	Post-test mean±SD	Within subjects			Between subjects			Group time interaction		
				F	p	η^2	F	p	η^2	F	p	η^2
TC	CG	164.25±25.7	161.12±41.5									
	HIIT2	169.55±35.6	170.66±33.6	.188	.669	.008	.151	.861	.013	.117	.890	.010
	HIIT4	170.44±23.2	165.88±25.3									
HDL-C	CG	42.25±5.8	43.37±4.3									
	HIIT2	46.33±8.6	44.66±7.6	.004	.949	.000	.597	.559	.049	.601	.557	.050
	HIIT4	47.55±12.5	47.88±14.0									
LDL-C	CG	102.37± 22.8	93.125±34.4									
	HIIT2	106.00±25.6	102.77±22	2.08	.162	.083	.500	.613	.042	.171	.844	.015
	HIIT4	95.88±24.7	90.22±27.4									
TG	CG	99.25±46.7	122.62±67.0									
	HIIT2	86.00±22.5	114.22±64.2	2.38	.136	.094	.404	.673	.034	1.23	.310	.097
	HIIT4	135.00±70.4	138.77±69.3									

Legend: TC- Total Cholesterol, **HDL-** High Density Lipoprotein- Cholesterol, **LDL-** Low Density Lipoprotein- Cholesterol, **TG-** Triglyceride, **CG-** Control group

Table 3 shows that there is no statistically significant difference in nutrients (protein, fat, carbohydrate) and energy intake within subject, between subject and group by time interaction (p>.05).

Table 3. Changes in energy intake pre-mid and post HIIT programme

n=26	Pre-test mean±SD	Mid-Test mean±SD	Post-test mean±SD	Within subjects			Between subjects			Group*time		
	CG	HIIT2	HIIT4	F	p	η^2	F	p	η^2	F	p	η^2
Energy intake (kcal)												
Pre	1760.7±337	1864.2±520	2541.8±574									
Mid	2021±479	1856.4±467	2425.8±899	.072	.891	.003	2.52	.102	.180	1.36	.268	.106
Post	1948.8±712	2066.8±648	2218±733									
Protein intake (g)												
Pre	84.830±15.5	85.692±20.48	116.11±37.1									
Mid	90.738±21.6	93.025±23.17	112.82±48.8	.529	.593	.022	2.43	.110	.175	.190	.942	.016
Post	92.795±29.1	95.272±32.77	116.66±42.5									
Fat (g)												
Pre	66.121±15.6	72.326±27.19	85.26±21.3									
Mid	73.64±19.3	70.95±24.04	79.14±40.9	.401	.615	.017	.663	.525	.055	.279	.841	.024
Post	73.66±33.6	81.34±33.34	83.83±31.3									
CHO (g)												
Pre	196.84±50.6	203.77 ±64.49	313.07±128									
Mid	229.46±58.3	200.94±75.35	302.27±149	.385	.683	.016	1.92	.168	.144	2.54	.052	.181
Post	220.74± 81.4	229.75±83.99	239.55±143									

Legende: Cho- Carbohydrate, **CG-** Control Group

DISCUSSION

As it is known, HIIT is the most popular exercise trend of recent times. Most of the studies focusing on the blood lipid profile of HIIT have been studied in the unhealthy (obese, diabetes, metabolic syndrome) population and positive results have been observed (Fisher et al., 2015; Kong et al., 2016; Matsuo, So, Shimojo, & Tanaka, 2015; Paoli et al., 2013; Ruffino et al., 2017). However, there are very few studies examining the changes in blood lipid profile and body composition when physically active individuals without any health problems perform HIIT (Lira et al., 2019; Musa, Adeniran, Dikko, & Sayers, 2009).

In the current study, when the anthropometric measurements of the participants were examined, there was a statistically significant difference in BW, SLM and TMM values within subjects but no

statistically significant difference was found group by time interactions. The FM and BFP were examined, it was observed that there was a decrease in the training groups (HIIT2-HIIT4) and an increase in the CG, although it was not statistically significant. It is seen that long-term HIIT programs are used in studies where fat loss is observed (Dunn, 2009; Schröder et al., 2004; Trapp, Chisholm, Freund, & Boutcher, 2008). In the current study, it is thought that the reason for the lack of fat loss is due to the short duration of the training programme. Compared to other studies in which a decrease in fat was observed, the reason why there was no significant decrease in fat ratio in the current study can be explained by the fact that the individuals included in the current study had an optimal fat ratio while other studies were working with overweight or obese individuals (Gremeaux et al., 2012; Kong et al., 2016; Smith-Ryan, Trexler, Wingfield, & Blue, 2016). In addition, considering that anthropometric changes require more time, the low training period of the current study (6 weeks) may be among the reasons for the lack of fat loss.

The blood lipid profile results of the current study were examined, no statistically significant difference was found in TC, HDL-C, LDL-C and triglyceride values within subjects and in the group by time interaction. However, in the HIIT4 group, there was a 2.67% decrease in TC value and a 5.90% decrease in LDL-C value. There was a ~1% increase in the TC/HDL-C ratio (pre -27.89%/ post- 28.86%). LDL-C values showed a decreasing trend in all groups. Although not statistically significant, triglyceride values increased after 6 weeks in all groups, but this rise was still below the recommended 150 md/dL for healthy adult individuals. The increase in triglyceride level was noticeable in the control and HIIT2 groups, while a slight increase was observed in the HIIT4 group. Similarly, Nybo et al. observed no change in the TC, HDL, LDL and TC/HDL ratio of the HIIT group after the 12-week HIIT programme (Nybo et al., 2010). Considering the results of studies investigating the effect of HIIT programs on blood lipid profiles, it is reported that it has little effect, but this effect is not yet clear (Musa et al., 2009). As a result, although it was not statistically significant in the blood lipid profiles of the participants in our study, positive results were observed except for TG.

CONCLUSION

In a conclusion, no difference was found between the groups for body composition (BW, SLM, BFP, TMM and BFP); blood lipid profile (TC, HDL-C, LDL-C, TG). That is why there is insufficient evidence to prove the superiority and effectiveness of one of the protocols.

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RELATIONSHIPS BETWEEN LEVELS OF PHYSICAL ACTIVITY AND MORPHOLOGICAL CHARACTERISTICS OF CHILDREN

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ABSTRACT

Regular physical activity in early childhood is an important component, crucial for the physical and psychological development of children, for healt maintaining, and it is related to a large number of anthropological characteristics and abilities. The aim of the study was to determine the relationships between the levels of physical activity and morphological characteristics of children aged 12-13 years. The sample of respondents consisted of 97 students (47 boys and 50 girls) from the Elementary School "Bora Radić" from Bavanište, aged 12 and 13. The following variables were used to assess morphological characteristics: body mass, upper arm circumference, lower leg circumference, and body fat percentage. The level of physical activity was assessed using the FELS questionnaire. Data processing was realized using the statistical processing program Statistica 8.0, and canonical correlation analysis was applied to determine the relationship between the level of physical activity and morphological characteristics. Based on the obtained results it can be concluded that there is a negative correlation between low levels of physical activity and morphological characteristics, with the greatest correlation between total physical activity and the percentage of body fat (p=.000).

Keywords: physical activity, morphological characteristics, children

INTRODUCTION

Early childhood is a crucial period for the physical and psychological development of children. During childhood, regular physical activity has numerous benefits for children's health (Popović, Cvetković, Mačak, Šćepanović, Čokorilo et al., 2020). Modern lifestyle and reduced physical activity result in the appearance of various health problems of school children around the world.

Children's and adolescents' physical activity is one of the important factors that affect health in all age categories, as well as the prevention of various diseases (Petrić, Novak, & Šafarić, 2011). Based on some studies, it can be stated that physical activity contributes to health maintaining and preventing the occurrence of many modern diseases, such as cardiovascular disease, obesity, certain malignant diseases, etc. (Oliveira & Guedes, 2016; Pavlović, Marinković, Đorđić, & Pelemiš, 2018). Due to reduced physical activity and high levels of sedentary behaviour, obesity and various metabolic problems occur (Fearnbach et al., 2020). In the last two decades, there has been a trend of increasing overweightness and obesity in children and adolescents (Anderson, 2018; Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018; Garrido-Miguel et al., 2019). Body mass and physical activity are closely related- physical activity is considered to be an important regulator of body mass. Regular physical activity in both boys and girls is associated with a lower percentage of body fat in the total body composition. There are differences in the amount of body fat in children aged 12-13 who are physically active and physically inactive and they are greater in girls than in boys (Bralić, 2008). The existance of positive correlation between regular physical activity and morphological characteristics of children is confirmed by the data of individual studies conducted in the USA and Canada (Pabayo, Gauvin, Barnett, Nikiéma, & Séguin, 2010). Children who actively travelled to school (walking, cycling, etc.) had noticeably less body fat. The American College of Sports Medicine (ACSM) recommends children to be physically active for at least one hour a day, which includes a trip to school, participation in a Physical Education classes, playing outside, organized games,

etc. Intensity during physical activity should be moderate to high (ACSM, 2018). When it comes to sedentary behaviour, recommendations for recreation that includes this type of behaviour are a maximum of two hours a day (Jakšić, Mandić, Maksimović, Milošević, Roklicer, Vuković et al., 2020).

Some studies indicate that children spend less and less time in physical activities, with some data suggesting that this population spends an average of 7 hours a day in sedentary activities, using mobile phones, computers, watching TV, etc. Also, there are data indicating a decrease in participation in physical activities over the years, which indicates that younger adolescents (11-13 years) are more physically active than older adolescents aged 14 to 19 years (López-Sánchez, Emeljanovas, Miežienė, Díaz-Suárez, Sánchez-Castillo, Yang et al., 2018).

The aim of this study is to determine the relationships between levels of physical activity and morphological characteristics of children aged 12-13 years.

METHODS

Subjects

The sample of respondents in the research consisted of fifth and sixth grade students of the Elementary School "Bora Radić" in Bavanište, aged 12 and 13. The total number of students was 97, i.e. 47 boys and 50 girls.

Procedure

The following parameters were used for the assessment of morphological characteristics: body mass, lower leg circumference, upper arm circumference, and body fat percentage (Slaughter et al., 1988). For determining the level of physical activity (PA), a survey protocol was applied with a standardized international questionnaire for assessing the level of physical activity for children and youth– FELS PAQ for Children (Treuth, Hou, Young, & Maynard, 2005). This questionnaire contains questions on the frequency and intensity of physical activity in the field of sports, physical activity in leisure time, physical activity at home and total physical activity. The validity and reliability of the questionnaire for this population group was confirmed in the studies of Treuth et al. (2005) and Abreu, Nascimento, Jardim, & Rozov (2010). The questionnaire was also used in some previously conducted studies (Chinapaw, Mokkink, van Poppel, van Mechelen, & Terwee, 2010).

Statistical analysis

Statistical data processing was realized using the statistical package Statistica 8.0. The basic parameters of descriptive statistics (Mean, SD, Max, Min, Range) were calculated. Canonical correlation analysis was applied to determine the relationship between the level of physical activity and morphological characteristics.

RESULTS

Table 1 shows the descriptive parameters of the level of physical activity and morphological characteristics of children aged 12 and 13 years. Based on the obtained results it can be concluded that a good number of variables for assessment of PA level and morphological characteristics showed good discriminativity of measurements.

When determining the relationship between the level of PA and the domain of morphological characteristics (Table 2), it was found that there is a statistically significant correlation in one pair of canonical factors (p=.000). The canonical correlation is .61 (R=.61), and the coefficient of determination R^2=.37, which explains 37% of the total variability.

Table 1. Descriptive statistics

	n	Mean	SD	Max	Min	Range
Sport	97	3.90	.68	1.67	5.00	3.33
Leisure time	97	4.00	.50	2.67	5.00	2.33
Housework	97	3.46	.61	2.00	5.00	3.00
Total PA	97	11.36	1.04	8.67	13.67	5.00
Body mass	97	45.73	9.09	31.00	73.00	42.00
Lower leg circumference	97	32.95	3.70	26.00	40.00	14.00
Upper leg circumference	97	25.00	3.01	20.00	34.00	14.00
BF%	97	20.73	6.46	9.60	36.30	26.70

Legend: n- number of respondents, **Mean-** mean value, **SD-** standard deviation, **Min-** minimum value, **Max-** maximum value, **PA-** physical activity, **BF%-** percentage of body fat

Table 2. Isolated canonical function

	R	R^2	X^2	df	p
0	.61	.37	50.02	16	.000**
1	.27	.07	9.11	9	.427
2	.16	.03	2.46	4	.651
3	.01	.00	.01	1	.938

Legend: R- canonical correlation, **R^2-** coefficient of determination, **X^2-** Bertlett's Hi-square test, **df-** degree of freedom, **p–** level of significance
** p<.01

Table 3 shows the factor structure of isolated factors, levels of physical activity and morphological characteristics. The highest values for the parameters of the level of physical activity were achieved by the variables Total PA (-.98) and Sport (-.79). This factor can also be called the Physical Activity Factor. The highest values in the space of morphological characteristics were achieved by the variables BF% (.96), body mass (.55) and upper leg circumference (.44). This factor may be called the subcutaneous adipose tissue factor.

Table 3. Factor structure

	Root 1		Root 1
Sport	-.79	**Body mass**	.55
Leisure time	-.46	**Lower leg circumference**	.36
Housework	-.43	**Upper leg circumference**	.44
Total PA	-.98	**BF%**	.96

Legend: PA- physical activity, **BF% -** percentage of fat

DISCUSSION

The results obtained in the research show that children who less participate in physical activities have a higher percentage of body fat as well as higher values of voluminosity. In such children, body weight, adipose tissue as well as circular dimensionality are of higher values than in children who are physically active and spend less time in sedentary activities. Total activity and time spent in moderate or vigorous physical activity were inversely proportional to total body fat in the study of Bowen, Taylor, Sullivan, Ebrahim, Kinra, Krishna et al. (2015). The results of the mentioned study showed that 10 minutes more

spent in physical activities of moderate or high intensity contributes to the reduction of body fat by 145 g. In contrast, 10 minutes a day spent in sedentary activities contributes to an increase in body fat by 26 g. Other studies (Jiménez-Pavón, Kelly, & Reilly, 2010) suggest that there is an association between physical activity and body fat percentage, and that children with low BF% and high levels of physical activity have better neuromuscular performance than children with high body fat percentage and low level of physical activity (Morrison, Bugge, El-Naaman, Eisenmann, Froberg et al., 2012). Such data were also confirmed by a meta-analysis realized by Kelley & Kelley (2013).

It is known that the amount of adipose tissue, in addition to genetic factors, is influenced by diet and the level of physical activity, which indicates that with increasement of physical activity level the percentage of body fat decreases. When comparing the amount of adipose tissue of children who are physically active and of those inactive ones, a significant difference in favour of children who are physically active and had significantly less adipose tissue was determined (Maksimović, Ristić, Maksimović, Backović, Vuković, Ille, & Milović, 2009).

The obtained results indicate that children who have a low level of physical activity have higher body weight values. Similar to these data, other studies have shown that a sedentary lifestyle in children, especially watching television for two or more hours a day, is associated with the development of obesity or overweightness (Rey-Lopez, Vicente-Rodriguez, Biosca, & Moreno, 2008). Data from previous studies have shown that there is a positive association between physical activity in children and adolescents and better physical, mental and cognitive health outcomes. Many benefits of physical activity are noticed with on average 60 minutes of moderate and high physical activity per day, with additional physical activity, i.e. over 60 minutes a day provides additional health benefits (Bull, Al-Ansari, Biddle, Borodulin, Buman, Cardon et al., 2020).

Regular physical activity prevents a sudden increase in body weight and the development of diseases associated with obesity. Children who regularly exercise, according to the recommendations of the World Health Organization, have lower body fat estimates, as well as lower body weight, according to the data from the Mitić study (2011).

CONCLUSION

Physical activity significantly affects the physical and psychological health of children. It is recommended that children be physically active for at least 60 minutes a day, and that the intensity of exercise should be moderate to high. Previous research has shown that a small number of children meet these norms. In the realized research, the connection between the levels of physical activity and morphological characteristics of children aged 12 and 13 was determined. The results showed that the greatest correlation existed between total physical activity and the percentage of body fat as total physical activity and body weight. Children who have a low level of physical activity have higher values of the percentage of body fat as well as higher values of body mass. The results obtained in this way indicate that physical activity should be the everyday life of children, and that it is necessary to pay special attention to the promotion of physical activity. In this way, in addition to a positive impact on morphological characteristics, physical activity would have benefits on the overall health of children.

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INFLUENCE OF MUSCLE EXERCISE PROGRAMS ON THE FUNCTIONAL STATE OF THE ORGANISM IN OLDER AGE

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ABSTRACT

In order to determine the impact of the program of exercising muscle abilities on the functional state of the organism in old age, which is the main goal of our study, we reviewed the researches of available journals in the field of sports sciences. The problem of the paper was the collection of literature data and the analysis of the results and conclusions reached by the authors of the research. Muscle strength, muscular (local) endurance and flexibility, as the main components of muscular abilities, are directly related to the health and functional state of the organism in old age. In research on older subjects, the combination of strength training and endurance was equally effective for both strength development and endurance development. The authors conclude that this type of exercise can be more effective, when the most functional physical condition needs to be achieved, in comparison to programs that encourage the development of one ability only. In order to preserve strength and vitality in old age and live well during retirement days, it is best to start maintaining fitness while still young. With regular muscle exercise, a good hereditary basis and a careful diet, one can live a quality and long life.

Keywords: exercise, muscle strength, old people

INTRODUCTION

Although the link between physical exercise and health has been established long time ago, scientists have gained more complete knowledge about the usefulness of the health form as a result of a physically active lifestyle in the past few decades. The habit of regular physical activity has been found to provide effective protection against a variety of chronic diseases, including heart and blood vessel disease, hypertension, obesity, diabetes, and osteoporosis (Rowland, 2007). Aging is genetically conditioned, but it also depends on the levels of physical activity, which means that physical passivity has a negative effect on various physiological systems of the human body, and thus on physical fitness. Organ systems such as muscle, bone, endocrine or cardiovascular, can be improved by certain exercise programs (Singh, 2004). Muscle strength, muscular (local) endurance and flexibility, as the main components of muscular abilities, are directly related to the health and functional state of the organism in old age. Exercising these abilities, in addition to improving the general health of older people and facilitating daily activities by increasing the overall quality of life, is one of the successful ways to combat premature aging (Hakkinen, 2003). Muscle strength training involves systematic and well-planned exercise in which the musculoskeletal system is progressively exposed to a continuous load, with the aim of developing muscle capacity (ACSM, 2009). This type of exercise with a gradual increase in load can be practiced in old age (Kraemer, Adams, Cafarelli, Dudley, & Dooly, 2002; Fleck & Kraemer, 2003). In order to determine the impact of the program of exercising muscle abilities on the functional state of the organism in old age, which is the main goal of our study, we reviewed the researches of available journals in the field of sports sciences. The problem of the paper was the collection of literature data and the analysis of the results, so as conclusions reached by the authors of the research.

METHODS

The collecting of literature data was performed using internet search bases (Google Scholar, KoBSON, PubMed) of available journals in the field of sports sciences. The search was performed using the keywords: exercise, muscle strength, old people. The review of the literature included more than 50 studies, of which more than half dealt with the impact of muscle fitness training programs on the functional state of the organism in old age. The systematization of the studies was performed according to the criterion of the impact of the program of exercising muscular abilities on the organism of older people. The method of data processing is descriptive, because the authors of the study applied different exercise programs, and measurements were performed with different measuring instruments, which is why there was no possibility of comparing the results by other methods.

RESULTS

Anton, Spirduso, & Tanaka (2004) have come to the conclusion that muscle strength is progressively declining even from earlier years than previously thought. The total size of the decrease in muscle strength is greater in tasks that require more complex and stronger movements. Age decline rates are higher in women than in men only in cases where more complex and explosive strength is required. Campbell & Geik (2004) considered age-related changes in body composition. Older people should take into account the intake of nutrients, especially carbohydrates, for storage and use of glucose as an energy source during exercise, and protein for muscle hypertrophy caused by strength training. Emphasis should also be placed on the intake of certain micronutrients in the diet, as well as on the potential need to add certain vitamins, minerals and folates. Deschenes (2005) concluded that loss of muscle mass (sarcopenia) in the elderly (fiber atrophy, especially among type II fibers), directly results in decreased muscle function, leading to several common chronic ailments, including osteoporosis, insulin resistance, and arthritis. The physiological mechanisms responsible for the development of sarcopenia are denervation resulting in loss of motor units and thus muscle fibers, decreased production of anabolic hormones such as testosterone, growth hormone, and insulin-like growth factor that impairs skeletal muscle ability to include amino acids and synthesize proteins. Faigenbaum (2007), in a study, concluded that participation in resistance exercise programs has a potentially positive effect on several measurable health indicators. In addition to strengthening the musculoskeletal system, it helps strengthen bones, facilitates weight control, improves psychosocial well-being and improves one's cardiovascular risk profile. Faigenbaum, Lloyd, MacDonald, & Myer (2016) suggest that different forms of resistance training can cause performance improvement and structured interventions that include targeted movements, but also strength and fitness activities that are appropriate, progressive, and necessary to achieve athleticism which is in line with the Olympic motto. Frontera & Bigard (2002) argue that complex biochemical changes also participate in explaining the decline in performance during aging. Along with muscle atrophy, there is a real decrease in the ability of fibers to produce force. The origin of this dysfunction is still unclear, but it could include the properties of the myosin molecule itself, whose synthesis and turnover rate are slowed down. American College of Sports Medicine (2009) indicate that muscle strength training involves systematic and well-planned exercise in which the musculoskeletal system is progressively exposed to continuous load, with the goal of developing muscle capacity. Glowacki, Martin, Maurer, Baek, & Green (2004) concluded that with muscle training, weight and lean body mass (LBM) were significantly increased ($p<0.05$), and the percentage of body fat was significantly reduced. Strength was improved in subjects in all groups, but jump strength improved significantly in only one group and no group showed a significant change in vertical jump height. Hickson (1980) investigated how individuals adapt to a combination of strength and endurance training compared to adaptations produced by strength or endurance training alone. The results showed that simultaneous training of strength and endurance results in reduced capacity for strength development, but will not affect the magnitude of the increase in VO_2max. Ivy, Goforth, Damon, McCauley, Parsons, & Price (2002) tested the hypothesis that carbohydrate-protein supplementation (CHO-Pro) would be more effective in restoring muscle glycogen after exercise compared with carbohydrate supplementation with the same carbohydrate content (LCHO) or caloric equivalence. The results obtained suggest that a CHO-Pro supplement is more effective for rapidly replenishing muscle glycogen after exercise than a CHO supplement of equal CHO or caloric content. Kahrović, Murić, & Radenković, (2019) reviewed the literature and concluded that a well-designed strength training program in early childhood will be reflected in adulthood in the form of better mental health and satisfaction, a positive attitude towards physical activity and better lipid profile and body composition in general. The results and conclusions of the study indicate that this type of activity increases the production of maximum force, which is generated by a muscle or group of muscles.

Karlsson, Ahlborg, Obrant, Nyquist, Lindberg, & Karlsson (2002) indicate that in addition to increasing muscle strength and aerobic endurance, which is achieved through circular strength training with this type of exercise, the risk of bone fractures in adulthood is greatly reduced. In addition, the skeletal gains of physical activity during growth and development are maintained in old age. Also Karlsson & Rosengren (2012), after the results of the study, stated that there is evidence to support the idea that skeletal gains of mechanical load during growth are maintained at an advanced age despite a decrease in physical activity in adulthood. Kraemer et al. (2002) came to the conclusion that muscle strength training, which involves systematic and well-planned exercise in which the musculoskeletal system is progressively exposed to continuous load with the aim of developing muscle capacity, can be practiced in the elderly age. Lloyd, Faigenbaum, & Stone (2014) indicate that, in addition to improving muscle condition and increasing bone density in old age, various strength training programs reduce cardiovascular risk factors, facilitating weight control. The results of the research done by McCarthy, Pozniak, & Arge (2002) provide a physiological basis for several studies that consistently indicate that the simultaneous exercise of strength and endurance does not impair the development of strength in the short term. The combination of strength training and aerobic endurance does not diminish adaptation to strength or muscle hypertrophy. The results of another study (Putman, Xu, Gillies, MacLean, & Bell, 2004) showed that the exercise of aerobic endurance interferes with the development of maximum strength, because in this way glycolytic fibers are converted into oxidative ones, which reduces the degree of hypertrophy. The results of the study realized by Rhea, Alvar, Burkett, & Ball (2003) show that moderate-intensity exercise (60% of the maximum number of repetitions) causes maximum effects in exercisers who are just included in a program of muscular activities (unused persons), while it is necessary to increase the intensity (80% most effective with better trained) of exercise by increasing training. Rowland (2007) indicates that the habit of regular physical activity represents, in addition to muscle hypertrophy, effective protection against various chronic diseases, including cardiovascular disease, hypertension, obesity, diabetes, and osteoporosis. Smith, Eather, Morgan, Plotnikoff, Faigenbaum, & Lubans (2014) found strong evidence for a positive link between exercise and bone health and increased muscle mass. Evidence of an association between physical exercise and musculoskeletal pain and cognitive abilities was inconsistent. The results of one study (Singh, 2004) indicate that aging, although genetically determined, also depends on the level of physical activity. Physical passivity has a negative effect on various physiological systems of the human body, including physical fitness. Organic systems such as muscle, bone, endocrine or cardiovascular, can be improved by exercising certain exercise programs. The results of the Welle study (Welle, 2002) showed that reduced protein synthesis leads to atrophy, and slower fractional protein turnover contributes to longer retention of proteins that may be damaged by free radicals. The simultaneous exercise of strength and aerobic endurance in the elderly have shown equal efficiency in the development of these abilities (Wood, Reyes, Welsch, Favaloro, & Sabatier, 2001).There has been an increase in leg, back and shoulder strength, improved flexibility and coordination, and cardiovascular endurance.

DISCUSSION

A well-designed exercise program for maintaining and improvement of physical fitness must also include exercise of muscular abilities, which includes exercises with load. This type of exercise, which begins with warming up and ends with cooling of the body, should not be an isolated component, but part of a comprehensive program for improving physical abilities. But, before moving on to exercises that use weights and a smaller number of repetitions, it is necessary to work on maintaining and increasing endurance, primarily muscle, ie the possibility of multiple repetitions of a particular exercise (Kahrović et al., 2019). Strength as an important muscle ability declines rather slowly until the fifth decade of life, since when the process of declining muscle strength accelerates sharply. This happens due to the process of losing muscle mass (so-called sarcopenia), which contributes to the weakening of older people, due to which they fall and injure themselves more often (Welle, 2002). This process is associated with other accompanying disorders such as osteoporosis, insulin resistance and arthritis, caused by atrophy of muscle fibers and their deterioration, due to insufficient secretion of testosterone, which is responsible for building muscle fibers and other factors that lead to muscle loss (Deschenes, 2005). Despite this fact, numerous studies have confirmed that the condition of musculature can improve, even in the 1990s (Fiatarone, O'Neill, Doyle Ryan, Clements, & Solares, 1994). Exercise with a load contributes to an increase in muscle strength (Faigenbaum, 2003, 2007), an increase in the production of maximum force generated by a muscle or muscle group (Faigenbaum, 2003), as well as an improvement in muscle endurance (Faigenbaum & Westcott, 2009). In addition to increasing muscle strength and aerobic endurance achieved through circular strength training (Faigenbaum, 2003), this type of exercise greatly reduces the risk of bone fractures in adulthood (Karlsson et al., 2002). The fact that former athletes have

a lower risk of fractures than expected in later years does not contradict the view that physical activity during growth and adolescence is important and should be supported as one feasible strategy to reduce future fracture rates (Karlsson & Rosengren, 2012). Recent researches (Faigenbaum et al., 2016; Lloyd et al., 2014; Smith et al., 2014) indicate that, in addition to improving muscle condition and increasing bone density, various strength training programs, reduce cardiovascular risk factors, facilitating weight control. The combination of strength training and aerobic endurance reduces the effects on strength, but not on aerobic endurance (Hickson, 1980). Exercising strength affects fast-contracting fibers, while exercising aerobic endurance affects slow-contracting fibers. Exercise of aerobic endurance hinders the development of maximum strength, because in that way glycolytic fibers are converted into oxidative ones, which reduces the degree of hypertrophy (Putman et al., 2004). Other research suggests that the combination of strength training and aerobic endurance does not diminish adaptation to strength or muscle hypertrophy (McCarthy et al., 2002). In research on older subjects, the combination of strength training and endurance was equally effective for both strength and endurance development. The authors concluded that this type of exercise can be more effective when the most functional physical condition needs to be achieved, than programs that encourage the development of only one ability (Wood, Reyes, Welsch, Favaloro, & Sabatier, 2001). Research on untrained subjects has shown that such a combination does not interfere with strength development, but may interfere with aerobic capacity development (Glowacki et al., 2004). Exercising strength in older people creates contractile proteins, increases muscle mass and strength, which makes it easier to perform daily activities. Strength training almost negates the effects of age on muscle performance. This type of training results in an increase in muscle mass which is mainly the result of increased protein synthesis. Strength performance has also been improved, at the level of the entire muscle as well as the fiber itself. The effects of strength training in the elderly result in the improvement of simple functional tests such as speed walking or climbing stairs. However, specific responses of myosin isoforms to training in the elderly remain to be determined (Frontera & Bigard, 2002). While examining records in power lifting, Anton et al. (2004) found that maximal muscle strength begins to decline much earlier than previously thought, declining with more complex and powerful movements, both upper and lower body, as well as that in women with aging, the explosive power and strength manifested in complex movements decreases more than in men. Major changes during aging occur in endocrine function in men (during andropause) and women (during menopause), because the body reacts strongly to physical changes. Loss of muscle fibers and total muscle mass with age causes muscle weakness. Such programmed cell death (apoptosis) further accelerates physical inactivity. The degree of decline in muscle strength is much smaller in people who exercise regularly compared to inactive people. However, changes in the function of the endocrine glands during aging reduce the body's ability to respond to the same degree of signal for protein synthesis and metabolic support as in youth. This decreased anabolic hormonal response (testosterone secretion, growth hormone, IGF-1, insulin) explains the reduced positive response to muscle exercise (Zatsiorsky & Kraemer, 2006). In order to improve the impact of exercise on the muscle mass of older individuals, renew muscle tissue and thus slow down the process of losing muscle cells, good eating habits are also very important. In order to encourage muscle hypertrophy, it is necessary to satisfy the needs for energy, which is achieved by the intake of nutrients, and especially by a higher intake of proteins (Campbell & Geik, 2004). To improve protein synthesis, essential amino acids and carbohydrates should be taken half an hour before, during, and half an hour after exercise. Take energy snacks during physical activity and immediately after the activity take an energy supplement with several hundred calories of a mixture of carbohydrates and proteins (Iv et al., 2002). In addition, it is important to take in vitamins and minerals, as well as enough fluids, because changes in thermoregulation occur in old age, which increases the susceptibility to dehydration. Current muscle abilities determine the way you will exercise. If the person is not trained, it is necessary to use 60% of the maximum load (maximum load is the maximum weight that can be lifted only once, i.e. Repetition Maximum- RM). With increasing training, the load increases to 80% (Rhea et al., 2003).

CONCLUSION

The beneficial effects of exercising muscle abilities for the elderly include increasing muscle capacity such as strength, endurance and flexibility, more energy, creating a better image of one's own body and greater self-confidence. Exercise at a certain time is a stimulus for the development of muscle strength, and it is not crucial how it is applied. In addition to increasing muscle mass, muscle endurance and flexibility, bone mass also increases, which is very important for the health of older people and their recovery after activity. The positive effects of good muscle status prevent the more severe consequences of osteoporosis and enable an active life until old age. Increasing muscle abilities improves the quality of

life and facilitates daily physical work. The best results are achieved by a combination of activities under the load of body weight and resistance exercises, with a diet that includes an adequate intake of carbohydrates, proteins, minerals and vitamins. Regardless of the age, every person can maintain the basic components of muscular abilities, strength, endurance and mobility, which will enable him to remain active until old age. We have learned to distinguish strength training from aerobic endurance training and what the effects are on neighboring tissues and organs. Most authors believe that the combination of strength training and aerobic endurance reduces the effects to maximum strength, because in that way glycolytic fibers are converted into oxidative ones, which reduces the degree of hypertrophy, but not aerobic endurance. In research on older subjects, the combination of strength training and endurance was equally effective for both strength development and endurance development. The authors conclude that this type of exercise can be more effective, when the most functional physical condition needs to be achieved, in comparison to programs that encourage the development of one ability only. In order to preserve strength and vitality in old age and live well during retirement days, it is best to start maintaining fitness while still young. With regular muscle exercise, a good hereditary basis and a careful diet, one can live a quality and long life.

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PHYSICAL ACTIVITY IN THE TREATMENT OF DIABETES MELLITUS

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ABSTRACT

Being engaged in physical activities, particularly those well organized in the form of a training program, can improve the health of people with diabetes mellitus to a great extent. This systematic review is aimed at analyzing recent scientific research data on a given topic and thus gain new knowledge about the benefits of physical activity to provide better control of the disease and hence, the better quality of life of patients. The results of the research analyzed in this paper were collected after searching the following electronic databases: *Google Scholar, PubMed, SCIndex, Medline*. The search was conducted on all the papers published in leading journals, in the medical science and sports science field. Then, the papers were selected based on the frequency of keywords and their combinations: *diabetes mellitus, cardiorespiratory fitness, prevention, training, nutrition* (in Serbian and English). A total number of 132 studies were identified, 20 of which (10 male, 1 female and 9 studies of both sexes) were selected and systematically reviewed and analyzed. There were 1254 respondents in total, 585 females and 669 males who were over 30 years old. Based on the results, we can conclude that in all of the 20 selected studies, there was a positive effect of physical activity, i.e. training, on the health condition of people with diabetes mellitus. Physical exercise of aerobic type, accompanied with a proper and moderate diet, has a strong influence on the prevention and treatment of type 2 diabetes and is the essential tool in the fight against the disease.

Keywords: diabetes mellitus, cardiorespiratory fitness, prevention, training, nutrition

INTRODUCTION

Diabetes mellitus is a chronic systemic metabolic disorder characterized by hyperglycemia, elevated blood glucose levels (Ѓорѓиева, 2017). Type 2 diabetes is a hereditary disease, with polygenic disorders, systemic in manifestation, and chronic in the course (Popović, 2018). Improper dietary habits, physical inactivity, stress and genetic predisposition have a substantial share in the development of diabetes. Today, diabetes is one of the most common endocrine diseases with an increasingly growing number of patients (Veljković, 2011). The discrepancy between developed and underdeveloped countries is particularly noticeable. Research has shown that in 2000 there were 171 million people in the world with diabetes mellitus, and only in 2015 that number rose to 415 million (Zimmet & Alberti, 2016). The World Health Organization (WHO) has made a growth prediction model for the disease in which a considerable disparity can be detected between developed and developing countries. Namely, in 1995 it was recorded that developing countries had 20% more population suffering from this disease and that in 2025 this difference will reach as much as 70% (WHO, 2002).

Common complications caused by hyperglycemia are heart disease, stroke, diabetic retinopathy and nephropathy, and damage to blood vessels (Popović, 2018). Also, diabetic ketoacidosis, hyperglycemic hyperosmolar condition and hypoglycemia are severe complications of diabetes (Jurić, Simić, & Nesek Adam, 2020). The downside of this disease is that, at first, it is often asymptomatic so patients do not start with timely therapy and treatment, which causes a worsening of the clinical picture. The modern age, characterized by a sedentary lifestyle, hypokinesia and an unhealthy diet, is directly responsible for the rapid growth of this disease (Parikka et al., 2001). Aerobic exercises such as brisk walking, jogging, cycling, swimming and others, have a positive impact on improving the sensitivity of cells to insulin (Kosinac, 2012). Moreover, a balanced and controlled diet, accompanied by this type of exercise, provides additional benefits in the treatment.

Based on the collected data, we have determined that there are many research papers related to this topic and a smaller number of review papers dealing with the impact of a diet program on diabetes mellitus. Rapid progressive growth of diabetes in the world also speaks to the relevance of this topic (Tuomilehto et al., 2001). This systematic review had an objective to analyze the collected recent scientific research on a given topic and thus provide new knowledge about the benefits of physical activity to improve the disease control and hence a better quality of life of patients with diabetes mellitus.

METHODS

Search strategy

The research results analyzed in this paper were collected by searching the following electronic databases: *Google Scholar, PubMed, SCIndeks, Medline*. We searched all the papers published in leading medical and sports science journals. Then, they were selected based on the frequency of keywords and their combinations: *diabetes mellitus, cardiorespiratory fitness, prevention, training, nutrition* (in Serbian and English). In the first phase of the search, we checked the relevance of the titles and abstracts. In the second phase of the search, the entire papers were downloaded and considered for inclusion. We reviewed all the references to obtain as much research studies in this area as possible. In the end, 20 papers relevant to the study were selected. The procedure of collection, analysis and elimination of papers is shown in Diagram 1.

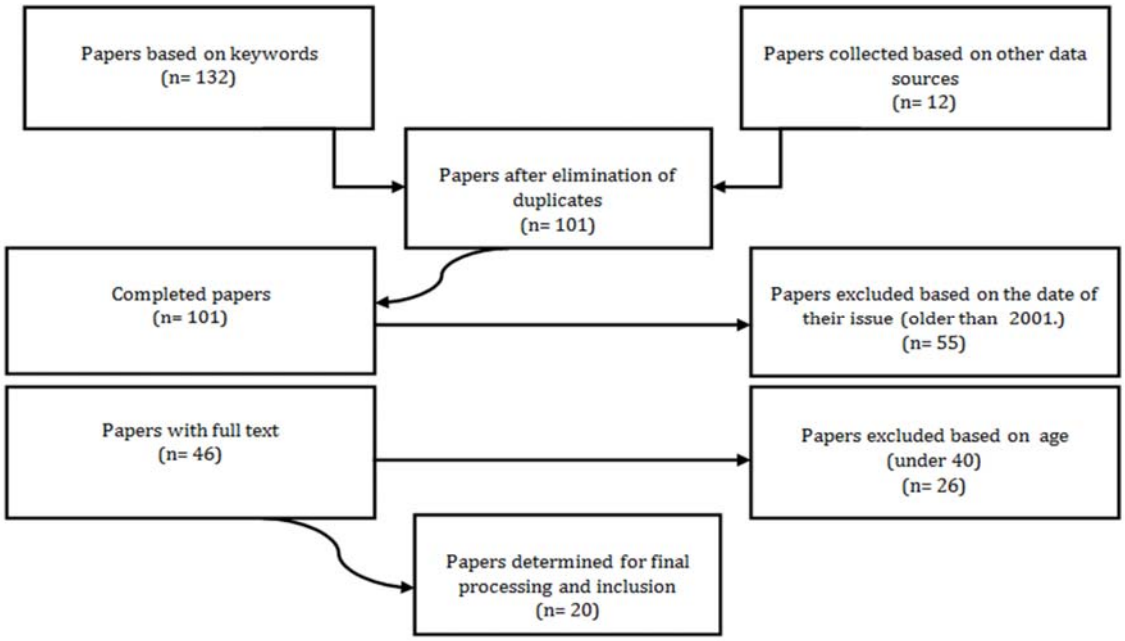

Diagram 1. Schematic diagram of the work search strategy

Data collecting

When selecting the papers to be included in the research, there were certain *criteria* for *inclusion* and *exclusion*. *The inclusion criteria* were: (1) original scientific papers, (2) papers written in Serbian and English, (3) research with some type of training treatment, (4) respondents with diabetes mellitus, (5) respondents older than 30 years of age, (6) research not older than 20 years. *Exclusion criteria* were as follows: (1) review studies, (2) studies with respondents under the age limit (younger than 30 years), (3) respondents without diabetes mellitus, (4) studies with unadequately presented results or with missing parameters required for analysis.

Theoretical consideration of the problem

The basic method in the paper was descriptive. Ssystematization, analytical and comparative methods were applied as well. The research included 20 papers published in the period 2001-2021, whose respondents were aged 30-80.

RESULTS

Selection of studies

By searching electronic databases based on keywords, we identified a total of 132 significant studies. Moreover, based on other data sources, additional 15 papers were collected. Upon removing the duplicates, 101 studies remained. Fifty-five studies were excluded based on the time of their publication (older than 2001), while we included 46 papers in further analysis. Afterwards, 26 works were excluded based on the fact that the respondents were younger than 30 years. The remaining 20 papers met the set inclusion criteria and thus entered the systematic review survey.

Study characteristics

All studies included in the systematic review survey were published in Serbian and English between May 2001 and August 2021. The total sample size was 1254 subjects, of which 585 females and 669 males aged over 30. Ten studies included only males (Loimaala et al., 2003; Brooks et al., 2007; Manders et al., 2010; Bello et al., 2011; Moura et al., 2014; Cugushi et al., 2015; Yavari et al., 2015; Mendes et al., 2016; Saeidi et al., 2021; Tinduh et al., 2021). One study included only female subjects (Motahari-Tabari et al., 2015), while nine studies included subjects of both sexes (Tuomilehto et al., 2001; Castaneda et al., 2002; Kirk et al., 2003; Tudor-Locke et al., 2004; Yokoyama et al., 2004; Araiza et al., 2006; Kadoglou et al., 2007; Corrêa et al., 2021; Kaviraja et al., 2021). In four studies it was noted that a controlled and well-defined diet accompanied by physical activity had a positive effect on improving patients' health (Tuomilehto et al., 2001; Manders et al., 2010; Saeidi et al., 2021; Tinduh et al., 2021).

Based on the results, one can detect that in all 20 studies there was a positive effect of physical activity, i.e. training, on the health status of people with diabetes mellitus. Table 1 presents the obtained results of all of the processed papers.

Table 1. Tabular presentation of analyzed research

Reference	Population	Subjects	Treatment	Protocol	Results
Tuomilehto et al. (2001)	M and F, average age 55 yrs Patients with DM	F=350 M=172 Random division into EG and CG	EG– A program of endurance moderate to high intensity exercises, conducted in the form of individual circuit training	TT – minimum 30 minutes a day, number of repetitions at stations of moderate to high intensity, 15-60 -second pause between rounds.	Type 2 diabetes can be prevented by lifestyle changes, increased dietary control and regular exercise.
Castaneda et al. (2002)	M and F, aged 66±8 yrs, Patients with DM	F=40 M=22 Random division into EG and CG	EG - progressive load training; CG - normal activities of glycemic control and body composition in persons	TT - 16 weeks, 3 times a week, duration 45 min including warm-up at the beginning and stretching at the end.	Improvements in all tested variables. Progressive load training improves control associated with MS in people with DM.
Loimaala et al. (2003)	M. 53.3±5.1 yrs Patients with DM	M=50 Random division into EG and CG EG=25 CG=25	EG - Assessment of the effects of walking and jogging (65-75% VO_2max), as well as muscle strength training on baroreflex sensitivity, running frequency variability, VO_2max.	TT - 12 months, 2 times a week, minimum 30 minutes per workout.	Improvements in baroreflex sensitivity of DM, increase in exercise capacity, muscle strength and glycemic control. Improving prognosis and delaying complications. Significant reduction in the likelihood of cardiac death in people with DM
Kirk et al. (2003)	M and F, 57.6±7.9 yrs Inactive individuals with DM.	M=35 F=35 Random division into EG and CG CG=35 EG=35	EG- consultations, the importance of FA, cognitive strategy, accelerometer control of BMI, lipid and fibrinogen concentrations.	TT- 6 months	Consultation and targeted application of exercises have a very large impact on insulin control in type 2 diabetes mellitus, as well as on improving the health of patients.
Yokoyama et al. (2004)	M and F, 53.0±12.2 yrs Patients with DM	M=6 F=17	EG – bycicle ergometer, walking. Aerobic activity - reducing the rigidity of arterial blood vessels, improving insulin sensitivity	TT – 3 weeks	Short-term aerobic exercise significantly reduced the rigidity of arterial blood vessels in the carotid and femoral arteries, reduced rigidity was associated with improved insulin resistance and clinical DM.
Tudor-Locke et al. (2004)	M and F, 52.9±5.0 yrs Patients with DM	n= 47 M=55% F=45% EG=24 CG=23	EG- walk followed by a pedometer with not less than 8800 steps within 3 days	TT– 16 weeks, 30 minutes every day	Half-an-hour walk a day did not lead to a significant physiological improvement in the health condition of people with DM, while the effect was better in those who also took therapy.

Araiza et al. (2006)	M and F, 33-69 yrs Inactive individuals with DM	EG=15 CG=15	EG-10000 steps per day followed by a pedometer. Glycemic control, KI, cardiovascular risk.	TT- 6 weeks, 5 or more days of walking, at least 10,000 steps a day.	Short-term interventions with a pedometer increased physical activity and a positive effect on plasminogen 1 inhibitor activators in previously inactive individuals with DM.
Brooks et al. (2007)	M, 55±6 yrs Patients with DM	M=62 Random division into EG and CG EG=31 CG=31	EG- Strength Training; body composition (muscle component) was monitored	TT - 16 weeks, 3 times a week, three sets of 8 repetitions.	Body composition also improves glycemic control. It remains to consider the use of this program in the continuous control of glycemia in people with DM.
Kadoglou et al. (2007)	M and F, 61.64±4.9 yrs Patients with DM	M=26 F=34 Random division into EG and CG EG=30 CG=30	EG- walking and running on a treadmill, cycling, calisthenic exercises	TT- Six months, duration 50 minutes (50–75%, VO2) including warm-up at the beginning, 4 times a week, break between series 5 minutes	Increased cardiorespiratory fitness and reduced inflammation in people with DM
Manders et al. (2010)	M, 57±2 yrs Patients with DM	M=9	EG - High-intensity isometric training (HIIT)	TT- 60 min at 35%, or 30 min at 70% (Wmax), glycemic control 24 h	Physical activity, together with diet, significantly reduces the frequency of hyperglycemia during the 24 hours after exercise in long-term type 2 diabetes patients.
Bello et al. (2011)	M, 46.22±9.79 yrs Patients with DM	M=18 Random division into EG and CG EG=9 CG=9	EG - Individually prescribed aerobic exercise CG - (Usual activities) glycemia, glycosylated hemoglobin, HDL, LDL, WHOQ	TT – 8 weeks, 3 times a week, 30 min.	Treatment showed considerable improvement in most of the monitored variables. The quality of life has significantly improved.
Moura et al. (2014)	M, 51.1±8.2 yrs Patients with DM	M=8, only EG	EG– Bicycle ergometer consumption at 50–60% of VO2max, body composition, glycemia.	TT – 8 weeks, 3 times a week, 30 – 60 min.	After TT increase VO2max. Advances in glycemic control. This treatment gives a positive effect and can replace additional medications.
Yavari et al. (2015)	M, 40-65 yrs Patients with DM	Random division into EG and CG EG=35 CG=30	EG – aerobic training; CG – standard activities, monitored glycosylated hemoglobin level, glycemic level	TT - 16 weeks, 3 times a week, 90 min.	In EG aerobic training led to a decrease in the value of glycosylated hemoglobin, in body weight, a significant decline in blood pressure. Glycemic control can be achieved with this treatment.

Cugushi et al. (2015)	M, 52.2±9.3 yrs Patients with DM	M=18, only EG	EG- Training program performed in water (31-32ºC)	TT- 12 weeks, 3 times a week, 50 min.	A training program in water is a safe and effective way to improve the quality of life, as well as cardiometabolic parameters in patients suffering from DM. It is also very favorable fordisabled people with DM, as they are not able to conduct training in any other way.
Motahari-Tabari et al. (2015)	F, 49±2.9 yrs Patients with DM	Random division into EG and CG EG=27 CG=26	EG- A program of moderate to intense aerobic exercise	TT- 8 weeks, 3 times a week, 50 min.	An aerobic training program has a positive effect on insulin resistance in people with DM.
Mendes et al. (2016)	M, 62.92 ± 5.92 yrs. patients with DM	n= 43, only EG	EG- Combined training program (aerobic, resistance training, agility, flexibility and balance)	TT- 9 month, 3 times a week, lasting 70 min.	Combined training program significantly influenced the improvement of the subjects' motor skills, but it was also determined that the aerobic method of high-intensity interval training is appropriate in terms of improving the health of patients with DM.
Corrêa et al . (2021)	M and F, 63.56±9.27 yrs Patients with DM	M=13 F=5	EG- Aerobic training on the treadmill with an intensity of 50% of the maximum load, as well as moderate resistance training.	TT- Treadmill tape for 30 minutes, 3x10 with moderate load for 30 min.	Combined training was effective for acute glycemic status in the elderly with DM, with aerobic training proving to be most responsible for this.
Kaviraja et al. (2021)	M and F, 57±2 yrs Patients with DM	n=30, EG(a)=15 EG(b)=15	EG- Pilates ball training, as well as resistance training	TT- 12 weeks, 5 series, duration 30 min.	By comparing the initial and final measurements within the groups, there were statistically significant differences in the mean value for blood sugar levels. It was concluded that resistance training increases insulin sensitivity and glucose tolerance, while Pilates ball training improves glycemic control.
Saeidi et al. (2021)	M, 40-60 yrs Patients with DM	M=44 Random division into EG and CG EG=11 (training + broccoli) EG=11 (training + placebo) CG=11 (no training + broccoli) CG=11 (no training + placebo)	EG- Training with a load of 45 min. (60-70% of 1-RM), followed by aerobic training on the treadmill for 30 min. (60-70% of VO2peak)	TT- 12 weeks, 3 times a week, 85 minutes with 10-min warm-up.	The combination of aerobic training and exercise training, as well as the use of broccoli in the diet leads to a significant increase in the levels of plasma Dectin 1 protein, cardiorespiratory fitness, glycemic control and insulin resistance compared to the initial state.

Tinduh et al. (2021)	M, 35-55 yrs Patients with DM	M=22 Random division into EG and CG EG=11 CG=11	EG - Aerobic program of moderate intensity on treadmill tape, VO_2max before and after treatment.	TT- 4 weeks, 3 times a week, 30 min., with a gradual increase in speed and inclination each week	There was a significant increase in VO_2max in EG after aerobic training. It was also concluded that a change in diet and regular exercise could improve both blood sugar control and insulin sensitivity of cells.

Legend: M- male, **F**- female, **yrs**- years, **DM**- diabetes mellitus type 2, **EG**- experimental group, **CG**- control group, **VO_2max**- maximum oxygen consumption, **TT**- treatment, **MS**- metabolic syndrome, **1-RM** - one maximum repetition, **Wmax**- maximum working capacity.

DISCUSSION

This systematic review aimed to analyze the collected research papers related to the impact of physical activity on diabetes mellitus and thus determine whether this parameter has a positive effect on improving the patients' health.

Based on the results, a total of 1254 subjects were registered, 624 of which comprised the experimental group that underwent some physical exercise. The longest-lasting treatment was recorded in the research conducted for 3.2 years (Tuomilehto et al., 2001), in which the highest number of respondents was registered, namely 350 females and 172 males. Other papers had a treatment range of 6 to 16 weeks. The average frequency of activities in the experimental groups ranged from three to five workouts per week. The reviewed materials indicate that aerobic programs and diet control are the most significant segments in preserving and improving the patients' health. The duration of the program in most papers has a similar time range, the programs that showed the best effects were related to the period of 8 to 12 weeks during which participants were intensively monitored (Bello et al., 2011; Moura et al., 2014; Cugushi et al., 2015; Motahari-Tabari et al., 2015; Kaviraja et al., 2021). We noticed that the primary goal of the training programs was to activate large muscle groups, train with moderate to high intensity, prefer aerobic training during which constant proper and controlled breathing was enabled. Detailed processing confirmed that aerobic exercise proved to be the most effective means that leads to a reduction in blood sugar levels, i.e. glycemic control (Kirk et al., 2003; Tudor-Locke et al., 2004; Yokoyama et al., 2004; Araiza et al., 2006; Kadoglou et al., 2007; Bello et al., 2011; Moura et al., 2014; Yavari et al., 2015; Motahari-Tabari et al., 2015; Saeidi et al., 2021; Tinduh et al., 2021). High-intensity interval training, as type of aerobic training, was responsible for improving the patients' general condition (Mendes et al., 2016). Also, strength training, i.e. resistance training, increases insulin sensitivity in people with diabetes mellitus (Castaneda et al., 2002; Brooks et al., 2007; Kaviraja et al., 2021), while the combination of strength training with aerobic training has an acute improvement in glycemic status (Corrêa et al., 2021). Speaking of specific exercises, walking and running on a treadmill and cycling for a period of six months, with an average training duration of 50 minutes, four times a week, moderate to high intensity, affected the increase in cardiorespiratory fitness, as well as reduction of inflammation in patients with diabetes mellitus. In the work of Cugushi et al. (2015), a water training program was applied, which proved to be a safe and effective way to improve both the quality of life and cardiometabolic parameters in patients with diabetes mellitus. This type of training is very favourable for people who, in addition to diabetes, also have a disability and, therefore, cannot exercise in any other way. In addition to physical activity, some studies have shown a positive side effect of a controlled and moderate diet on lowering blood sugar levels (Tuomilehto et al., 2001; Manders et al., 2010; Saeidi et al., 2021; Tinduh et al., 2021).

Based on all above mentioned, it was determined that the combination of physical activity of the aerobic type, accompanied with a controlled and strictly determined diet, has a great potential to become a very beneficial for the improvement of the condition, as well as the course of this disease.

CONCLUSION

We can conclude that type 2 diabetes has a destructive effect on overall health, and it is certainly best to prevent the occurrence of the disease by pointing out all the factors that act preventively on the appearance and development of this disease. The essence is to change bad life habits, primarily by educating members of the general population and members of risk groups about the positive effects of physical activity on the human body. The main goals of treatment are, by making appropriate lifestyle changes that the introduction of physical activity implies, to accelerate metabolism, maintain normal blood glucose levels, restore optimal body weight, improve cardiorespiratory fitness and build self-confidence and reduce anxiety. As aerobic and strength training is recommended for people with type 2 diabetes, the training process must be adjusted to each patient individually. Regular physical activity leads to the organism adaptation in the blood glucose concentration control, an increase in cellular insulin sensitivity and a decrease in risk factors for cardiovascular disease development. In general, physical activity should be low to moderate in intensity and longer in duration to benefit from it. However, this largely depends on the patient's current condition- it has been noted in some studies that even high-intensity training can positively affect the course of the disease. Essentially, a blood glucose level should be checked before and after training to prevent hypoglycemia. In addition to physical activity, diet is vital for glycemic control and the patient's overall health. Therefore, two fundamental tools in the fight against this disease are physical exercise, primarily well-organized aerobic training programs, accompanied by a

proper and moderate diet that helps in achieving a positive effect in the prevention and treatment of type 2 diabetes.

Recommendations for further research refer to examining the effects of new training programs related to budo martial arts such as karate, judo, taekwondo and aikido. Since these skills are dominated by moderate to high-intensity aerobic exercise combined with endurance and strength exercises, they could be a wise choice for physical activity that would most likely lead to a significant improvement in the case of diabetes. In addition, it is of great importance to mention a specific type of Ibuki breathing characteristic of these budo skills, which would have a considerable benefit on the overall health, especially to those patients who have cardiovascular health issues as a complication of diabetes.

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SERBIAN UNIVERSITY STUDENTS' ATTITUDES TOWARDS SPORT INFLUENCE ON HEALTH AND IMPROVEMENT OF MENTAL HYGIENE: A SYSTEMATIC REVIEW

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ABSTRACT

The aim of this review was to establish the university students' attitudes towards sport influence on health and improvement of mental hygiene among student population in the Republic of Serbia. Gathering of published researches was done in the following electronic databases: PubMed, SCIndeks, PEDro, J-GATE, DOAJ and Google Scholar. The search was limited to articles published from 2011 till 2019 by using the following keywords: university sports, young adult population, health promotion, mental health, life habits. The final analysis included ten researches. Analyzed researches have shown that the complexity of the transition period from high school to university and the accumulation of academic obligations combined with bad life habits (sedentary lifestyle, smoking, alcohol, drug use, improper and irregular diet), may lead to stress and psychophysical disorder of health in student population. Reasons for students` physical inactivity and the existing trend of aerobic fitness decreasing are different- from poor information on sports and recreational activities at university to reduced students` interest for extracurricular and recreational activities.

Keywords: opinion, physical activity, students, university sport, healthy lifestyles

INTRODUCTION

The modern way of life, characterized by constant technological innovations (IT), inadequate diets and insufficient physical activity, has resulted in a sedentary lifestyle, rise in asocial behaviors, increase in obesity and a host of other health issues in all age groups (Ostojić, Stojanović, Veljović, Stojanović, Međedović, & Ahmetović, 2009). Marked demographic shifts and a rise in the number of elderly people suffering from certain health problems typical of old age have featured in most countries around the world in recent years, and are often ascribed to poor habits and inadequate lifestyles during youth (Chan & Woo, 2010). A sedentary lifestyle during childhood and adolescence, especially while studying, can pose a significant health problem and be the cause of various diseases (Irwin, 2007). As one of the most important components of physical wellbeing, physical activity is one of the most worthwhile ways of improving the overall health condition of a body (Čokorilo & Mikalački, 2015). The human need for socializing, movement and physical activity is, under contemporary living conditions, best satisfied in a planned and organized manner (Кордић & Бабић, 2011). Although physical activity, which increases energy consumption, includes various types of movement we engage in daily, such as walking, climbing, various household chores, riding the bike to the store and the like, what is required in order to improve one's overall psychophysical health is physical exercise that is programmed, planned and administered in an organized manner (Ostojić, et al., 2009). Bearing in mind that sport is defined as a social phenomenon with a specific social agenda and tasked with fulfilling a person's social needs, the fact that over half of all university students are physically inactive is particularly worrying (Keating, Guan, Piñero, & Bridges, 2005).

Changes in one's lifestyle, namely the complexity of the transition from high-school to university duties and obligations and the accumulation thereof, lead to shifts in the habits students have acquired, resulting in a decrease in participation in sports activities and a transitioning into a sedentary lifestyle (Nešić, Srdić, & Fratrić, 2013). The rising incidence of psychophysical health disorders among the student population is caused by numerous negative environmental factors and psychosocial stressors (Chew-Graham, Rogers, & Yassin, 2003). Numerous studies have been conducted to date, by researchers in Serbia and abroad, with the aim of finding a solution to this issue and enhancing student health status, changes in higher education, changes in behavior and poor lifestyle habits, raising awareness and motivating young people to participate more actively in sports and recreational activities in their free time (Кордић & Бабић, 2011; Nešić & Kovačević, 2011; Nešić, Lolić, Srdić, & Meholjić-Fetahović, 2011; Čokorilo & Mikalački, 2015). The objective of this study was to examine student attitudes toward the effects of sport on health and enhancing mental hygiene among the student population in the Republic of Serbia.

METHODS

In order to collect existing research on the effects of sport on the health and enhanced mental hygiene of the university student population in the Republic of Serbia, the following electronic databases were searched: PubMed, SCIndeks, PEDro, J-GATE, DOAJ and Google Scholar. Papers included in the search were those published between 2011 and 2019. The following keywords were used when searching the databases: 'university sports', 'young adult population', 'health promotion', 'mental health', 'life habits'. Thus retrieved study titles, abstracts and full texts were then read and analyzed. A selection was made among the retrieved papers based on the following criteria: study participants were university students in the Republic of Serbia, and the study examined attitudes toward the effects of sport on health and enhancing student mental hygiene.

Those studies that fulfilled the criteria set were then analyzed and presented in terms of the following parameters: reference (author last name and year of publishing), participant sample (age, total number), study objective and results.

RESULTS AND DISCUSSION

A search of the electronic databases retrieved 192 research studies dealing with the relevant subject matter. Further analysis and application of the criteria set, in accordance with the present study's objectives, yielded a total of 10 studies that were included in the final analysis, as can be seen in Figure 1.

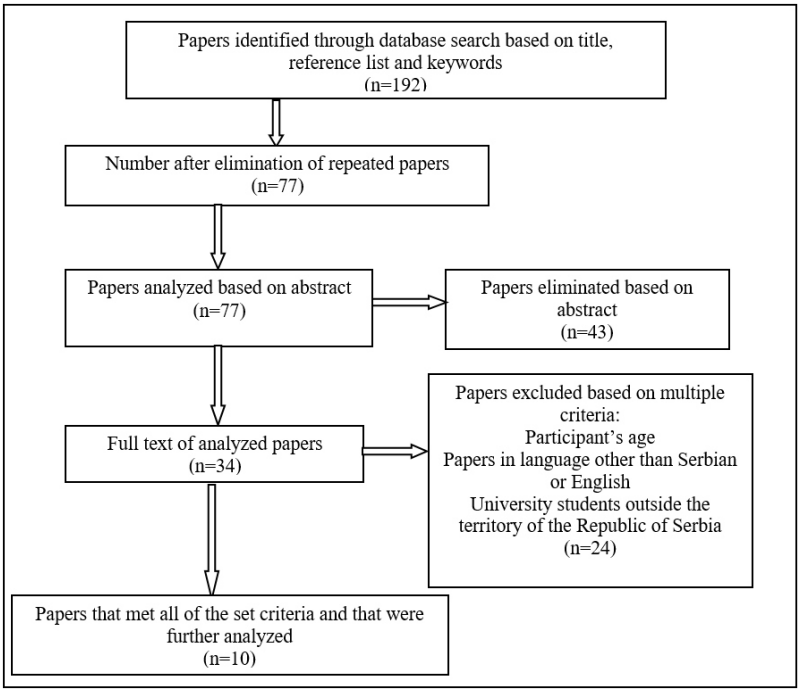

Figure 1. Flow diagram of data retrieval procedure

Table 1. Summary of selected studies

Study (year)	Student population	Sex	Sample age (Mean±SD)	Sample size	Study objective and instruments	Results
Кордић & Бабић (2011)	Students of Belgrade University (180) and Singidunum University (61)	M=123 F =118	X	n=241	CI-student awareness of the state of sport at Belgrade universities; In-AL	68% of participants were familiar with sports societies being available at university; 62% unaware the university had available indoor sports facilities; 40% aware of subsidies for using sports facilities; 86% of students like sports activities, 10% do sports actively, 59% engage in sports recreationally, while 19% do sports only sporadically; 10% do sport every day, 41% multiple times a week while 40% several times a week; 42% are unable to do sports; 52% of students are interested in doing sports, while 35% are prepared to take part in a sport association; 95% believe sport to be beneficial to a healthy life, physical strength and fitness; 93% believe it helps make new acquaintances; 91% that it improves one's mental health; 89% that it promotes the spirit of competition.
Nešić & Kovačević (2011)	Students of the Educons University in Sremska Kamenica	M=200 F=30	G=18–20 (11.9%) G=21-25 (45.8%) G=26–30 (15.1%) G=31–35 (14%) G>35 (13.3%)	n = 430	CI-identifying specific student habits that may affect dedication to do sports at university; In-A.	34.4% students engage in physical activities on a regular basis, 39.5% do them occasionally, while 26% of students do not do any sports; 65.5% are aware of the positive effects of physical activity, 46.2% of female participants are inactive, while this percentage is 19.3% in the total sample; a positive attitude toward the usefulness of organizing sports and recreational activities at university was expressed by 91.6%; 50.5% consume cigarettes; 69.8% consume alcohol, 21.3% have tried illegal substances on at least one occasion; poor dietary habits (having breakfast occasionally or never- 56.2%; two meals per day - 38.6 %), irregular daily rest "rhythm" 44.2%.
Budakov et al. (2012)	Students of the University of Novi Sad	M=400 F=400	G=20-24	n=800 I year I M=200 F=200 year IV M=200 F=200	Ci-establishing nutritional status and physical activity status among 1st and 4th year students at the University of Novi Sad; In-A.	Male participants IV-BMI=24.49, I-BMI=23.36, unlike female students, where BMI was higher in younger participants (BMI=20.49) compared to older ones (BMI=20.37). There were 116 (29%) overweight and obese students, while 62 (15.5%) female students were undernourished. A total of 451 (56.4%) students were physically active. 4th-year students were more physically active, 481 (60.1%) compared to first-year students: 399 (49.9%), with a level of statistical significance of $p<0.01$. Students who were more physically active had higher values of BMI. It was observed that 52.1% of students spend more than two hours every day watching television or in front of the computer screen.
Prebeg et al. (2012)	Student at the Faculty of Sport and Physical Education in Belgrade	M=389 F=216	G=18–28	n=605	CI-trend of aerobic fitness among students in different time periods over the last 15 years. In-A; UKK 2km.	A decreasing trend was observed in terms of the fitness index in male students, from 104.1 to 77.3, and in female students the decrease was from 96.4 to 84.8. T-tests confirmed differences in the fitness index, at the level of $p < 0{,}05$ for both sexes. Maximal oxygen consumption among male students fell from 51.3 to 40.3 ml/kg /min, and among female students from 37.5 to 33.7 ml/kg /min. Such results indicate a decreasing trend in aerobic fitness in both sexes, but also show the trend is less pronounced among female participants. Students of both sexes had fitness index values below the standard norms for the Swedish population. In the Cooper oxygen consumption test, the students went from the category "Excellent" to "Very good".
Čokorilo & Mikalački (2015)	Students of both sexes in Kikinda	M=49 F=55	G=22	n=104	Ci-to establish differences in student health status in relation to their physical activity status; In-A; SF-36.	Results showed that 41.3% of students train actively in a sports club, while 58.7% are not physically active. Regarding frequency, 44.2% of participants responded with every day, 24% reported exercising 5 times per week, 13.5% 2-4 times per week, 13.5% once per week, 13.5% once per month and 1% never. Their reasons for participating in physical activities were varied: 26.9% for their physical appearance, 18.3% for their health status, 15.4% for pleasure, 9% for socializing, and 1.9% for developing their motor skills. Exam pressures work to reduce physical activity completely in 22.1% of participants, partially in 49%, and not at all in 26.9%. Results indicate that 34.4% of inactive students report more frequently that their health prevents them from engaging in these activities.

Detanac et al. (2014)	Years I and IV students at the Department of Biomedical Sciences, State University of Novi Pazar	M=48 F=39	Year I 19.54±0.60; Year IV 23.36±2.24;	n=87 year I: n=42 year IV : n=45	Ci- assessment of physical activity status and identification of certain relevant indicators of unhealthy lifestyle habits among students at the University of Novi Pazar; In-A.	Results show that, among 1st-year students, 61.9% have had a cigarette at least once, while this percentage is 57.78% among 4th-year students. Heavy smokers comprise 14.28% of students in year I, and 26.67% of students in year IV. Alcohol is consumed by 45.25% of first-year students and 55.56% of 4th-year students. Among year I students, 14.29% do sport professionally, compared to 20% of 4th-year students. 28.57% of first-year students engage in no sports or recreational activities, almost twice as many as the 15.56% of 4th-year students. A significantly higher proportion of 4th-year students exercise 2-3 times per week (37.78%), compared to 1st-year students, where 19.05% exercise 2-3 times weekly. The data indicate that only 4.76% of 1st-year students and 17.78% of 4th-year students do not watch television. Between 33-40% of students watch up to 1 hour of television per day. 50% of junior students and 33.33% of senior students watch between 1-4 hours of television daily, 11.9% junior and 8.89% senior students watch in excess of 4 hours of television per day. Over 57.14% of junior and 55.56% of senior students do not play computer games.
Janković et al. (2017)	2nd-year students at the School of Medicine in Belgrade	M=155 F=335	G=19.97±0.56	n=490	Ci-physical activity and dietary habits of 2nd-year medical students at the Faculty of Medicine, Belgrade University. In-A(IPAQ)	Results show that 22.40% of the total number of participants are very active physically, while 62.20% are minimally to moderately active, while 15.30% are not physically active. Of the total number of students, 76.90% were smokers. Moreover, 75.80% of the sample comprised students with a normal weight, 6.40% were undernourished, 16.60% were overweight, and 1.20% were obese. There was a statistically significant difference among the participants in terms of diet in relation to participant sex. A positive correlation was found between the levels of physical activity, calculated based on IPAQ questionnaire, and habits related to sports activities after enrolling at the university (0.34), as well as students' self-evaluation of their levels of physical activity (0.44).
Stankov et al. (2018)	3rd (final) year students at the Preschool Teacher Training College in Šabac	M=2 F=48	X	n=50	Ci-the extent to which students engage in recreational activities, the types of activities they opt for, their motivation, and their assessment of the importance of doing sports recreationally for successfully working in children's education. In-A.	Results show that 2/3 of participants regularly take part in individual sports-recreational activities, motivated primarily by preserving health and physical ability, and reducing psychological fatigue. Those who are active only occasionally or not at all cite a lack of free time as the main reason. From the student perspective, the most salient effect of sports-recreational activities on the development of certain character traits and abilities is in terms of responsibility, confidence, tenacity, realistic setting of goals and self-discipline. A positive attitude toward the importance of physical fitness for teachers and of promoting a healthy lifestyle in order to be able to meet the daily requirements of working with children was found in a great majority of students (90%), whereas ⅔ of students, those active in this field themselves, responded positively on the necessity of preschool teachers engaging in sport-recreational activities, with the goal of having the appropriate impact on children's physical development.
Nešić et al. (2019)	Students of six faculties in the fields of tourism and sport in the Autonomous Province of Vojvodina	M=184 F=148	G=19-27	n=332	Ci-relationship among various elements of a healthy lifestyle and stress levels in students. In-A (SSQ-15).	Results show that 40% of students have heightened stress levels. It was possible to differentiate between two groups of participants, a larger one, which had very high stress levels, and a smaller one, which had very low average values. Results show that students participate insufficiently in structured physical activities and attend health check-ups very rarely. Analysis of variance showed that those students who self-identified as passive sports fans had the highest levels of stress, while athletes, those who do sport for recreation, as well as, somewhat unexpectedly, those who were "anti-sport", had significantly lower stress levels. Moreover, students who evaluated their overall health as poor also had significantly higher stress levels, while those participants who went for regular health examinations had the lowest stress levels. Male participants had higher stress levels compared to their female counterparts.
Popović-Ilić et al. (2019)	Year III and IV students at the Faculty of Sport and Physical Education in Leposavić	M/F	X	n=, 41	Ci- differences in body mass index and dietary habits among students of the Faculty of Sport and Physical Education. In-A, InBody™ 720.	Results show that over 60% of students have three meals a day, and consume fruit (53.7%) and vegetables (41.5%) two to four times per week, while 39% of them also consume sweets. A considerable proportion of students consume sweetened drinks only once per week (34.1%), while a majority of them (68.3%) consume alcohol only once per week or less. The established body mass index (BMI) results indicate that 68.3% have a normal nutritional status. No statistically significant differences ($p < 0.05$) were found between groups of students in terms of BMI, nor in terms of dietary habits. Additionally, a positive trend was discerned in terms of dietary habits.

Legend: M- male; **F**- female; **X**- not stated; **n**– number of participants; **p**– statistical significance; **Ci**-study objective; **In**-instrument for assessing attitude; **A**-survey; **AL**-Likert-scale type survey;

The results presented in Table 1 indicate that there are a considerable number of studies that have delved into this subject matter. The total number of participants in the reviewed studies was 3,180 students of both sexes. The largest participant sample (comprising 800 students) was noted in the study

examining the nutritional status and physical activity status in first- and fourth-year students at six different faculties at the University of Novi Sad (Novi Sad, Serbia). The smallest participant sample (41 students) was that in the study of third- and fourth-year students at the Faculty of Sport and Physical Education in Leposavić (Leposvić, Serbia), whose objective was also to establish nutritional status (body mass index), as well as to assess dietary habits during the course of university studies.

A systematic review of the studies collected found that the obligations imposed by study programs and insufficient physical activity can affect students' overall health. The study whose objective was to determine the relation between different elements of a healthy lifestyle and stress levels in students (Nešić, et al., 2019) concluded that stress occurs very frequently among students, and that regular physical activity is a significant factor of differentiating between those with high and those with low stress levels. This study showed that students who are physically active generally tend to have lower stress levels, which confirms the hypothesis on the significance of sport and recreation in overcoming or reducing the detrimental effects of stress. The authors emphasized this study's contribution to improving the methodology of stress qualification as one of particular significance. Authors of the study (Кордић & Бабић, 2011) looking into student awareness of the state of sports at universities and their attitudes toward the effect of sport on student life found that sport activities are highly valued, that students are physically active and aware of the importance sport has in their life, mental health and studies.

The study (Budakov et al., 2012) which dealt with ascertaining the nutritional status and physical activity status among first- and fourth-year students at the University of Novi Sad (Novi Sad, Serbia) found that a sedentary lifestyle was present to a large extent, more so among third-year students and seniors, as well as finding that male students were more prone to obesity while female students were more likely to be undernourished, which points to the need for an integrated approach for prevention and control of risk factors, especially among the young. A sedentary lifestyle, caused by a change in lifestyle of the student population, often results in changes in their dietary habits (Singh, Siahpush, Hiatt, & Timsina, 2011), and exercise can play an important part in preventing metabolic disorders from forming due to increased energy intake and reduced physical activity (Macanović, Marković, Ferati, Arsić, Jocić, & Arsić, 2013). Results of the study whose objective was to examine dietary habits among second-year students at the Medical Faculty of the University of Belgrade (Belgrade, Serbia) indicate that students have good nutritional habits, as well as having good awareness of their own physical activity status and the need to improve this status in the future (Janković, et al., 2017). Similar results were obtained in the study examining third- and fourth-year students at the Faculty of Sport and Physical Education in Leposavić (Leposavić, Serbia), where the authors concluded that there were no statistically significant differences between participants at the level of the examined morphological characteristics and dietary habits, as well as finding that the students had developed good nutritional habits as a result of their academic background in sport and taking part in sports activities (Popović-Ilić, et al., 2019).

That students exhibit strong tendencies toward poor lifestyle habits, while at the same time recognizing the importance of and need for regular physical exercise, and expecting external support from the university in order to engage in exercise, was the finding of the study of Nešić & Kovačević (2011), aimed at identifying specific student habits that could affect how motivated one is to do sports at university. The trend identified in one of the studies reviewed (Prebeg, et al., 2012), toward decreased aerobic fitness among the population, noted among students and teaching staff at the Faculty of Sport and Physical Education, could be a consequence of the reduction in number of hours of practical's and decreased student interest in extracurricular or recreational activities. Engaging students in recreational sports activities, recognizing their affinity for certain activities, and motivation for participating in sports recreationally was the focus of the study Stankov et al. (2017), where the authors concluded that engaging students in various sports events can be one way of providing support for those who engage in sports and recreational activities on a regular basis, as well as providing encouragement to those who are insufficiently active. One confirmation of the positive effect of physical activity on health is found in the study conducted with the objective of establishing differences in student health status as a function of being physically active, where the authors found that those students who engage in physical activity more frequently assess their health as excellent or very good compared to students who do not engage in physical activity (Čokorilo & Mikalački, 2015). Consequently, Detanac et al. (2014) note that what is needed, on the path toward maturity and responsibility, both towards oneself and towards one's community, is the timely identification and elimination of unhealthy lifestyle habits (smoking, consuming alcohol, sedentary lifestyle) and insisting on the adoption of healthy lifestyle habits by students.

CONCLUSION

Study results show that the complexity of the period of transition from high school to university and the proliferation of academic obligations, accompanied by poor lifestyle habits (a sedentary lifestyle, smoking, consuming alcohol and drugs, irregular or inadequate diet), can lead to the emergence of stress and adversely affect the psychophysical health of the student population.

The analysis of study results has also demonstrated that, although students tend to have poor lifestyle habits, at the same time they are cognizant of the importance of and need for regular physical exercise for their health and mental hygiene, but they also expect external support from the university in order to do so. Motivating students to join various sports events could be one way of providing such support to those who are insufficiently active, alongside continuous advocating for the importance of adopting a healthy lifestyle, which certainly includes engaging in sports and recreational activities.

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BODY COMPOSITION IN PE STUDENTS: GENDER DIFFERENCES

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ABSTRACT

It has been confirmed many times that physically active people are characterized by "positive", i.e. health-desirable body composition. PE students, in addition to being selected from the population of athletes prior to start of their studies, they have a lot of practical classes during the studies, so it can be said that these are young people with a physically active lifestyle. The main objective of this research was to examine and compare body composition of 24 male and 59 female PE students, aged 18-25. Their baseline characteristics (age, body height and mass, body mass index and resting metabolic rate) were established, as well as their body composition (percentage of fat and muscle tissue, and visceral fat level). The data were analyzed (descriptive statistics, Kolmogorov-Smirnov test, Mann-Whitney U test) using SPSS 21.0. Research results showed the presence of statistically significant gender differences ($p<0.001$) which are in favor of male PE students when it comes to percentage of muscle tissue (M: 40.6%, F: 28.6%), so as visceral fat level (M: 5.9, F: 3.6), i.e. "in favor" of female PE students when it comes to percentage of body fat (M: 19.6%, F: 31.9%).

Keywords: fat tissue, muscle tissue, visceral fat

INTRODUCTION

Human body composition is of great importance in various medical disciplines, when risk factors for origin and development of the disease are in question, but it is also very important for understanding the process of growth and development of the human body (Bjorntorp, 1990). Although the body size and composition are greatly influenced by heredity, there is a little possibility of changing them, both through diet and exercise, and there is a sample of evidence that physically active individuals differ significantly in many somatic characteristics from those with a sedentary lifestyle (Sivapathy, Chang, Chai, Ang, & Yim, 2013; Radu, Popovici, & Puni, 2015; Zombra, 2018).

Quantification of the composition of the human body is one of the elements within the physiological profile, and in the population of athletes it occupies a very important place because it has an important role in monitoring all the performances of athletes and training regimes (Chengliang & Li, 2011). This especially reffers to strength sports (judo, wrestling, boxing, weightlifting), the so-called gravitational sports (ski jumping, cycling) and aesthetic sports (rhythmic gymnastics, artistic gymnastics, artistic swimming and figure skating), in which the composition of body tissues deeply affects the sports result and placement (Ortansa & Ileana, 2006; Ackland, Lohman, Sundgot-Borgen, Maughan, Meyer, Stewart, & Müller, 2012; Purenović-Ivanović, Popović, Bubanj, & Stanković, 2019). Nothing less specific and less important is a population of students of the Faculty of Sports and Physical Education, who are specifically selected for studies because they are required to have above-average somatic characteristics and motor skills. Namely, the existence of a corelations between the anthropometric characteristics of student athletes and their performance in motor activities has been established long time ago (Bale, 1978, 1979, 1980), which unequivocally indicates the necessity of paying attention and evaluating their body composition.

University students form a specific population group of mentally working people in the age range from 18 to 26 characterised by typical health and nutritional problems (Juříková, 2014). Most of them appear to have the opportunity to live outside the family for the first time, which tends to influence and sometimes completely change their lifestyle. Namely, the rate of physical activity changes over the course of life and it significantly decreases throughout schooling, especially in urban areas (Selmanović, Čale-

Mratović, & Ban, 2014). Compared to high school, psychological demands increase especially during the study period, because there is less need for physical effort, while the need for sitting-related activities increases. And just at the transition from high school to college, there is a critical point in decreasing the levels of physical activity (Bray, 2007; Ćurković, 2010; Kwan & Faulkner, 2011). Research studies concerning a physical activity of university students have shown that approximately 35% to 75% of students fail to achieve the recommended level of physical activity (Ćurković, Andrijašević, & Caput-Jogunica, 2014), therefore there is a significant decline in the age group from 18 to 24 years of age (Gomez-Lopez, Gallegos, & Extremera, 2010; Jeffrey, 2013; Ćurković et al., 2014).

Unlike all other faculties, the faculties of sports and physical education (FSPE) have a uniqe combination of theoretical and practical teaching, with a larger fund of classes provided for the implementation of the practical part of teaching. This type of teaching "does not allow" students to be physically inactive, and the selection process itself (entrance exam) is such that sports studies can be enrolled only by those candidates who have a satisfactory level of motor, functional and other abilities. Thus, physical education (PE) students are mostly former or current athletes, which means that their level of physical activity is significantly higher than the rest of the student population, so they are expected and implied the presence of "positive" body composition: a lower percentage of adipose tissue and a higher proportion of muscle and bone tissue. The main goal of this research is to determine the body composition of the PE students and to determine possible gender differences, as well as to draw conclusions based on the lifestyle of PE student of both genders, but also on possible health risks to which they are potentially exposed.

METHODS

Participants

For the purpose of this research, a sample of participants was drown from the population of first- and third-year students of Basic Academic Studies from the Faculty of Sport and Physical Education of University of Niš. The study included 83 PE students (M=24, F=59), aged 20.71±1.51 years (M: 19.88±1.39 years, F: 21.05±1.43 years).

Measures and Procedures

The data were collected during October 2020 and March 2021 at FSPE in Niš. The testing was conducted in agreement with the principles stated in the Helsinki Declaration (WMA, 2013), and all of the measurements were taken by authors in the optimal climatic conditions, with the participants in underwear**.** By interviewing the participants we came to the data on their age (date of birth), and their body height (cm) was determined by Martin Anthropometer and according to the method proposed by International Biological Programme (Weiner & Lourie, 1969). Body composition parameters, such as Body Mass (in kg), Body Mass Index- BMI (in kg/m^2), Body Fat- BF% (in %), Skeletal Muscles- Muscle% (in %), Visceral Fat- Visc F (level) and Resting Metabolic Rate- RMR (in kcal), were assessed with a tetrapolar bioimpedance device- Omron BF511 (Kyoto, Japan), and after entering the data on participants' age, gender and body height.

Statistical procedures

The collected data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc, Chicago, USA). Descriptive statistics [average value (Mean), standard deviation (SD), minimum (min) and maximum (Max)] were summarized for all variables. Normality was tested using the one-sample Kolmogorov-Smirnov test (K-S), and the Mann-Whitney *U* test was performed to determine gender differences. The level of significance was set at $p<0.05$.

RESULTS AND DISCUSSION

The baseline characteristics of the sample in total, and subsamples (gender categories) are presented in Table 1, and the descriptive statistics data of the measured body composition parameters are presented in Table 2.

Table 1. The baseline characteristics of PE students

Groups	Variables	Age (yrs)	Body Height (cm)	Body Mass (kg)	BMI (kg/m^2)	RMR (kcal)
Male PE students (n=24)	*Mean±SD*	19.88±1.39	178.03±5.99	77.03±12.76	24.22±3.28	1755.0±165.69
	Min – Max	19.0 – 25.48	169.0 – 186.8	54.9 – 98.7	18.4 – 29.4	1458.0 – 2015.0
	K-S (Sig.)	.009*	.934	.912	.924	.918
Female PE students (n=59)	*Mean±SD*	21.05±1.43	165.3±6.21	61.89±8.54	22.64±2.95	1335.66±104.99
	Min – Max	18.7 – 24.97	153.0 – 182.4	46.0 – 88.4	18.4 – 32.5	1145.0 – 1583.0
	K-S (Sig.)	.112	.859	.813	.371	.892
Total sample (N=83)	*Mean±SD*	20.71±1.51	168.98±8.43	66.26±12.04	23.09±3.11	1456.92±228.21
	Min – Max	18.7 – 25.48	153.0 –186.8	46.0 – 98.7	18.4 – 32.5	1145.0 – 2015.0
	K-S (Sig.)	.034/	.675	.187	.239	.038*

Legend: n, N- number of study participants, **PE-** physical education, **Mean**- average value, **SD**- standard deviation, **Min-** minimum value, **Max-** maximum value, **K-S-** Kolmogorov-Smirnov test, **Sig.-** significance, **yrs-** years, **BMI**- body mass index, **RMR-** resting metabolic rate.

*absence of normal distribution (significant at p<0.05)

Scrutinizing Table 1, and according to cut-off points of BMI rating scale for adults, 13 (54.17%) male PE students are within the normal range, 10 of them (41.67%) are obese, and only one (4.16%) is bellow the recommended BMI values (BMI=18.4 kg/m^2). Among female PE students, the following situation was recorded: the largest number of female students are of normal nutritional status (n=50, i.e. 84.75%), six of them (10.17%) were pre-obese, two (3.39%) were obese (class I, BMI=32.5 kg/m^2), and one (1.69%) female student was undernourished (BMI=18.4 kg/m^2). In a research conducted eight years ago, on a sample of FSPE student population from Belgrade (Moskovljević, 2013), slightly lower BMI values were recorded (M: 23.69±1.61 kg/m^2, F: 21.17±1.93 kg/m^2), but also higher average body height values were recorded (M: 181.75±6.01 cm, F: 169.3±5.15 cm) in comparison to FSPE students from University of Niš (Niš, Serbia). When it comes to body mass, a slightly higher average value (78.21±6.01 kg) was recorded among male students athletes from Belgrade, and slightly lower (60.32±5.86 kg) among female students. There is a research conducted on the student non-athletes population of 175 students of the Faculty of Medicine of University of Zagreb (Zagreb, Croatia) (Mašina, Zečić, & Pavlović, 2014), that recorded similar BMI values (M: 23.62 kg/m^2, F: 21.59 kg/m^2), as well as of 198 students of different departments in Dubrovnik (Croatia) (Selmanović et al., 2014): 23.89 kg/m^2 (M), 22.5 kg/m^2 (F). However, in a study conducted on the American population of non-athlete students (Pribis, Burtnack, McKenzie, & Thayer, 2010), a slightly higher BMI values were recorded (M: 24.1±4.5 kg/m^2, F: 24.0±5.3 kg/m^2), which can be attributed to the fact that higher BMI value correlates with a sedentary lifestyle (the leading cause of increasement of fat mass tissue among students), but also with better socio-economic conditions in the country (Subramanian, Perkins, Özaltin, & Davey Smith, 2011).

Considering the fact that PE students are selected from the population of athletes and that during their studies they have a lot of practical teaching classes, we can state that these are young people with a physically active lifestyle, and it has been confirmed many times that physically active people have "positive", that is health-desirable body composition. Precisely on this type of sample of respondents, the authors Du & Zhao (2013) conducted a four-year longitudinal study that showed an improvement in a number of fitness parameters, as well as body composition (reduction of fat mass, percentage of fat, visceral fat, as well as reduction of waist and hip circumference). The authors concluded that studying at the Faculty of Sports enabled students to reduce the percentage of adipose tissue, increase muscle mass, which overall improved the respiratory and cardiovascular systems capacities and efficacy of functioning, but also enhanced muscle strength and flexibility. In contrast, a four-year longitudinal studies realized on population of non-athlete students (Racette, Deusinger, Strube, Highstein, Deusinger, 2008; Gropper, Simmons, & Ulrich, 2012) showed the opposite: weight gain, but at the expense of increasing fat tissue. In this study, when it comes to the relative mass of adipose tissue, the mojority of students (n=13, i.e. 54.17%) have a normal percentage of adipose tissue; as many as seven students, i.e. 29.17%, have a very high percentage of body fat (BF≥2.05%); three (12.5%) high (39.4<BF<44.0%) and only one (4.16%) has a low percentage of adipose tissue (BF=7.8%) (see Table 2). In the study conducted by López-Sánchez,

Radzimiński, Skalska, Jastrzębska, Smith, Wakuluk, & Jastrzębski (2019) a comparison of student athletes from Spain and Poland was made and on that occasion a lower percentage of adipose tissue was determined when compared to Serbian student athletes: 14.73±5.01% (Spanish students) and 14.28±5.32% (Polish students). In the subsample of female PE students, the situation is much more favorable in relation to male PE students, if reference values and classifications based on them are taken into account, and, in fact, viewed in absolute values, a significantly higher average value of adipose tissue percentage was recorded (Table 2): the majority of female PE students (n=39, i.e. 66.1%) had a low percentage of adipose tissue; 12 of them (20.35%) have a normal percentage of adipose tissue; a high percentage of adipose tissue was registered in seven (11.86%) female PE students, and only in one (1.69%) a very high value (BF=47.6%). Compared to these values of BF%, lower average values of the percentage of adipose tissue (M: 11.6±6.5%, F: 22.4±6.7%) were found in a study conducted on a sample of 5101 students from different faculties of a private university in America (Pribis et al., 2010), which is an another proof of the harmfulness of a sedentary students' lifestyle.

Table 2. Body composition profile of PE students

Groups	Variables	BF%	Muscle%	Visc F
Male PE students (n=24)	*Mean±SD*	19.59±7.01	40.6±4.01†	5.92±2.9†
	Min – Max	7.8 – 33.4	32.2 – 47.3	1 – 10
	K-S (Sig.)	.858	.576	.554
Female PE students (n=59)	*Mean±SD*	31.99±5.81†	28.58±2.75	3.64±1.09
	Min – Max	22.2 – 47.6	23.2 – 38.9	2 – 6
	K-S (Sig.)	.641	.979	**.001***
Total sample (N=83)	*Mean±SD*	28.41±8.35	32.06±6.32	4.3±2.07
	Min – Max	7.8 – 47.6	23.2 –47.3	1 – 10
	K-S (Sig.)	.332	**.006***	**.000***

Legend: n, N- number of study participants, **PE-** physical education, **Mean**- average value, **SD**- standard deviation, **Min-** minimum value, **Max**- maximum value, **K-S-** Kolmogorov-Smirnov test, **Sig.-** significance, **BF%**- body fat percentage, **Muscle%-** muscle mass percentage, **Visc F-** visceral fat level.

* absence of normal distribution (significant at $p<0.05$)

† Mann-Whitney *U* test ($p<0.001$)

It is a known fact that adipose tissue is a ballast (Rowland, 199) which burdens the cardiovascular system. However, perhaps an even bigger problem, primarily from the health aspect, is abdominal obesity, i.e. the presence of visceral fat. Abdominal obesity is something that is more typical and present in males, and this study confirmed it (M: 5.92±2.9 vs. F: 3.64±1.09). However, among individuals who are physically active, such as athletes, as the case with the current sample of respondents, the status of visceral fat is favorable: the vast majority of student athletes (n=19, i.e. 79.17%) have a normal level of visceral fat, noting that there are those with high levels of visceral fat (n=5, i.e. 20.83%), but it is around the lower limit (Visc F=10). In the female subsample, only normal values of visceral fat levels were recorded. A very important component of body composition, which positively and highly correlates with a physically active lifestyle, is the relative mass of skeletal muscles (McGlory, van Vliet, Stokes, Mittendorfer, & Phillips, 2019; Edholm, Veen, Kadi, & Nilsson, 2021). Given that the sample of respondents in this study are physically active population, i.e. population of student athletes, the results obtained are fully consistent with all previous research conducted on the sports population. Namely, the largest percentage of FSPE students (58.33%, i.e. n=14) have a very high percentage of skeletal muscle mass (Muscle≥39.0%), nine of them (37.5%) have a high percentage of muscle mass, and only one student (4.17%) has a normal percentage of muscle mass (Muscle=32.2%). In the subsample of female PE students, the situation is as follows: the majority of female PE students (n=44, or 74.58%) have normal values of the percentage of skeletal muscle mass, 12 of them (20.34%) have a high percentage of muscle mass (30.4<Muscle<35.3%), one (1.69%) has very high (Muscle=38.9%), and two (3.39%) have a low percentage of skeletal muscle mass (Muscle<24.3%).

Comparison of body composition parameters among athletes and non-athletes (Santos, Gobbo, Matias, Petroski, Gonçalves, Cyrino et al., 2013; Yang, Lee, Kim, Him, & Kim, 2013; Zombra, 2018; Пуреновић-Ивановић, Величковић, Пенчић, Ђошић, Живковић, & Поповић, 2021), as well as among athletes of one sports branch and athletes of (non)related sports (Bayios, Bergeles, Apostolidis, Noutsos, & Koskolou, 2006; Beekley, Abe, Kondo, Midorikawa, & Yamauchi, 2006; Mala, Maly, Zahalka, Bunc, Kaplan, Jebavy, & Tuma, 2015; Fields, Metoyer, Casey, Esco, Jagim, & Jones, 2018), attracts the attention of numerous researchers. Additionally, no less popular is the comparison of student-athletes with non-athlete students (Malinauskas, Cucchiara, Aeby, & Bruening, 2007). In the study of Wang & Chen (2009) the body composition of student-athletes and non-athlete students was analyzed and compared, and significantly higher values of fat, muscle and fat-free mass were found in student-athletes, and when it comes to female PE students, the values of muscle and fat-free body mass are higher in female PE students than in female non-athlete students. Even in the case of resting metabolic rate, higher values are recorded in non-athlete male students.

Bearing in mind that there are anatomical-functional as well as morpho-functional differences between men and women (Đorđić, 2008; Đurašković, 2009), which entails numerous other differences, comparison of persons of opposite gender seem illegitimate, and yet challenging for many researchers. Additionally, although the existence of a cause-and-effect relationship between body composition and physical activity has been confirmed several times, and it has been confirmed that male students are more motivated and more involved in sports activities than female students (Cerar & Kondrič, 2014; Fučkar, Reichel, Špehar, & Gošnik, 2014), we find it is still necessary to make comparisons between student athletes of different genders. Scrutinizing Table 2, we see that FSPE students from Niš differ statistically significant in all of the selected parameters of body composition, and these established differences, when it comes to the relative mass of muscle tissue and visceral fat, are "in favor" of male students, while larger values of the percentage of adipose tissue are recorded in female FSPE students, which is physiological thing (Đorđić, 2008). The same results were obtained by other authors, i.e. by such as those who had FSPE students as a sample (Purenović-Ivanović, Popović, Đorđević, & Živković, 2013), and as those who conducted the research among medical students (Mašina et al., 2014), as well as among Teacher education faculty students (Mraković, Horvat, & Brčić, 2007).

CONCLUSION

The results of this research confirmed the hitherto known facts related to differences, among other things, in the body composition of males and females, which are primarily conditioned by hormonal status: women's bones are shorter, thinner, more porous and brittle; until puberty there are no major differences in the muscle mass of boys and girls, but in puberty, boys increase muscle mass under the influence of testosterone, and girls lack this testosterone effect- in the body composition of women is lower proportion of muscle and bone tissue and higher of fat tissues (estrogen effect). Going towards an older age, the level of physical activity decreases, there is an energy imbalance and hormonal changes, which cause undesirable changes in body composition, both women and men: the percentage of muscle and bone tissue decreases, and the percentage of adipose tissue increases. This entails certain health risks: in women osteopenia and osteoporosis occur postmenopausal, as well as frequent fractures, and in men the biggest problem is adipose obesity, i.e. large amount of visceral fat around inner organs, which is an overture primarily to cardiovascular diseases, to which men are more susceptible.

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Physical Education

THE CORRELATION BETWEEN MORPHOLOGICAL CHARACTERISTICS AND MOTOR ABILITIES IN NINE-YEAR-OLD GIRLS

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ABSTRACT

Special interest in scientific research is related to the relations between nutritional status and motor abilities in children of different age. Excess mass and higher development of subcutaneous fatty tissue in children are associated with lower levels of functional motor abilities. The aim of this study was to determine whether there is a connection between morphological characteristics and motor abilities in normal and overweight nine-year-old girls. The sample consisted of 85 third grade female students of elementary schools in the City of Niš. After measuring body height and mass and calculating BMI, two sub-samples were formed: normal weight (n=58) and overweight (n=27). The morphological characteristics were determined by measuring 16 parameters of longitudinal, transversal, circular dimensionality and body mass, and subcutaneous fatty tissue by measuring skinfold thickness. For the assessment of motor abilities (explosive strength, coordination and speed) a battery of nine tests was applied. Relations between morphological characteristics and motor abilities were assessed by a canonical correlation analysis. The results of canonical correlation analysis indicate that the connections between morphological and motor areas are not statistically significant in both groups (p>.05). Thus obtained results suggest that the level of motor abilities in normal and overweight subjects does not depend on their morphological characteristics.

Keywords: prepubescent age, morpho-motoric status, nutritional status

INTRODUCTION

Prepubescent age is a very sensitive developmental period. Although this is a period of slower growth, one calendar year in this ontogenesis period can be considered as developmental stage, in which changes in child's body directly affect individual motor abilities (Turek, 2006).

Within the growth and development and the mutual relations between morphological characteristics and motor abilities in children, certain rules can be defined that depend on the endogenous and exogenous factors, such as gender, age and physical activity (Bala, Jakšić, & Popović, 2009). Defining of rules is based on the fact that individual differences among children are influenced by different body constitutions and types of motor abilities. Knowing of these rules, which are being manifested by relations between the anthropological dimensions, is necessary for understanding the efficiency of any motor ability. The manifestation of motor abilities depends on the morphological characteristics. Motor abilities in children are quantitatively lower and structurally different compared to adults. Accordingly, the relations between morphological characteristics and motor abilities in children are different compared to those in adults.

The biological development of children is manifested through changes in physical and motor development. One of the important aspects of the development, which is associated with physical and motor development, is the level of nutritional status. The nutritional status of children is one of the important indicators of health, mental and physical capabilities and potential for normal and healthy growth and development. It is assumed that bigger deviation from optimal body weight is one of the indicators of health disorder symptoms.

Facing the challenges of modern life, anthropological status of children is exposed to many risk factors (lack of physical activity, irregular and high-calorie diet, etc.). It is notable that great attention of the

scientific community is focused on the physical status of children, pointing to a worrying prevalence of overweight and obese children. According to the World Health Organization (WHO), overweight and obesity are defined as abnormal and excessive fat accumulation that may impair health (WHO, 2019). The results of research that took place in Serbia show that children of prepubescent age are obese in 4.6-8.2% of cases and in 11.3-32% of cases are overweight (Bogdanović & Čolović, 2011; Ostojić, Stojanović, Stojanović, Marić, & Njaradi, 2011; Djordjić, Radisavljevic, Milanovic, Bozic, Grbic, Jorga, & Ostojic, 2016). These results correspond with the ones documented in countries with a high level of obesity among children.

Special interest in scientific research is related to the relations between nutritional status and motor abilities in children of different age. Excess mass and higher development of subcutaneous fatty tissue in children are associated with lower levels of functional motor abilities (Ara, Moreno, Leiva, Gutin, & Casajús, 2007; Casajús, Leiva, Villarroya, Legaz, & Moreno, 2007; Leskošek, Strel, & Kovač, 2007; Milanese, Bortolami, Bertucco, Verlato, & Zancanaro, 2010; Esmaeilzadeh & Ebadollahzadeh, 2012; Ostojić et al., 2011). Compared to normal weight children, overweight and obese children had more problems in activities that required lifting and projecting body mass through space (Malina, Beunen, Claessens, Lefevre, Eynde, Renson et al., 1995; Ara et al., 2007; Casajús et al., 2007; Leskošek et al., 2007). Obesity in childhood is often associated with physical inactivity (Stettler, Signer, & Suter, 2004; Bukara-Radujković & Zdravković, 2009). Level of physical activity in these children is significantly lower than in normal weight children (Trost, Kerr, Ward, & Pate, 2001; Ara et al., 2007). Some authors believe that obesity represents an obstacle for motor development and generation of motor habits (Graf, Koch, Dordel, Schindler-Marlow et al., 2004; Graf, Koch, Kretschmann-Kandel, Falkowski, Christ et al., 2004; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006; Bala, 2007; Cawley & Spiess, 2008).

The aim of this research is to determine whether there is a connection between morphological characteristics and motor abilities in normal and overweight nine-year-old girls.

METHODS

Subjects

The research was conducted on the sample of 85 third grade elementary school students attending "Ratko Vukićević," "Car Konstantin" and "Sveti Sava" elementary schools in Niš, aged 8.98±0.57 years. The sample included those girls whose parents gave signed consent for their participation, and who were healthy on the day of the testing. The measuring took place in the school facilities which met the necessary requirements.

After measuring body height and body mass and calculating body mass index (BMI), two sub-samples were formed, according to children's BMI and in accordance with the work of Cole, Bellizzi, Flegal & Dietz (2000). The first sub-sample consisted of 58 girls of normal body weight and an average BMI value of 16.68±1.71 kg/m^2 and age of 9.17±0.32 years. The second sub-sample consisted of 27 overweight girls and an average BMI value of 21.00±1.26 kg/m^2 and age of 8.08±0.51 years.

Procedure

Morphological characteristics were determined by measuring 16 parameters of longitudinal, transversal, circular dimensionality and body mass, and subcutaneous fatty tissue by measuring skinfold thickness. Within the longitudinal dimensionality of the skeleton the following parameters were determined: body height, leg length and arm length; within the transversal dimensionality: shoulder width, pelvic width, and hip width; within the circular dimensionality and body mass: thorax volume, upper arm volume, thigh volume and calf volume; within the subcutaneous fatty tissue: subscapular skinfold, abdominal skinfold, thigh skinfold and medial calf skinfold.

The measuring technique for the morphological characteristics followed the guidelines of the methodology recommended by the International Biological Program (Weiner & Lourie, 1969).

Basic parameters of the motor abilities were determined by using the battery of tests used in the study by Kostić, Đurašković, Pantelić Uzunović, Veselinović, & Mladenović-Ćirić, 2010): plyometric jump (Nazarenko, 2000), hyperextension, twist, and throw (Kosti, Đurašković, Pantelić, Živković, Uzunović, & Živković, 2009), standing depth jump (Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975), 20 sidesteps with a baton (Kurelić et al., 1975), horizontal jump rope (Kurelić et al., 1975), running and rolling (Kostić et al., 2009), hand tapping (Kurelić et al., 1975), 5×10 meter run (Kurelić et al., 1975), and foot tapping against a wall (Kurelić et al., 1975).

Statistical analysis

For all the parameters of the morphological characteristics and motor abilities, mean arithmetic values and standard deviations were calculated, while the connection between the morphological characteristics and motor abilities was determined by using a canonical correlation analysis. The biorthogonal method of canonical correlation analysis was used. For each isolated canonical function the following parameters were given: extent of the canonical correlation (R), canonical root of determination (R^2), Bartlett's Chi-square test (H^2), degree of freedom (df) and significance level (p). All of the analyses were carried out with help of the SPSS 16.0 program.

RESULTS

Table 1 shows the arithmetic mean values and standard deviations of all the variables of morphological characteristics and motor abilities for both sub-samples. The descriptive statistical parameters indicate that the group of normal weight girls is superior in almost all of the tested motor abilities, while the values of almost all of the morphological characteristics are higher in overweight girls.

Table 1. Basic descriptive statistical parameters

Morphological characteristics			Motor abilities		
	Normal weight (n=58)	**Overweight (n=27)**		**Normal weight (n=58)**	**Overweight (n=27)**
	Mean±SD	*Mean±SD*		*Mean±SD*	*Mean±SD*
Body height	139.4±5.84	140.05±6.30	**Plyometric jump**	19.01±5.78	16.85±6.02
Leg length	78.99±4.50	78.46±4.02	**Hypertension, twist, and throw**	69.88±18.08	53.62±17.33
Arm length	58.9±3.66	59.16±2.89	**Standing depth jump**	121.07±21.25	111.93±24.93
Shoulder width	30.11±1.59	31.35±1.58	**Horizontal jump rope**	6.33±5.07	4.48±4.11
Pelvic width	20.92±1.43	23.34±1.22	**20 sidesteps with a baton**	23.47±8.88	26.35±1.80
Hip width	23.06±1.71	24.85±1.50	**Running and rolling**	18.18±2.52	20.23±2.60
Body weight	32.53±4.68	41.34±5.16	**Hand tapping**	32.84±4.41	28.67±4.20
Thorax volume	64.94±5.25	73.11±5.68	**Foot tapping against a wall**	16.81±2.16	18.37±3.85
Upper arm volume	19.98±2.06	22.96±1.66	**5×10 meter run**	17.21±1.73	17.72±1.34
Thigh volume	41.44±4.63	45.71±4.88			
Calf volume	28.32±2.28	31.81±1.79			
Triceps SF	12.71±3.53	20.34±5.13			
Sub-scapular SF	8.89±3.54	18.77±5.95			
Abdominal SF	11.99±6.88	24.16±7.65			
Thigh SF	16.85±5.20	24.8 5.73			
Medial calf SF	11.80±4.33	16.16±4.27			

Legend: Mean- average value, **SD-** standard deviation, **SF-** skinfold, **n-** number

The cross-correlation matrix between morphological characteristics and motor abilities for the group of normal weight and overweight participants are shown in Table 2 and 3. Based on the results presented in those tables, a small number of statistically significant correlations is evident. The course of the relationship varies, which is evident in the trend of the correlation coefficients, which may be the result of the correlation essence, but also the result of the method used for measuring and assessing some time-related motor abilities. It is noted that in both subject groups there were not significant correlations between morphological characteristics and tests for the assessment coordination (20 sidesteps with a baton and running and rolling).

By analyzing statistically significant coefficients (Table 2), it is evident that plyometric jump is in correlation with subscapular skinfold. Hyperextension, twist and throw is in correlation with leg length.

Standing depth jump is in correlation with subscapular and abdominal skinfold. Horizontal jump rope is in correlation with shoulder width, subscapular and abdominal skinfold. Foot tapping against a wall is in correlation with arm length and medial calf skin fold. Test 5×10 m run is in correlation with subscapular skinfold.

Table 2. The cross-correlation matrix between morphological characteristics and motor abilities in normal weight girls

	Plyometric jump	Hyperextension, twist, and throw	Standing depth jump	Horizontal jump rope	20 sidesteps with a baton	Running and rolling	Hand tapping	Foot tapping against a wall	5×10 meter run
Body height	-0.10	0.13	0.11	-0.03	-0.20	-0.00	0.09	-0.16	0.00
Leg length	-0.05	0.25*	0.11	-0.06	-0.14	0.06	-0.00	-0.10	-0.01
Arm length	-0.15	0.06	0.05	-0.13	-0.20	0.05	0.10	-0.25*	-0.01
Shoulder width	-0.08	-0.11	0.05	-0.27*	-0.11	0.08	0.19	-0.20	-0.06
Pelvic width	-0.14	0.05	-0.12	-0.01	-0.14	0.05	0.12	-0.09	0.20
Hip width	-0.15	0.21	-0.00	0.01	-0.16	-0.15	0.07	0.05	0.02
Body weight	-0.12	0.14	0.06	-0.02	-0.19	-0.14	0.02	-0.03	-0.01
Thorax volume	-0.09	0.00	-0.05	-0.12	-0.24	-0.14	0.08	-0.12	0.17
Upper arm volume	-0.14	0.02	-0.06	-0.14	-0.20	-0.21	0.10	-0.05	0.05
Thigh volume	-0.01	-0.01	0.04	-0.04	-0.03	-0.20	0.18	-0.03	0.02
Calf volume	-0.05	0.05	0.16	0.09	-0.08	-0.16	0.07	0.08	-0.12
Triceps SF	-0.20	0.05	-0.17	-0.03	-0.15	-0.06	0.01	0.02	0.16
Sub-scapular SF	-0.32*	0.03	-0.36**	-0.26*	0.13	0.09	0.19	-0.10	0.35**
Abdominal SF	-0.23	-0.04	-0.25*	-0.28*	0.04	0.05	-0.00	-0.15	0.24
Thigh SF	-0.16	0.06	-0.12	-0.13	0.10	-0.03	0.11	-0.03	0.18
Medial calf SF	-0.14	0.17	0.06	0.19	0.04	-0.04	-0.09	0.27*	-0.01

Legend: SF- skinfold; level of significance ** $p < .01$; * $p < .05$

By analyzing cross-correlation matrix (Table 3), it is evident that plyometric jump is in correlation with triceps skinfold. Hyperextension, twist and throw is in correlation with body height and shoulder width. Standing depth jump is in correlation with triceps and abdominal skinfold. Horizontal jump rope is in correlation with triceps skinfold. Hand tapping is in correlation with body height, leg length, arm length and body mass. Foot tapping against a wall is in correlation with abdominal skinfold, arm length and thigh volume. Test 5×10 m run is in correlation with triceps, subscapular and thigh skinfold.

The correlation between the set of morphological and motor variables was determined by applying canonical correlation analysis. Table 4 shows the results of the canonical correlation analysis in the group of normal weight (left) and overweight subjects (right). Based on the application of canonical correlation analysis, statistically significant correlation coefficients between morphologic characteristics and motor abilities were not found in both groups. Thus, these results will not be analyzed.

Table 3. The cross-correlation matrix between morphological characteristics and motor abilities in overweight girls

	Plyometric jump	Hyperextension, twist, and throw	Standing depth jump	Horizontal jump rope	20 sidesteps with a baton	Running and rolling	Hand tapping	Foot tapping against a wall	5×10 meter run
Body height	0.05	0.44*	0.36	0.16	-0.30	-0.19	0.59**	-0.31	-0.02
Leg length	-0.07	0.32	0.28	0.10	-0.21	-0.16	0.59**	-0.21	0.11
Arm length	0.05	0.25	0.34	0.05	-0.06	-0.22	0.52**	-0.43*	-0.04
Shoulder width	0.04	0.38*	0.29	0.19	-0.26	-0.14	0.27	0.34	-0.27
Pelvic width	-0.02	0.08	0.12	-0.25	-0.20	-0.27	0.09	-0.01	0.06
Hip width	-0.08	0.23	0.36	0.10	-0.26	-0.21	0.31	0.01	-0.05
Body weight	0.03	0.34	0.23	0.08	-0.30	-0.25	0.48**	-0.24	0.03
Thorax volume	-0.06	0.16	-0.09	0.03	-0.06	-0.23	0.16	-0.34	0.03
Upper arm volume	-0.10	0.03	-0.21	-0.14	0.08	-0.10	0.07	-0.27	0.18
Thigh volume	0.06	-0.02	-0.10	-0.08	0.02	-0.18	0.31	-0.39*	0.11
Calf volume	-0.13	0.21	0.23	-0.09	-0.08	0.03	0.11	-0.10	0.06
Triceps SF	-0.48**	-0.32	-0.42*	-0.44*	0.21	0.22	-0.11	-0.04	0.47*
Sub-scapular SF	-0.37	-0.15	-0.25	-0.23	0.17	-0.03	-0.08	-0.26	0.45*
Abdominal SF	-0.22	-0.29	-0.41*	-0.23	0.22	-0.00	-0.23	-0.46*	0.21
Thigh SF	-0.14	-0.14	-0.29	-0.22	0.27	-0.06	-0.05	-0.37	0.39*
Medial calf SF	-0.33	0.30	-0.10	-0.12	0.06	0.09	0.11	-0.20	0.10

Legend: SF- skinfold; level of significance ** p < .01; * p < .05

Table 4. The canonical correlation between morphological characteristics and motor abilities in normal weight (left) and overweight girls (right)

	Normal weight girls					Overweight girls				
	R	R^2	Chi-Sqr.	df	p	R	R^2	Chi-Sqr.	df	p
0	0.81	0.66	164.62	144	.116	0.98	0.96	163.53	144	.128
1	0.75	0.56	117.35	120	.551	0.96	0.92	121.19	120	.453
2	0.70	0.49	81.20	98	.890	0.92	0.85	88.29	98	.748
3	0.55	0.31	51.27	78	.992	0.89	0.79	63.64	78	.880
4	0.50	0.25	35.11	60	.996	0.84	0.70	43.15	60	.950

DISCUSSION

The results of the cross-correlation in normal weight girls indicate that subcutaneous fatty tissue is impeding factor in the manifestation of explosive leg strength. It is expected that greater development of adipose tissue will have a negative impact on the realization of standing depth jump and plyometric jump, which is consistent with previous research (Malina et al., 1995; Raudsepp & Jürimäe, 1997; Suchomel, 2005; Milanese et al., 2010). Also, the negative effect of subcutaneous fatty tissue in normal weight subjects is evident in tasks designed to evaluate leg coordination and speed. Since the movement structure in these motor tests require fast and efficient lifting and projecting body mass through space, it is logical that subcutaneous fatty tissue, as a ballast mass, would be a disruptive factor in the realization of these motor tests, as evidenced by numerous previous studies (Biskanaki, Panagiotou, Papadopoulou, Spiridou, Gallos et al., 2004; Suchomel, 2005; Tokmakidis, Kasambalis, & Christodoulos, 2006; Ara et al., 2007; Brunet, Chaput, & Tremblay, 2007; Casajús et al., 2007; Leskošek et al., 2007; Siahkouhian, Mahmoodi, & Salehi, 2011). Hyperextension, twist and throw is in positive correlation with leg length.

Longer extremity length in subjects enables better execution of these task, which is manifested through further throw of the medicine ball.

Similar results of cross-correlation matrix were noted in overweight subjects. Variables for assessing subcutaneous fatty tissue had a negative correlation with plyometric jump, standing depth jump, horizontal jump rope and 5×10 m run. This is also the case in motor tasks whose movement structures require lifting and projecting body mass through space, and in which subcutaneous fatty tissue represents a disruptive factor. Thus obtained results were expected, considering the fact that we were testing the group of overweight subjects. When it comes to frequent movement speed of arms, its performance is positively determined by body height, arm length, leg length and body mass. Studies confirm that the arm length is an essential factor in the effectiveness of performing this task, while increased voluminosity and body mass do not impose disturbing factors (Ara et al., 2007; Leskošek et al., 2007; Pejčić, 2007; Podstawski & Boryslawski, 2012; Malacko, Pejčić, & Tomljenović, 2014).

The growth and development of children, as well as their morphological characteristics, influence the realization of various motor tasks (Pate, 1989; Taylor & Baranowski, 1991; Malina et al., 1995; Matić, 2006; Turek, 2006; Kondrič, Mišigoj-Duraković, & Metikoš, 2002). However, this phenomenon does not always hold true. By analyzing the results of canonical correlation analysis it can be concluded that in normal and overweight nine-year-old girls there is no statistically significant correlation between the areas of morphological characteristics and motor abilities ($p>.05$). Thus obtained results are not in line with previous research, and therefore they should approached with a dose of skepticism.

CONCLUSION

Morpho-motoric status of prepubescent students provides useful information in the process of evaluation of their growth and motor development, effectiveness of the teaching process and early detection of any developmental problems. Continuous monitoring of physical growth and motor abilities of students in the scope of physical activity classes at school enables the creation of a database for scientific examination of different aspects in the sphere of motor functioning of children and allows better organizing of physical education classes.

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STUDY REGARDING HOW THE PHYSICAL EDUCATION LESSONS ARE CONDUCTED IN A RURAL ENVIRONMENT, CONSIDERING THE COVID-19 PANDEMIC

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ABSTRACT

This paper aimed to identify the way in which the physical education classes are conducted in a rural environment during the Covid-19 pandemic. Before the academic year of 2020-2021, solutions were searched to increase the quality of e-learning and face-to-face learning but also to ensure safe conditions for the pupils and the teachers. One of the solutions that were used was the color system, divided into three scenarios. Scenario 1, or green scenario, was used in the areas where the rate of infection was under 1 per thousand population. This scenario let all pupils participate in their classes in person, every day. Scenario 2, or yellow scenario, was used in the areas where the rate of infection was between 1 and 3 per thousand population. This scenario used the hybrid method, meaning the group of pupils was divided in two, and the face-to-face learning is performed by rotation, once every week or two. The pupils who weren't physically in class had online classes. Scenario 3, or red scenario, was used in the areas where the rate of infection was over 3 per thousand population. Here, every class was conducted online. On February 8, 2021, a new model was made to include the scenarios in schools. The first scenario (green) was applied in the areas where the SARS-CoV-2 rate of infection was up to one per thousand population. All pupils are physically present in class. The second scenario (yellow), was used in the areas where the rate of infection was over one per thousand population. Here the children's physical presence is required for kindergarten, primary school and terminal grades (eighth, twelfth). The third scenario (red) was applied in the case of over three per thousand population. Here, the ones whose physical presence is required are kindergarten, primary school and terminal grades (eighth, twelfth) pupils. The classes are conducted 100% online only when the rate of infection is over six per thousand population. One year after the pandemic started, over 168 million children, in Romania, were doing e-learning, while 214 million, meaning 1 in 7 pupils was not able to participate in three quarters of the face-to-face classes.

Keywords: pupils, Covid-19, rural environment

INTRODUCTION

When the SARS-CoV-2 virus hit the entire world, things went through quick transformations, a great capacity for adaptation being required. On March 16, 2020, Romania went into a state of emergency, followed by a state of alert on May 18, 2020, because of the SARS-CoV-2 pandemic. Because of the pandemic, Romania went through a radical transformation, the education process having to adapt to it. The e-learning format ensures that every pupil has a chance to education. The rapid chance to e-learning has encountered multiple problems, because of a lack of guidelines and clear instructions in regards to platforms. The e-learning platforms does not respect the pupils' right to privacy, etc. Once the face-to-face classes were suspended, the educational process has continued online up to the end of the semester. The Romanian education system was not ready to deliver a quality and effective e-learning for all participants, the quality of face-to-face classes being far superior to the online ones (Heghes, 2020). Before the academic year of 2020-2021, solutions were searched to increase the quality of e-learning and face-to-

face learning but also to ensure safe conditions for the pupils and the teachers. One of the solutions that were used was the color system, divided into three scenarios. Scenario 1, or green scenario, was used in the areas where the rate of infection was under 1 per thousand population. This scenario let all pupils participate in their classes in person, every day. Scenario 2, or yellow scenario, was used in the areas where the rate of infection was between 1 and 3 per thousand population. This scenario used the hybrid method, meaning the group of pupils was divided in two, and the face-to-face learning is performed by rotation, once every week or two. The pupils who weren't physically in class had online classes (Pop, 2021).

The physical education is defined as the activity that systematically capitalizes on all forms of exercise, aiming to primarily increase the human being's biomotor potential in accordance with the social demands (Alexe, 1974).

Ciapa (2020) stated that in regards to physical education teachers, the type of connection with the pupils must be established, in the sense of getting closer to them and directing them toward achieving their individual motor goals. This can manifest as attracting the pupils/students towards the volunteer practice of exercise, not as a result of 'legal constraints'. Highlighting the effects of exercising in fighting depression, anxiety, stress and uncertainty can lead to an increase in one's level of self-confidence, improving their state of mind, creating a beneficial disposition among the practitioners. The physical and mental health of each pupil/student should be a main priority for each physical education teacher/trainer during their lessons (Ciapa, 2020).

METHODS

The research methods used in this research were as follows:

1. The study of the professional literature,
2. The inquiry method (application of a questionnaire),
3. The statistical-mathematical method (analysis of the data gathered from the questionnaire),
4. The graphical representation method.

Subjects

The subjects of this research were 18 physical education teachers and 77 fifth grade pupils, during the academic year of 2020-2021, in rural schools in the counties: Bacău, Iaşi and Suceava.

Procedure

In order to observe how the physical education lessons were conducted rurally during the Covid-19 pandemic, two questionnaires were used. The first questionnaire was addressed to the teachers, and comprised the following questions:

1. **What was the attendance during your online classes?**
a) 80-100% b) 50-80% c) 20-50%
2. **How much of the curriculum did you manage to go through during e-learning?**
a) 80-100% b) 50-80% c) 20-50%
3. **What problems did you encounter during e-learning?**
4. **How did you do the assessment for the first semester?**
a) Videos b) Projects c) Tests d) Evaluation charts
5. **How did you assess the pupils who did not have Internet?**
a) Evaluation charts b) Verbally (over the telephone) c) Videos
6. **Did you have the necessary material support to work with the pupils during this pandemic?**
a) Yes b) No
7. **Did you have the possibility to correct the pupils when their performance was not according to the standards? (in e-learning)**
a) Yes b) No
8. **How much of your teaching projects did you succeed in doing during e-learning?**
a) 80-100% b) 50-80% c) 20-50%
9. **What method of explaining the exercises did you use during e-learning?**
a) Videos b) Explanation c) Demonstration
10. **What were you able to approach more from the curriculum in e-learning?**
a) Mobility training b) Speed training c) Strength development d) Endurance development

e) Acrobatic exercises f) Applicative exercises g) Invasion games.

11. **Were you able to supervise all pupils when they performed the exercises in e-learning?**

a) Yes b) No

12. **Did you get help from the parents?**

a) Yes b) No

13. **Did you conduct more practical or theoretical lessons during e-learning?**

a) Practical lessons b) Theoretical lessons

The second questionnaire was addressed to the fifth graders, containing the following questions:

1. **How many online classes did you attend?**

a) 80-100% b) 50-80% c) 20-50%

2. **How often do you exercise?**

a) Once a week b) Twice a week c) Three or more times a week

3. **Are the physical education and sports classes beneficial for your health and harmonious physical development?**

a) Yes b) No

4. **What do you prefer between online and face-to-face classes?**

a) Online classes b) Face-to-face classes

5. **How are the socially distant physical education classes?**

a) Boring b) Fun

6. **Did you have the possibility to create exercises during e-learning?**

a) Yes b) No

7. **Were you able to perform all the exercises given to you by the teacher during e-learning?**

a) Yes b) No

8. What did you do more during e-learning?

a) Static exercises (in place) b) Dynamic exercises (in motion)

9. What method was used to assess you for marks?

a) Videos b) Power Point presentations c) Tests d) Oral evaluation

10. **Were you always informed at the beginning of the physical education class what will be the content of the lesson?**

a) Yes b) No

11. **Were you corrected by the teacher when your performance was not according to standard, during e-learning?**

a) Yes b) No

12. **Which is a better way for you to internalize the information regarding a new performance technique?**

a) Verbal explanation (description) b) Watching videos c) Having a teacher or colleague perform it in front of me

13. **What are the advantages of the physical education class, compared to other subjects?**

a) It helps you get to know yourself better b) It helps you get to know your classmates better

c) It helps you form new friendships d) It helps develop team work

14. **Up to what number do you count during your warm-up?**

a) 4 b) 6 c) 8

15. **What would you change in the physical education classes?**

RESULTS

The analysis of the questionnaires applied in the various schools in the counties of Iași, Suceava and Bacău revealed the following answers:

Table 1 - Answers given to the questionnaire by the physical education teachers from a rural environment

1. What was the attendance during your online classes?	a) 80-100% - 10 answers b) 50-80% - 6 answers c) 20-50% - 2 answers
2. How much of the curriculum did you manage to go	a) 80-100% - 3 answers

through during e-learning?	b) 50-80% - 8 answers c) 20-50% - 7 answers
3. What problems did you encounter during e-learning?	Lack of technology / no Internet - 6 answers Lack of physical interaction with the pupils - 2 answers The pupils' refusal to turn on their cameras - 3 answers The pupils' absence from the online classes – 1 answer Lack of space necessary for the exercises - 3 answers Lack of teaching materials - 1 answer No problems - 2 answers
4. How did you do the assessment for the first semester?	a) Videos - 12 answers b) Projects – 2 answers c) Tests – 2 answers d) Evaluation charts – 2 answers
5. How did you assess the pupils who did not have Internet?	a) Evaluation charts - 5 answers b) Verbally (over the telephone) – 5 answers c) Videos – 8 answers
6. Did you have the necessary material support to work with the pupils during this pandemic?	a) Yes – 12 answers b) Nu – 6 answers
7. Did you have the possibility to correct the pupils when their performance was not according to the standards? (in e-learning)	a) Yes - 11 answers b) No - 7 answers
8. How much of your teaching projects did you succeed in doing during e-learning?	a) 80-100% - 1 answer b) 50-80% - 10 answers c) 20-50% - 7 answers
9. What method of explaining the exercises did you use during e-learning?	a) Videos - 4 answers b) Explanation – 8 answers c) Demonstration – 6 answers
10. What were you able to approach more from the curriculum in e-learning?	a) Mobility training - 6 answers b) Speed training - 0 answers c) Strength development - 10 answers d) Endurance development - 0 answers e) Acrobatic exercises - 1 answer f) Applicative exercises - 1 answer g) Invasion games - 0 answers
11. Were you able to supervise all pupils when they performed the exercises in e-learning?	a) Yes - 5 answers b) No - 13 answers
12. Did you get help from the parents?	a) Yes - 10 answers b) No - 8 answers
13. Did you conduct more practical or theoretical lessons during e-learning?	a) Practical lessons - 16 answers b) Theoretical lessons - 2 answers

Table 2 - Answers given to the questionnaire by the fifth graders from a rural environment

1. How many online classes did you attend?	a) 80-100% - 60 answers b) 50-80% - 10 answers c) 20-50% - 7 answers
2. How often do you exercise?	a) Once a week - 10 answers b) Twice a week - 32 answers c) Three or more times a week - 35 answers
3. Are the physical education and sports classes beneficial for your health and harmonious physical development?	a) Yes - 70 answers b) No - 7 answers
4. What do you prefer between online and face-to-face classes?	a) Online learning - 72 answers b) Face-to-face learning - 5 answers
5. How are the socially distant physical education classes?	a) Boring - 52 answers b) Fun - 25 answers
6. Did you have the possibility to create exercises during e-learning?	a) Yes - 50 answers b) No - 27 answers
7. Were you able to perform all the exercises given to you by the teacher during e-learning?	a) Yes - 45 answers b) No - 32 answers
8. What did you do more during e-learning?	a) Static exercises (in place) - 61 answers b) Dynamic exercises (in motion) - 13 answers
9. What method was used to assess you for marks?	a) Videos - 26 answers b) Power Point presentations – 5 answers c) Tests – 30 answers d) Oral evaluation – 17 answers
10. Were you always informed at the beginning of the physical education class what will be the content of the	a) Yes - 66 answers b) No - 11 answers

lesson?	
11. Were you corrected by the teacher when your performance was not according to standard, during e-learning?	a) Yes - 59 answers b) No - 18 answers
12. Which is a better way for you to internalize the information regarding a new performance technique?	a) Oral explanation (description) - 25 answers b) Watching videos - 25 answers c) Having a teacher or colleague perform it in front of me - 27 answers
13. What are the advantages of the physical education class, compared to other subjects?	a) It helps you get to know yourself better - 9 answers b) It helps you get to know your classmates better - 4 answers c) It helps you form new friendships - 3 answers d) It helps develop team work - 61 answers
14. Up to what number do you count during your warm-up?	a) 4 - 20 answers b) 6 – 8 answers c) 8 – 49 answers
15. What would you change in the physical education classes?	Nothing - 36 answers There should be more football - 5 answers There should be more team / group activities - 8 answers The invasion game should be changed - 5 answers There should be competitions with awards - 5 answers No more genuflections, push-ups (for girls), or crouch walking - 5 answers More physical education classes per week - 9 answers

DISCUSSION

"School is the place where useful information is transmitted to us every day, giving us ideas, concepts, thoughts about the world and society, it is the place where new skills and abilities are developed in us, necessary for our existence, it is a place where real friendships are created, a place where the educational act must be performed through the best contributions of the teachers, through the unconditioned and active participation and involvement of the students/pupils. More than that, the quality of the educational act can represent the foundation of our evolution, as a society. The changes that society went through lately have determined the use of a form of transmission of information during education, which was neglected in many ways, being undeveloped: the e-learning" (Ciapa, 2020). In the context of the COVID-19 pandemic it can be said that the most important obstacles are: limitation of travels - legislation, social distancing, sanitary protection measures, limitation to infrastructure and services (e.g., gymnasiums, pools, physical education classes), and the main consequences are: a tendency toward a sedentary lifestyle, social and mental stress, a need to stimulate the immune system (Sandu et al., 2021).

CONCLUSION

Because most rural pupils do not have access to a minimum of technology (Internet, laptop, or tablet), the authors have noticed, during this Covid-19 pandemic, an infringement of the children's right to education. The pupils' evaluation system was superficial, conducted using tests, Power Point presentations, oral examinations and videos. The quality of physical education and sports lessons has decreased considerably during the pandemic, because e-learning did not allow a proper development of all motor skills. Each teacher focused on the content that the pupils were able to perform at home, without any help from their parents. The answers received from the teachers and pupils have shown the problems of each category. The primary condition, for both categories, to conduct online physical education classes is Internet and a computer (laptop, PC, or tablet). In the cases where the number of pupils was very large, the teacher, unfortunately, could not track the performance of every pupil and give them the advice needed to correct their mistakes. The curriculum content could not be applied completely during e-learning. This was a major setback for the pupils, because they ended up with gaps in their knowledge.

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COORDINATION ABILITIES OF CHILDREN IN THE PHYSICAL EDUCATION CURRICULUM FOR ELEMENTARY SCHOOLS

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ABSTRACT

This article reports about coordination abilities of children in the elementary schools and the reason why physical education curriculum with extracurricular activities is efficient. The scientific research used different groups of female children with extracurricular activities. All of the students attended their obligatory physical education classes twice a week. The sample of participants in this research was 73. The participants were divided into two groups: the first group consisted of 41 and the second of 32 Serbian female elementary school students. The students' age ranged from 10 to 12 years and artistic gymnastics was their sport of choice in elementary school. All of the students participated in their sport of choice for at least one year, and three years at most. The sample of variables consisted of anthropometric and motor variables. For the assessment of motor coordination abilities, a battery of tests consisting of six measuring instruments that cover the field of coordination in rhythm, movement frequency speed, and agility was applied. The differences in anthropometric measurements of the female students from different groups show that there is a statistically significant difference at the significance level of 100% on both tests (VISI= .000, TEZI= .000). The differences in coordination in rhythm among is a statistically significant in 100% for the Rolling and walking exercises along a line accompanied by asymmetrical hand motions (KHAR= .000), while for Arrhythmic hand drumming, there were no statistically significant differences (NBUR= .320). Differences in the movement frequency speed can be seen at the significance level of 100% on both tests (TAPR= .000; TAPN= .000). The differences in agility between the female students from two different groups can be seen at statistically significant level of 100% on both tests (RBNR= .002, LECS= .000). The female school children who opted for an additional class had greater affinities and interest toward training artistic gymnastics, which indicate the obtained results: they all scored better results in five out of the six applied tests. Informed by these findings, we conclude that concept of classes designed for a selected sport in the elementary schools of the Republic of Serbia has proven to be quite successful due to the improvements in physical activity and self-awareness of the concept of sports activities of the female students, which later scored higher results at school competitions.

Keywords: coordination abilities, elementary school, extracurricular activities

INTRODUCTION

The physical education curriculum was designed to use various types of motor knowledge and abilities to enable students (adolescents) to use physical exercise in everyday life. Physical education programs in elementary schools were designed based on the gender and age of the children, and include several phases: determining the state of the individual; determining class content based on the specific age of the children; determining the means and methods for realizing the work tasks; realizing educational goals and monitoring and evaluating the effects of the work. Program content for elementary schools is realized during regular classes, extracurricular activities and any other kind of work outside of regular school hours (Dragić & Pešić, 2012). Physical education classes, as part of the educational system, include two classes per week, and free or extracurricular activities are included with an additional class per week. As part of their extracurricular activities, the students are able to select a certain sport which they can improve in during an additional class per week. The goal of physical education – one's sport of choice – is to contribute to the realization of the goals of physical education as an integral part of the

education system, and at the same time satisfy the individual needs of the students and their desire to achieve success in their sport of choice. Extracurricular activities are organized in the form of school sports activities, which are a part of sports-educational work, and enable students to prepare for the school competition system, which is organized by the Serbian School Sport Federation. The Serbian School Sport Federation has its own system of qualification competitions based on school districts, regions, and at the national level as well – national school competitions.

The tasks of physical education classes should be to encourage the growth and development of children, and to, by using select physical content, influence proper body posture. During physical education classes, moderate development of the basic motor abilities should be provided, including: speed, strength, endurance, agility and coordination. All motor exercises should encourage children to aesthetically perform movements. One of the accompanying factors of physical education classes is the socialization of the children in the group, as well as a desire for self-affirmation and competition. By participating in the system of school competitions, children acquire ethical values and norms. It also encourages the moral-voluntary features of the students. Participation in the system of school competitions represents a good basis for the children to opt for improvement in a particular sport. The program of basic sports (artistic gymnastics, swimming and athletics) has been well-developed by the various national sports associations. These associations monitor national school competitions so as to discover potential talents for a particular type of sport. Artistic gymnastics programs in schools include elements of basic movements, including: walking, running, jumping and leaping. All of the elements are a required part of the curriculum for each semester.

The theory of artistic gymnastics primarily defines the concept, content, characteristics and timing of the figures, but also all the factors of their development. In addition to these factors, the terminology of artistic gymnastics, as the language of the gymnastics profession, includes the choice of methods of communication, training and competition. The basic requirements for the promotion of this sport include training and the competition hall, equipment, and leotards for the gymnasts. Artistic gymnastics belongs to a group of aesthetic coordination sports, such as rhythmic gymnastics, figure skating, and ski jumping. Motor abilities are primarily important for the success of the gymnasts (Di Cagno et al., 2016; Donti et al., 2016; Lloyd & Oliver, 2014; Petković, D., 1996; Petković, E., 2009, 2010; Todorovski, 1998). An important part of the exercise for gymnastics compositions are coordination abilities (Delignieres, Teulier, & Nourrit, 2009). Coordination in artistic gymnastics can be general and specific. General coordination is the basis for the development of specific coordination. Specific coordination enables the gymnast to perform complex technical and tactical structures in a variety of conditions quickly, accurately, and easily. It is developed by carrying out specific sport-related movements from unusual starting positions, and under more difficult circumstances (Grigorea, Mitrachea, Predoiua, & Rosca, 2012; Ivashchenko, Khudolii, Iermakov, & Prykhodko, 2018; Petković, 2004). Petković (2017) determined that the distribution of situational coordination in female gymnasts is divided into five factors: 1. The evaluation of the speed of performing complex motor tasks – the use of the obstacle course and obstacle course backwards as selection criteria in gymnastics; 2. The assessment of agility - defined as the ability to change the direction of movement without losing balance, speed, strength, and movement control; 3. The evaluation of the precise range of motion in the shoulder joint - precise movement in the shoulder joint - hand movements in the frontal and sagittal plane (under the specified angles); 4. The estimation of coordination in rhythm - for the realization of motor structures by moving the body in space, performing complex movements in time and space; 5. The estimation of the accuracy of the realization of complex motor tasks – exercise with jumps and movements with asymmetrical work of the upper and lower extremities.

METHODS

Vandorpe et al. (2012) determined after two years of evaluating technical and coordination exercise criteria that the only valid predictor criterion was motor coordination. Based on the competitive performance of the gymnasts, it was determined that there is more than a 40% difference in the prediction of the results for a sample of 23 gymnasts aged seven and eight. Gallotta et al. (2016) conducted a study on a sample of 230 children and examined the impact of a five-month focused physical education program on motor abilities, among which coordination on the balance beam showed the greatest contribution to progress. According to Belej et al. (2006) in modern gymnastics training the condition for loading has reached its limits, especially in the training process, where the priority should be the development of coordination capacities. In the work of Kochanowicz et al. (2009) three tests were used on a sample of 18 gymnasts aged 7-9 for the evaluation of coordination abilities.

The aim of this study was to determine the existence of possible differences in coordination abilities in the physical education curriculum for elementary school children in the Republic of Serbia. Coordination

abilities in elementary schools were assessed by measuring instruments for the estimation of coordination in rhythm, speed of movement frequency, and agility, on a sample of girls aged 10 and 12 from the territory of the municipality of Niš.

Subjects

The sample of participants in this research was 73 which were divided into two groups: the first group consisted of 41 (age: 11 yrs ± 6 months; body height: 161±0.5 cm; body mass: 65±0.5 kg) and the second of 32 (age: 9 yrs ± 6 months; body height: 143±0.5 cm; body mass: 33±0.5 kg) Serbian female elementary school students. The students' age ranged from 10 to 12 years and artistic gymnastics was their sport of choice in elementary school. In addition to attending obligatory physical education classes twice a week, all of the students participated in their sport of choice for at least one year, and three years at most. The first group attended classes twice a week, while the other group in addition to their regular classes, also participated in an additional class.

Procedure

The study was approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš, in accordance with the Helsinki Declaration (WMA, 2002). All of the participants, their parents and teachers were informed about the aims of the research. The parents signed a consent form which allowed their children to participate in this research. All of the measurements were taken indoors under optimal climatic conditions (gym temperature between 16°C - 20°C). All of the tests were carried out at the end of the winter semester (2017/18 school year). The sample of variables consisted of anthropometric and motor variables. The anthropometric measurements were carried out using ISAK guidelines: body height (*VISI, in centimeters*) and body mass (*TEZI, in kilograms*). During the anthropometric measurements, the adolescents wore light clothes, and their feet were bare. Only non-invasive standard anthropometric measurements were performed. Body height were measured with a GPM 101 anthropometer (Siber & Hegner, Zurich, Switzerland). Body mass was measured to the nearest 100 grams using a portable SECA 799 electronic scale (SECA, Birmingham, UK). The coordination variables were calculated from the sample of motor variables. Standardization of the tests had been determined previously (Petković, 2017; Veličković, 1999). For the assessment of motor coordination abilities a battery of six tests that cover the field of movement coordination in rhythm, movement frequency speed, and agility was applied. The coordination tasks were adapted for the sample of participants and had shown optimal measuring characteristics in previous studies (Bala, Stojanović, & Stojanović, 2007; Hariss & Cale, 2006; Petković, 2004, 2017).

The coordination abilities were estimated using measuring instruments in terms of coordination in rhythm, speed of movement frequency, and agility. Coordination in rhythm: *Rolling and walking exercises along a line accompanied by asymmetrical hand motions (KHAR, in number of errors incurred), Arrhythmic hand drumming (NBUR, in frequency);* Movement frequency speed: *Hand tapping (TAPR, in frequency), Feet tapping against the wall (TAPN, in frequency);* Agility: *Rhythmic leg and hip drumming (RBNR, in frequency), 10x4 Lying down, squatting and jumping (LECS, in frequency).* The scoring was carried out by tree teachers who are licensed gymnastics judges. Table 1 presents the criteria of evaluation for the description of the performance of the measuring instrument Rolling and walking exercises along a line accompanied by asymmetrical hand motions. Any deviation from the established order of conducting the exercises was considered an error. Any deviation is calculated as a single error.

Table 1. Criteria of evaluation for description of performance

Points	*Description of performance*
1	technical errors, each time
1	aesthetic errors, each time
1	order of exercises, each time
1	hands, legs, head, each time

Statistical analysis

The statistical analysis was performed by using the statistical package SPSS 20.0. The differences between the two groups of female students were established by means of t-test for small independent samples. The significance criterion was defined at the level of p≤ .05.

RESULTS

Table 2 shows the differences in anthropometric measurements of the female students from two different groups, and it can be seen that there is a statistically significant difference both in body height and body mass (VISI= .00; TEZI= .00, respectively). The height and body mass are varying due to fact they are in adolescent period which is characterized by intense growth and development. Also, these differences in anthropometric parameters can be due to increased extracurricular physical activities, which lead to a reduction in subcutaneous fat tissue and obesity.

Table 2. Differences in anthropometric measurements of female students from 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**
VISI	7.81	.00	9.10	71	.00	17.25	1.89
TEZI	3.96	.05	6.02	71	.00	22.57	3.74

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

Table 3 shows the differences in coordination abilities of the female students from two different groups and it can be seen that there is a statistically significant difference in coordination in rhythm (KHAR= .000), movement frequency speed (TAPR= .00, TAPN= .00), and agility (RBNR= .002, LECS= .000).

Table 3. Differences in coordination abilities of female students from two different groups

Variables	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
								Lower	Upper
KHAR	3.131	.081	7.057	71	**.000**	13.29101	1.88346	9.53550	17.04651
			7.896	45.477	.000	13.29101	1.68316	9.90194	16.68007
NBUR	.044	.835	1.002	71	.320	.67607	.67503	-.66991	2.02204
			1.014	69.304	.314	.67607	.66705	-.65455	2.00668
TAPR	.103	.750	3.920	71	**.000**	-6.35595	1.62135	-9.58883	-3.12306
			3.998	70.393	.000	-6.35595	1.58979	-9.52638	-3.18551
TAPN	13.156	.001	19.422	71	.000	-16.61966	.85573	18.32593	14.91339
			18.015	43.028	**.000**	-16.61966	.92253	18.48008	14.75925
RBNR	1.030	.314	-3.202	71	**.002**	-2.07851	.64915	-3.37288	-.78414
			-3.153	62.335	.002	-2.07851	.65925	-3.39619	-.76082
LECS	13.449	.000	6.440	71	.000	8.40664	1.30528	5.80398	11.00929
			6.935	61.976	**.000**	8.40664	1.21213	5.98360	10.82968

Legend: F- F test, **Sig.**- significance, **Mean**- average value, **Std. Err** -standard error of difference, **p≤.05.**

DISCUSSION

A good coordination means including the most suitable muscles for certain functions in the most efficient order, inhibiting antagonists and regulating the frequency of nerve impulses. To solve coordination problems, complete synchronization of higher regulatory centers and peripheral parts of the locomotor apparatus is necessary. Coordination is, of course, closely linked to the technique of the type of

sport, and is necessary for the athlete to operate efficiently and without difficulty as part of a specific technique, since well-coordinated movements are more economical and quicker than poorly coordinated movements. Recent research suggests that motor coordination in artistic gymnastics can be a crucial factor of success (Belej et al., 2006), but also a predictive criterion for success in this sport (Vandorpe et al., 2012). Experimental treatments carried out to improve coordination abilities have achieved a positive effect in both athletes and students (Gallotta et al., 2016; Tonić, Petković, Mekić, & Radenković, 2010). In artistic gymnastics, most of the previous research was performed by examining the influence of coordination abilities on competitive performance (Novak, 1984; Petković, 2017; Todorovski, 1998; Werner, Williams, & Hall, 2012) and the conclusion was an existence of relationship between situational-motor coordination tests and the single contribution to the competition performance in exercising on the Uneven bars and Balance beam (Petković, 2004), as well as in the All-around competition. Kochanowicz et al. (2009) concluded that quality assessments of coordination and motor abilities create the basics of training individualization in gymnastics in the initial training phase.

The physical education curriculum for the elementary school is divided into basic games with balls and sport gymnastics program. During the course of one semester students learn the basics of technical-tactical elements of training for collective sports (volleyball and handball) and perform exercise programs on the apparatuses. The handball program is consisted of following units: catching and passing with and without the ball, guiding the ball, moving along the 6-meter line, kicking and falls. The volleyball program includes following units: hitting and passing the ball, spikes, catching and passing the ball, and falls. The exercise program of gymnastics includes only exercises on the floor: the Handstand, Bridge, Walkover, and Roll on. The additional physical education class included exercises on the apparatuses. Children involved in their school sport of choice trained for the following disciplines: the Vault, Uneven bars, Balance beam, Floor exercise and All-around competition (the total amount of all the scored points for each of the individual disciplines).

The quicker pace of life marked by modern scientific-technological discoveries (computers, social games, a virtual world) can have a negative effect on the health of young people, who should be guided into healthier ways of life through sports activities. The sedentary way of life contributed to the energy intake of food being greater than energy consumption, which leads to increased body weight and obesity. These factors, overweight and obesity, represent a new global challenge to public health (Hajmer, 2010). Obesity is not just a question of beauty and looking good, but is connected to serious health conditions: a significantly increased risk of diabetes, disorders in the locomotor apparatus, increased blood pressure and psychological disorders. Based on the reports of the World Health Organization, insufficient physical activity has been named an independent risk factor and represents a great national health problem. The level of physical activity, generally speaking, decreases with age, there is evidence that this decrease is especially pronounced during adolescence (Kemper et al., 2001; Kimm et al., 2002). In the case of girls, it was noticed that compared to boys, the decrease in the level of physical activity occurs earlier. The elementary school program of basic sports with extracurricular activities is well-developed and has positive influence on the development of biomotor abilities of Serbian students. Schools should consider developing physical activity programs with extracurricular activities for positive relationships between physical activity and specific sport performance.

CONCLUSION

The difference in the coordination abilities of children from two different groups was indicated by the program carried out during the additional class of the selected sport, which extends the basic elements of regular physical education classes. The female school children who opted for an additional class had greater affinities and interest toward training artistic gymnastics and were more talented, which indicated the obtained results. They all scored better results in five out of six applied coordination tests. The differences in the coordination abilities are conditioned by the work methods which are used in artistic gymnastics. One of the methods is the obstacle course, which is used during the introductory part of the class, as a means of introducing the body to physical strain. Polygons are designed differently with various obstacles, so that the students can develop speed, agility, and flexibility, and these are all features of good body coordination, which is one of the goals of this sport.

The contributions of this research is improvement of new coordination exercise knowledge of physical education teachers in primary school, especially of those who lead the chosen sport in the field of gymnastics. Coordination abilities needs to be developed through systematic programming of the teaching process by choosing various coordination exercises from gymnastics training process.

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Interdisciplinary

CANNABIS USE IN ATHLETES: A 2021 PERSPECTIVE

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ABSTRACT

Cannabis contains in excess of 100 cannabinoids, phytocannabinoids, naturally occurring terpenes, flavonoids, and other chemical compounds, but its most important constituents are two cannabinoids: tetrahydrocannabinol (THC) and cannabidiol (CBD). According to the Code and List of Prohibited Substances and Methods for 2021, all cannabinoids except for cannabidiol are prohibited for use in competition. The detection of tetrahydrocannabinol in urine at a concentration greater than 180 ng/mL during analytical testing represents an adverse analytical finding, or so-called "a positive doping test". Existing research has shown that cannabidiol has anti-inflammatory, immunomodulatory, anxiolytic, antidepressant, and neuro-protective effects, which is why it could potentially be useful for athletes. However, the currently available scientific evidence is preliminary, at times inconsistent, and mainly based on preclinical studies carried out on lab animals. Using products containing cannabidiol in the field of sports medicine is at this time risky, since there are no sufficiently clear standards in the production process that would guarantee the purity and quality of the product. This is particularly important for athletes taking part in competitions, as well as for antidoping activities. We believe that the best strategy for prevention is the avoidance of all products which contain cannabidiol, since this prevents any unintentional doping caused by contaminated products.

Keywords: cannabidiol, analytical testing, antidoping

INTRODUCTION

Cannabis is a shared nomenclature for a plant that includes three species: *cannabis sativa*, *cannabis indica* and *cannabis ruderalis*. The reason for cannabis use (industrial, medicinal, recreational) is determined by the significant difference in the concentration of tetrahydrocannabinols and cannabidiols (Gamelin, Cuvelier, Mendes, Aucouturier, Berthoin, Di Marzo, & Heyman, 2020). Cannabidiols engage two different types of specific endogenic cannabinoid receptors: the CB 1 found in the central nervous system and the CB 2 predominantly found in the cells of the immune system. Activation of CB 1 receptors affects the excitatory and inhibitory neurotransmitters of post-synaptic membranes, while activation of CB 2 receptors affects the pro-inflammatory release of cytokines from immune cells and the modulation of migration of immune cells in order to lower the inflammatory response (Maurer, Mathews, Schleich, Slayman, & Marcussen, 2020).

Tetrahydrocannabinol is a psychoactive constituent of cannabis which is usually introduced into the human body by breathing in smoke or vapor, that is, through the respiratory system. At the same time, certain cannabis products can be ingested through the digestive system. Tetrahydrocannabinol has a high affinity for bonding with CB 1 receptors in the midbrain, the cerebrum, limbic system, and brain stem, which results in psychological effects on mood, perception, and cognition, as well as systematic effects on the cardiovascular, respiratory, digestive, immune, and endocrine systems (Trinh, Diep, & Robson, 2018). Typically, breathing in tetrahydrocannabinol causes a sense of euphoria, which leads to diminished anxiety and increased sociability, but also causes increased heart rate (tachycardia), difficulty breathing, and a sudden drop in arterial blood pressure after assuming an upright position (postural hypotension).

Cannabidiol can be introduced into the body in several different ways, most frequently through the digestive system in the form of oil, gel capsules, plant extracts, drinks, and candy; it can also be applied locally. Following absorption, due to its lipophilic structure, cannabidiol easily passes through

membranes in the entire body and bonds with CB 2 receptors. The terminal half-life of cannabidiols is approximately nine hours and they are primarily excreted through urine in free or in glucuronide form. Existing research showed that cannabidiol manifests anti-inflammatory, immune-modulatory, anxiolytic, antidepressant, and neuro-protective effects due to which it might be useful for athletes (McCartney, Benson, Desbrow, Irwin, Suraev, & McGregor, 2020). Unlike tetrahydrocannabinol, the use of cannabidiol does not cause euphoria or tachycardia (Naik & Trojian, 2021). However, the currently available scientific evidence is sometimes inconsistent and is mostly based on preclinical studies carried out on lab animals.

CANNABINOIDS AND ANTIDOPING ACTIVITIES

According to the Code (World Anti Doping Agency, 2021a) and List of Prohibited Substances and Methods in Sports for 2021 (World Anti Doping Agency, 2021b), all cannabinoids apart from cannabidiols are prohibited for use during competition. The term *In-Competition* refers to the period which begins twelve hours prior to a competition in which an athlete is to participate, and lasts until the end of the competition and the sample collection process, except if stated otherwise in the rules of the international federation organizing the competition (Radovanović & Stojanović, 2020).

During analytical testing (World Anti Doping Agency, 2021c) the detection of tetrahydrocannabinol (chemical: 11-Nor-delta-9-carboxy-tetrahydrocannabinol-9-carboxylic acid) in urine at a concentration greater than 180 ng/mL represents an Adverse Analytical Finding (AAF) or what in the sports jargon is referred to as "a positive doping test". What may seem confusing when interpreting findings is the information found in the technical manual of the World Anti Doping Agency (WADA), published in 2019, which states that the detection of tetrahydrocannabinol in a urine sample at a concentration greater than 150 ng/mL is defined as the maximum threshold; however, the same document clearly states, providing specific explanations, that the cut-off value for the detection of tetrahydrocannabinol is 180 ng/mL (World Anti Doping Agency, 2019). Even though no maximum threshold exists for the other cannabinoids, their detection in a urine sample is reported to the WADA as an adverse analytical finding, after which the appropriate decision is made.

There are several significant events tied to the use of cannabinoids concerning athletes and antidoping activities:

- In 1998, during the Winter Olympic Games held in Nagano, Japan, a urine sample taken from Ross Rebagliati, the Olympic gold medalist in snowboarding was found to contain tetrahydrocannabinol at a concentration of 17.8 ng/mL, while the upper limit was 15 ng/mL. Following an appeal which stated that the athlete had been exposed to second-hand cannabis smoke and that he had not been exposed to the substance during the competition, the International Olympic Committee decided that he would be allowed to retain his results and his gold medal;
- 1999 saw the foundation of the WADA;
- In 2004, the WADA placed all cannabinoids on the List of Prohibited Substances and Methods;
- In 2018, the WADA excluded cannabidiol, as the only member of the broad group of cannabinoids, from the List of Prohibited Substances and Methods;
- In 2021, the US athlete Sha'Carri Richardson did not participate in the Olympic Games in Tokyo because of an adverse analytical finding of tetrahydrocannabinol in her urine sample during her very successful performance at the American Olympic trials.

THE EFFECTS OF CANNABINOIDS ON THE SPORTS PERFORMANCE AND HEALTH OF ATHLETES

Some two decades ago that it was pointed out that cannabinoids affect perception, causing reduced abilities of concentration and focus (Huestis, 2002). Apart from the acute bronchodilatory effect and the ensuing increase in the forced expiratory volume in the first second ($FEV_{1.0}$), there is no shred of proof that cannabinoids can, in any direct or indirect manner, lead to an increase in the sports performance of athletes (Docter, Khan, Gohal, Ravi, Bhandari, Gandhi, & Leroux, 2020). On the other hand, there are documents outlining positive experiences of using products which contain cannabinoids to speed up recovery, decrease pain, and regulate sleep and appetite among athletes. At the same time, special emphasis is placed on the fact that cannabinoids are an effective alternative to the opioid and benzodiazepine group of medicines (Kramer, Sinclair, Sharpe, & Sarris, 2020). In an extensive review of previously published research into substances which are thought to increase exercise and/or sports

performance, and which are included on the List of Prohibited Substances and Methods, the authors point out that there is no scientific proof that cannabinoids can lead to an increase in sports performance among athletes (Heuberger & Cohen, 2019). The most recent systematic review (Charron, Carey, Marcotte L'heureux, Roy, Comtois, & Ferland, 2021) indicates that cannabinoids have a negative impact on the sports performance of athletes since they increase their heart rate, respiration rate, myocardial oxygen demand, as well as disrupt balance, whereby decreasing the physiological adaptation needed for high competition performance.

As previously stated, starting with 2018 cannabidiol was excluded from the List of Prohibited Substances and Methods. Products which contain cannabidiols are often sold as dietary supplements, a special type of food or cosmetics, and they can also be purchased in pharmacies, organic food stores, supermarkets and online, which renders them readily available. However, most products which contain allowed cannabidiol are sold as so-called "full spectrum" products since they also contain other cannabinoids (Lachenmeier & Diel, 2019; Mareck, Fusshöller, Geyer, Huestis, Scheiff, & Thevis, 2021). As a result, when using them, athletes need to be aware that some cannabidiol products obtained by extraction from cannabis can contain tetrahydrocannabinol, which results in a so-called positive drug test.

The WADA added the remaining cannabinoids (except for cannabidiol) to its List of Prohibited Substances and Methods, explaining that there are findings stating that cannabinoids can help athletes achieve better competitive results under pressure and reduce the stress that they experience during a competition (Huestis, Mazzoni, & Rabin, 2011), which is why the use of cannabis "violates the spirit of sport" and "clashes with the image of an athlete as a role model for younger generations the world over".

CONCLUSION

According to the Code and List of Prohibited Substances and Methods for 2021, all cannabinoids except for cannabidiol are prohibited for use in competition. The detection of tetrahydrocannabinol in urine at a concentration greater than 180 ng/mL during analytical testing represents an adverse analytical finding, or so-called "a positive doping test".

Existing research has shown that cannabidiol has anti-inflammatory, immunomodulatory, anxiolytic, antidepressant, and neuro-protective effects, which is why it could potentially be useful for athletes. However, the currently available scientific evidence is preliminary, at times inconsistent, and mainly based on preclinical studies carried out on lab animals. Even though cannabidiol is not prohibited, the available commercial products containing it often also contain tetrahydrocannabinol and other cannabinoids prohibited for use in sport, which is why using these products represents a risk which far outweighs any benefits it might have for athletes.

Using products containing cannabidiol in the field of sports medicine is at this time risky, since there are no sufficiently clear standards in the production process that would guarantee the purity and quality of the product. This is particularly important for athletes taking part in competitions, as well as for anti-doping activities. We believe that the best strategy for prevention is the avoidance of all products which contain cannabidiol, since this prevents any unintentional doping caused by contaminated products.

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EFFECTS OF ORAL SUPPLEMENTATION WITH PLANT SUPEROXIDE DISMUTASE EXTRACT ON COUNT OF LEUKOCYTE AND ITS SUBPOPULATION IN ELITE ROWERS: A PILOT STUDY

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ABSTRACT

The aim of this study was to investigate effect of supplementation with plant origin superoxide dismutase (SOD) on counts of leucocytes and its subpopulation, as important part of immune system, in elite rowers. Twenty young elite rowers were included in double-blinded study. Participants were randomly divided to experimental group who received 2 capsules (500mg) of plant origin SOD (GliSODin) and control group who received placebo i.e. same 2 capsules without active ingredient. Study was conducted during 6 weeks of preparation period. Blood samples was taken from antecubital vein in morning hours and used for on counts of leucocytes and its subpopulation. At the begging of a study all measured parameters were within normal range of values. However, there was some positive tendencies in supplemented group. It was concluded that more studies with large number of participant is needed to confirm if GliSODin can be considered as potentially good supplement in prevention of deleterious effects of intensive physical activity on leucocytes and its subpopulation.

Keywords: antioxidants, athletes, leucocytes

INTRODUCTION

Physical activity has many benefits to our health status. It is well known that regular physical training up-regulates the antioxidant enzymatic systems and stimulates the immune system (Cardoso et al., 2012). On the other hand, intense training causes immune suppression with increased susceptibility to infections (Simpson et al., 2012). One explanation for the immune suppression, reduced number of leukocytes, which makes the body more susceptible to the influence of pathogens in response to an intense physical exercise load, may be an increased use of body functions with exaggerated free radicals production and increased oxidative stress in tissues. Free radicals are molecules capable of independent existence that have one or more unpaired electrons in an atomic orbital, they are unstable and highly reactive molecular species. Most common form of free radicals in human body are reactive oxygen species (ROS). The main source of ROS is respiratory chain complexes in mitochondria. During intensive physical activity amount of oxygen uptake in skeletal muscles is 100-200 fold higher than normal, same as production of ROS (Deaton & Marlin, 2003). Human body can suppress this phenomenon using enzymatic or non-enzymatic antioxidants. When production of ROS overwhelms capacity of our antioxidant system oxidative stress occurs. Oxidative stress is an imbalance between production of free radicals and our antioxidant protection system. High level of free radicals in our body can cause damage to some very important molecules such as lipids, proteins and DNA and may result in cell damage and death. Intensive physical activity is one of the causes of oxidative stress. It has been noticed that in professional athletes

higher level of oxidative stress brings up to higher level of antioxidative protection. Despite this adaptive mechanism if the body does not have enough time to recover, high production of ROS may be harmful. Superoxide dismutase (SOD) is a key component of our enzymatic antioxidant defence system. This enzyme catalyses the reduction of superoxide anion in less reactive hydrogen peroxide which is further neutralised into the molecules of oxygen and water by activity of enzymes catalase(CAT) and glutathione peroxidase (GPX). Oral administration SOD in pure form as a nutritional supplement was without any effect because it was destroyed by our gastro-intestinal enzymes. Studies in the field of formulation have brought to development of gastro-resistant form of SOD. It is called GliSODin and it contains SOD chemically combined whit gliadin. Gliadin is a protein isolated from wheat. We hypothesized that oral supplementation with GliSODin, will reduce oxidative stress caused by intensive physical activity and limit immune suppression that can occur in professional athletes measuring leucocytes and its subpopulation, also with including specific index expressed as Granulocytes/ Lymphocytes ratio.

METHODS

This study was double blind, placebo controlled human study approved by Ethical committee of Faculty of Pharmacy of University of Belgrade, Serbia (protocol No. 2192/2). At the begining of the study all participants were informed about the nature of investigation and gave their written consent to participate in the study.

Subjects

Twenty rowers of national category participate in this study. Mean age in the group was 25.1±6.2 years, mean body height was 184.1±7.2 cm, body mass 83.20±12.71 kg, and body mass index (BMI) was 24.46±2.85 kg/m^2. Training experience was 6.2±4.3 years, average training sessions per week was 7.05±1.75, and duration of single training session was 113.9±35.1 minutes. All participants were randomly divided into experimental and control group. All athletes were healthy, without any chronicle diseases or surgical procedure in last 6 months. All participants were on a regular diet and have not been taking any other supplement during the study. The athletes were asked to inform scientific staff if they have been taking some other nutritional supplements or medicines during the study.

Procedure

Experimental procedure required rowers to be randomly dived into experimental and control group. Experimental group was receiving 500 mg of GliSODin, two capsules, once daily during six weeks. They have taken their supplement one hour before training or on days without training one hour before breakfast. GliSODin is an original formula made of special melon extract *(Cucumis meloLC, Cucurbiteceae*) rich in SOD combined with polymer gliadin, made by Isocell Nutra, France. Control group have been taking two capsules in same period of a day every day, capsules had same appearance but contained maltodextrin instead of active ingredient. Supplementation was conducted during 6 weeks of mesocyclus of basic preparation with habitual physical training work. On the first day of the study, before supplementation and in the end of 6 weeks supplementation period in the morning hours all participant have been taken vein blood samples. Blood samples were taken from antecubital vein using vacutainer tube coated with K2EDTA as anticoagulant. The number of total blood leucocytes and its subpopulation count parameters were determined on an AcT Diff Hematology Analyzer (Beckman Coulter) in laboratory of Biochemistry departure of Faculty of Pharmacy of University of Belgrade.

In this study we have used following eight variables:

1. WBC, number of white blood cells, expressed in 10^9/L
2. LY# x10^9/L, absolute number of lymphocytes expressed in 10^9/L
3. MO# x10^9/L, absolute number of mononuclear cells expressed in 10^9/L
4. GR# x10^9/L, absolute number of granulocytes expressed in 10^9/L
5. LY %, relative number of lymphocytes expressed in %
6. MO %, relative number of mononuclear cells expressed in %
7. GR %, relative number of granulocytes expressed in %
8. Index_GR/LY, index expresses granulocytes to lymphocytes ratio

Statistical analysis

A descriptive analysis of the data was first carried out for all variables and calculated average (MEAN) value with standard deviation (SD) for experimental and control group. Difference of average values of variables in relation to the tests in every group expressed like delta values in %. Delta value is calculated according to the formula: [(Test2/Test1)-1]·100, where Test1- is the average value of the variable before supplementation for particular group and Test2 - the value of the variable after supplementation for particular group. The influence of supplementation on the difference in and between the groups, partial Eta^2, was calculated using Repeated measure ANOVA statistical test. The level of statistical significance between variables was defined based on criterion $p \leq 0.05$ (Hair et al., 1998). All analyses were conducted using by Microsoft Office Excel 2007 and IBM SPSS v23.0 statistical software.

RESULTS

On the Table 1 are shown all descriptive results considering explored variables according to the tests. All rowers who were participating this study, including experimental and control group, had normal white blood cells count before and after the supplementation. Also absolute and relative number of lymphocytes, monocytes and granulocytes of all participants were fitting in reference value, before and after supplementation. Granulocytes to lymphocytes ratio (Index_GR/LY) was in recommended bounders (Dopsaj, 2012; Forget et al., 2017). We can conclude that all considered rowers had good health status.

Table 1. Descriptive results considering explored variables according to the tests (MEAN±SD)

	WBC x10^9/L	**LY %**	**MO %**	**GR %**	**LY# x10^9/L**	**MO# x10^9/L**	**GR# x10^9/L**	**Index_GR/ LY**
Experimental Group (N=12)								
Initial test	6.2±1.1	35.5±7.4	6.3±2.3	58.2±8.6	2.2±0.4	0.4±0.1	3.7±1.0	1.77±0.65
Final test	6.6±1.2	33.9±6.7	5.3±1.2	60.8±6.3	2.2±0.4	0.4±0.2	4.1±1.1	1.91±0.70
Control Group (N=8)								
Initial test	6.0±1.6	37.8±8.9	5.2±1.7	57.0±9.7	2.2±0.7	0.3±0.1	3.5±1.3	1.71±1.02
Final test	5.6±1.4	36.4±4.7	6.0±0.9	57.6±4.8	2.0±0.5	0.3±0.1	3.3±0.9	1.62±0.35

On the Table 2 are shown the results of general (Multivariate) and partial (Univariate) differences between groups considering tests. Results in this table are showing that there is no generally statistically significant difference between mean values of observed leucocyte variables before and after 6 weeks of supplementation in experimental (Wilks' Lambda Value = 0.863, p=0.910) and control group (Wilks' Lambda Value = 0.479, p=0.381) according to the tests (Initial and Final) as well as between groups according the tests (Experimental vs. Control, Initial test: WLV=0.740, p=0.744, Final test: WLV=0.776, p=0.820).

Observing white blood cells count there was no significant differences between groups before (p=0.727) and after supplementation (p=0.104) also no significant change in WBC in the groups considering the supplementation was found (EG: p=0.439, CG: p=0.587). Considering the relative number of lymphocytes (LY%) there was no significant change before and after supplementation either in experimental (p=0.854) or control (p=0.473) either between groups . Relative number of monocytes (EG: p=0.850, CG: p=1.00) and granulocytes (EG: p=0.421, CG: p=0.657) also had no significant change according to supplementation. Established value of Partial Eta^2=0.071 for MO% in initial test indicates higher values for experimental group and Partial Eta^2=0.138 for GR% indicates higher values in experimental group in final test. Absolute number of lymphocyte (LY# x10^9/L) showed no significant change in and between groups caused by supplementation. Absolute number of granulocytes (GR# x10^9/L) did not show any significant change in groups (EG: p=0.411, CG: p=0.865) but between groups Partial Eta^2=0.075 indicates tendency of higher values in experimental group after supplementation. Index GR/LY expressing granulocytes to lymphocytes ratio also was not statistically different in (EG: p=0.623, CG: p=0.806) and between (Initial test: p=0.881, Final test: p=0.298) according the supplementation, but established values of Partial Eta^2=0.60 indicates tendency of increase in experimental group, most probably provoked by supplementation.

Table 2. Results of general (Multivariate) and partial (Univariate) differences between groups considering tests

Differences	Experimental vs. Control Group		Initial vs. Final Test	
	Initial Test	*Final Test*	*Experimental Group*	*Control Group*
Wilks' Lambda Value	0.740	0 .776	0 .863	0.479
F	0.601	0.496	0.364	1.241
p	0.744	0.820	0.910	0.381
Partial Eta²	0.260	0.224	0.137	0.521
WBC x10⁹/L	F=.126, p=.727, P.Eta²=.007	F=2.92, p=.104, P.Eta²=.014	F=.621, p=.439, P.Eta²=.027	F=.308, p=.587, P.Eta²=.022
LY %	F=.067, p=.799, P.Eta²=.004	F=.755, p=.396, P.Eta²=.040	F=.034, p=.854, P.Eta²=.002	F=.543, p=.473, P.Eta²=.037
MO %	F=1.39, p=.254, P.Eta²=.071	F=.609, p=.445, P.Eta²=.033	F=.037, p=.850, P.Eta²=.002	F=.000, p=1.00, P.Eta²=.000
GR %	F=.134, p=.719, P.Eta²=.007	F=2.87, p=.107, P.Eta²=.138	F=.671, p=.421, P.Eta²=.030	F=.206, p=.657, P.Eta²=.014
LY# x10⁹/L	F=.388, p=.541, P.Eta²=.021	F=.840, p=.371, P.Eta²=.045	F=.318, p=.579, P.Eta²=.014	F=.156, p=.699, P.Eta²=.011
MO# x10⁹/L	F=1.16, p=.297, P.Eta²=.060	F=1.69, p=.210, P.Eta²=.086	F=1.59, p=.221, P.Eta²=.067	F=1.14, p=.303, P.Eta²=.075
GR# x10⁹/L	F=.093, p=.764, P.Eta²=.005	F=1.45, p=.244, P.Eta²=.075	F=.702, p=.411, P.Eta²=.031	F=.030, p=.865, P.Eta²=.002
Index_GR/LY	F=.023, p=.881, P.Eta²=.001	F=1.15, p=.298, P.Eta²=.060	F=.249, p=.623, P.Eta²=.011	F=.063, p=.806, P.Eta²=.004

On the Figure 1 are graphically presented all delta differences (in %) between tests (Test 1 and Test 2) according to variables considering groups (experimental and control). Even there was no statistically significant differences we can notice there was tendency of changes i.e. increasing of leucocytes and almost all its subpopulation in experimental group. On the contrary all measured variables of leucocytes and its subpopulation was decreased or obviously less magnified in control group, accept relative number of monocytes.

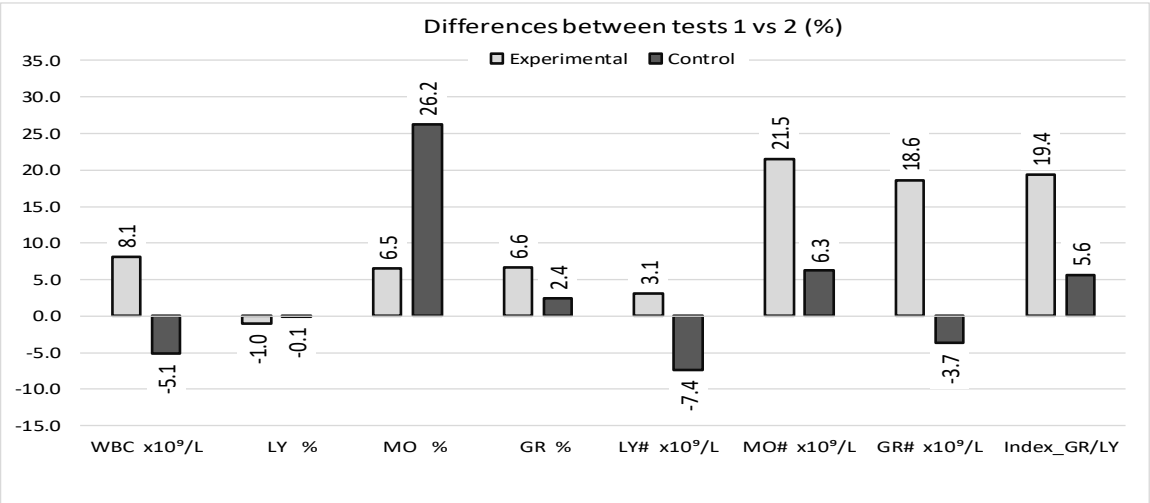

Figure 1. Descriptive results considering explored variables according to the tests and experimental suplementation groups expresed as a delta value (in % of differences)

DISCUSSION

This study was undertaken to examine effects of new orally effective antioxidant supplement consisting of wheat gliadin chemically combined with vegetable origin SOD, GliSODin, on white blood cell count in highly trained athletes. Twenty elite national class rowers was participating in the study, while supplementation was conducted during 6 weeks mesocycle of basic preparation period. Intensive exercise produce transient perturbation in immunity, including alteration in circulating leucocytes number, cytokine concentration and some cell functions. This alteration in immunity following exercise depends on the volume and intensity of the exercise. Usually this changes are resolved in a few hours after exercise (Koch, 2010). But when trainings become too long or very frequent as they can be during preparation and competition period these changes in immunity can become clinically relevant. Rowers and other professional athletes often go through a period of strenuous training and are suspected to have decrease of immunity system. Exercise is known to induce an immediate leucocytosis, the magnitude of which is related to the intensity and duration of the exercise (Galun et al., 1987). This study was aimed to explore if chronic intense exercise training have influence on leukocyte and its subpopulation count. It is documented that an acute bout of exercise results in a biphasic leukocyte response in which the immediate increase in leucocytes is followed by decrease 3-72h after intensive exercise. Sufficient recovery period is essential to avoid chronic immunosuppression of intensive exercise. Moreover, this immune suppression seems to be linked to the oxidative stress induced by exercise because there is an increased use of the functions of the organism with exaggerated production of ROS and increased oxidative stress in the tissues (Angeli et al., 2004).

Leucocytes or white blood cells (WBC) are blood cells aimed to protect the body from different kinds of foreign origin particles, every its subpopulation has specific part in this protection function. Granulocytes and monocytes play an important role in innate or nonspecific immunity. Granulocytes are the most numerous leucocytes (50-70% of leucocytes) and are first line of defence to eliminate infection agents, primary bacteria, together with monocytes. They are involved in muscle tissue inflammatory response to exercise induced injury. Lymphocytes (20-35% of leucocytes) include Natural killer (NK) cells part of innate immunity and T and B lymphocytes as main cells of adaptive immune system. Lymphocytes are responsible for protection from viral, fungal and some bacterial infection.

Rowers who participate our study had average number of WBC before (EG: 6.2±1.1 vs. CG: 6.0±1.6 x 10^9/L) and after (EG: 6.6±1.2 vs. CG: 5.6±1.4 x 10^9/L) the supplementation period within the normal range of values (3.4-9.7 x 10^9/L). Average absolute number of lymphocytes before (EG: 2.2±0.4 vs. CG: 2.2±0.7 x 10^9/L) and after supplementation (EG: 2.2±0.4 vs. CG: 2.0±0.5 x 10^9/L) was within the normal range for adult people (0.7-4.5 x 10^9/L). Absolute number of monocytes at the beginning of the study (EG: 0.4±0.1 vs. CG: 0.3±0.1 x 10^9/L) and at the end of a study was (EG: 0.4±0.2 vs. CG: 0.3±0.1 x 10^9/L) also within normal range (0.1-1.2 x 10^9/L). Granulocytes average number before (EG: 3.7±1.0 vs. CG: 3.5±1.3 x 10^9/L) and after supplementation (EG: 4.1±1.1 x 10^9/L, CG: 3.3±0.9 x 10^9/L) fit in normal range (2.1-6.5x10^9/L). This was very important fact that indicated that we were working with group of healthy young elite rowers.

Granulocytes-to-lymphocyte ratio Index_GR/LY has proven its prognostic value in cardiovascular diseases, infections, inflammatory diseases and in several types of cancers. Normal GLR values in an adult, non-geriatric, population in good health are between 0.78 and 3.53 (Forget et al., 2017). Values of this index before (EG: 1.77±0.65, CG: 1.71±1.02) and after supplementation (EG: 1.91±0.70, CG: 1.62±0.35) also confirmed good health status of our athletes. But when we take into account effect of supplementation in experimental group compared to control group, we can notice some tendencies in WBC and subpopulation count. Granulocytes absolute number in experimental group was higher for 18.6% and in control group lower for 3.7%. Monocytes absolute number was higher for 21.5% in experimental group and for 6.3% in control, lymphocytes was higher in experimental group for 3.1% but in control group values was lower for 7.4%. Index_GR/LY also was higher in experimental group after supplementation for 19.4% and in control group for 5.6%. Even this differences was not statistically significant it can be considered that supplementation with GliSODin could provide tendencies for better immune response to infection, especially bacterial infections. These results, it seems, indicate that GliSODin could be used as good nutritional support under conditions of prolonged and strenuous physical activity, supressing adverse effects of oxidative stress on immunity.

CONCLUSION

According to this results we can conclude that supplementation with antioxidant Glisodin 500mg per day in a population of elite rowers during 6 weeks of mesocycle of basic preparing period had no

statistically significant influence on they leucocytes and its subpopulation. Limitation of his study was small number of participants and duration of the study. Also study was conducted during basic preparation period when rowers did not have very severe, specifically intensive, training sessions. Higher granulocytes, monocytes and Index_GR/LY in supplemented group are reason why we think that further studies are needed with large number of participants and during longer period of time to confirm beneficial activity of GliSODin for professional athletes, protecting them from adverse effects of oxidative stress.

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ACUTE EFFECTS OF 15-SECOND SELF-ADMINISTERED VIBRATION MASSAGE ON PLANTAR EXTENSORS' MUSCLE STRENGTH PROPERTIES IN ADULT MALES: A PILOT STUDY

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ABSTRACT

Foam rolling as a technique of self-massage has been reported to induce different changes in muscle properties. Many of those changes found in literature are of confounding effects. Recent development of other types of exercise aids such as a foam roller with vibration presents a new and interesting way in exercise practice of targeting certain muscle properties and therefore requires better scientific understanding before it becomes a standard safe and useful tool in everyday practice. The aim of this study was to determine how a single short session of vibrating foam rolling affects certain muscle contractile properties, more specific, strength properties such as MVIC-maximal voluntary isometric contraction (F_{max}) and time for MVIC (tF_{max}). Twenty three recreationally active male subjects participated in this study (Age: 25±5.1 years, Height: 185.3±6.3 cm, Weight: 81.8±8 kg). After a warm up and baseline measurements subjects performed pretest, vibration foam rolling treatment and three posttests separated by 5 minutes rest intervals analyzing F_{max} and tF_{max} for both lower limbs. Subjects foam rolled with low frequency vibration (29Hz) the calf muscles of each leg for 15 seconds between the pre and posttests. No significant changes were found for F_{max}. Significant changes were found for tF_{max}. Data suggest that foam rolling as a technique of self-administered massage of short duration with low frequency vibration is a safe way for use in recreational exercise practice.

Keywords: foam roller, vibrating foam roller, MVIC, tMVIC

INTRODUCTION

Use of foam roller as an aid for self-massage has become so widespread and popular in recent years that it is almost impossible to find some sport where its use is not a daily occurrence. Although it was invented more than six decades ago in the field of physical rehabilitation as a part of "*Feldenkrais Method*" it has also become maybe even more widespread in many forms of recreational physical exercise practice as well, especially in the last decade. When it comes to human performance muscle strength is one those aspects that are undergoing research in terms of whether it is possible to improve it with the use of foam roller. Knee extension maximal voluntary contraction was found to be elevated after 2 minutes of foam rolling on three consecutive days compared to rest condition (Macgregor, Fairweather, Bennett, & Hunter, 2018). Three sets of 30 seconds foam rolling found no main effects or interactions for most contractile properties but found MVIC force developed in the first 200 ms showed 9.5% and 19.1% decreases at post-test and 5-min post-test (Cavanaugh et al., 2017). Roller massage using a roller stick on elbow flexors in duration of 5 minutes had no effect on recovery of MIVC in 36 healthy males classified as physically active who participated in the study (Medeiros et al., 2020). Study using foam rolling in duration ranging from 30 to 300 seconds suggested that foam rolling for more than 90 seconds or more was effective in order to increase the range of motion immediately without changing muscle stiffness and muscle strength (Nakamura et al., 2021).

Applying mechanical pressure to soft tissues induces changes in certain parameters therefore by altering muscle properties. Altering muscle properties should induce changes in athletic performance and

recovery protocols. Potential effects of foam rolling have been connected with several parameters such as mechanical, physiological, neurological and psychophysiological (Wiewelhove et al., 2019). Mechanical pressure on a muscle tissue can affect voluntary activation (Cavanaugh et al., 2017). Recent study found significant positive effect on the neuromuscular performance of upper extremities when using vibration at 35Hz on the forearms, MVC (maximal voluntary contraction) grip strength and grip endurance time at 50%MVC (Mohd Mukhtar Alam, 2021).

The aim of this study is to determine the acute effects of 15 seconds self-administered massage using vibrating foam roller on plantar extensors muscles strength properties.

METHODS

Subjects

Twenty three healthy male adults (Table 1) with no previous or current injuries volunteered for this study, which took place at MIL-the research laboratory of Faculty of sport and physical education, University of Belgrade. All subjects were very physically active (at least four times per week very strenuous weight training, for the last 6 months leading to this study) and were familiar with foam rolling.

Table 1. Basic descriptive characteristics of subjects

	Men (n=23)
Age (yrs.)	25.09±5.1
Height (cm)	185.3±6.3
Weight (kg)	81.8±8.0
BMI (kg/m²)	23.9±2.3
%Body fat	12.9±5.5
%SMM	49.9±3.2

Legend: n- number of subjects, **BMI-** body mass index, **%Body fat-** percentage of body fat, **%SMM-** percentage of skeletal muscle mass.

Experimental approach to the problem and variables

In a single group of subjects using a repeated measures controlled quasi-experimental design the acute effects of vibrating foam rolling on contractile muscle properties were investigated. Each subject attended the research laboratory for one experimental session. One experimental session consisted of taking anthropometric measurements, pretests, short bout of vibrating foam rolling, three posttests. The purpose was to examine in what way the vibration foam rolling affects the dependent variables: MVIC (F_{max}) and time for MVIC (tF_{max}).

Procedures

Upon arrival during experimental session each subject's anthropometric measurements were taken, height, weight and prior to warm up on a stationary bicycle. Warm up lasted 5 minutes on a stationary bicycle at 70 watts. Following bicycle warm up two sets, 30 per set of standing heal raise with fast movement execution was performed following with two more sets of 20 jumps per set, one set countermovement jumps and last set ankle jumps keeping the legs straight as possible for maximal calf muscles activation, with verbal instruction from the investigators to execute fast jumps. Subject was placed in a seated position with hips and knees at 90 degrees of flexion (see Photo 1). Standardized test procedure and equipment was used (Majstorović et al., 2020). Subjects performed pretreatment initial test, set of three attempts MVIC and with two minutes rest between attempts. After initial test subjects had a 15 minutes rest. At the end of the 15 min rest subjects rolled the calves, each for 15 seconds with legs crossed, using their bodyweight, over a vibrating foam roller (29Hz). After vibration foam rolling treatment three post-treatment sets consisting of three MVIC attempts. Sets were separated with five minutes rest to avoid any possible fatigue. A flow chart of the study design is presented in Figure 1.

Photo 1. Pre- and post-treatment measurements: MVIC and tMVIC

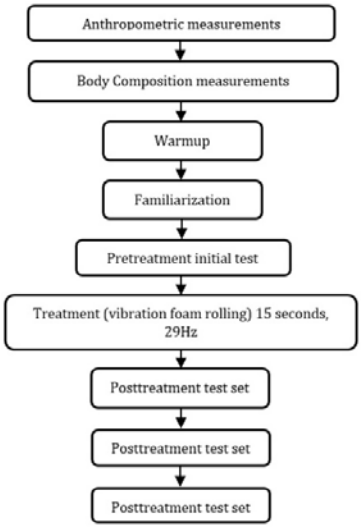

Figure 1. Flow chart of the study design

Measurements and testing equipment

Body composition data were collected using Inbody 720 body composition analyzer, Biospace, Korea. Body height was assessed with a standard anthropometer (GPM, Swiss Made) with an accuracy of 0.01 cm. Isometric Ankle Extensors Strength measurements were performed by specially designed construction with a fixed force transducer (Hottinger, Type S9, Darmstadt, Germany; tensile/compressive sensitivity 2 mV/n). Specially designed software-hardware system (Isometrics Lite, ver. 3.1.1) was used for data collection and processing (Majstorović et al., 2020). Vibration Foam rolling treatment was conducted using a Theragun Wave roller, Hypo-allergenic EVA high-density foam, dimensions 30 cm x 13 cm, 5 vibration frequencies, TheraBody, Los Angeles, California, USA.

Statistical analysis

Inter-test trial differences were established using by repeated measures ANOVA statistical procedure. Threshold of statistically significant statistical difference was set at a 95% probability level, p=0.05. All statistical procedures were done using the Microsoft® Office Excel 2007 and the SPSS for Windows, Release 17.0 (Copyright © SPSS Inc., 1989-2002).

RESULTS AND DISCUSSION

Table 2 shows basic descriptive statistics, mean, standard deviation (SD), minimum and maximum values, as well as the standard error of the mean (SEM). Based on the values of cV% as a measure of dispersion, ranging from 12.08 to 30.14% for both variables it can be concluded that all obtained values during pre and post treatment tests are homogeneous, therefore they could be interpreted in a valid way from the subjects characteristics point of view.

Table 2. Descriptive indicators of tested variables

	Mean	SD	cV%	SEM (Aps.)	SEM (Rel.)	Min	Max
F_{max}_Pre_Treatment_Test	3501.7	422.9	12.08	88.19	2.52	2670	4240
tF_{max}_Pre_Treatment_Test	1.144	0.193	16.89	0.04	3.52	0.712	1.518
F_{max}_Post_Treatment_Test_1	3471.5	475.4	13.7	99.13	2.86	2423	4276
tF_{max}_Post_Treatment_Test_1	1.081	0.326	30.14	0.067	6.29	0.156	1.557
F_{max}_Post_Treatment_Test_2	3456.6	441.1	12.76	91.98	2.66	2776	4192
tF_{max}_Post_Treatment_Test_2	1.305	0.220	16.89	0.045	3.52	0.69	1.608
F_{max}_Post_Treatment_Test_3	3412.7	423.9	12.42	88.40	2.59	2582	4136
tF_{max}_Post_Treatment_Test_3	1.250	0.359	28.77	0.0749	6.00	0.525	2.024

Legend: Aps.- absolute values, **Rel.-** relative values in %.

Table 3 shows ANOVA with repeated measures in relationship to dependent variable MVIC (F_{max}). The results show that the least significant difference was not found (Wilks' lambda Value = 0.918, F=0.599, p=0.623), also the effect of individual test was calculated on the level of 8.2% explained difference of mean values (Partial Eta^2 = 0.082).

Table 3. ANOVA with repeated measures in relationship to MVIC (F_{max})

Wilks' lambda Value = 0.918, F = 0.599, p = 0.623, Partial Eta^2 = 0.082, Observed Power = 0.152				
MEASURE_ MVIC (F_{max})		**Pairwise Comparisons**		
(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	p value
F_{max}_Pre_Treatment_Test	F_{max}_ Post_Treatment_Test_1	30.130	55.518	0.593
	F_{max}_ Post_Treatment_Test_2	45.000	53.125	0.406
	F_{max}_ Post_Treatment_Test_3	88.913	63.287	0.174
F_{max}_Post_Treatment_Test_1	F_{max}_ Post_Treatment_Test_2	14.870	49.066	0.765
	F_{max}_ Post_Treatment_Test_3	58.783	66.389	0.386
F_{max}_Post_Treatment_Test_2	F_{max}_ Post_Treatment_Test_3	43.913	51.176	0.400

Based on estimated marginal means.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 4. ANOVA with repeated measures in relationship to tMVIC (tF_{max})

Wilks' lambda Value = 0.482, F=7.151, p=0.002, Partial Eta^2 = 0.518, Observed Power = 0.954				
MEASURE_ tMVIC (tF_{max})		**Pairwise Comparisons**		
(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	p value
tF_{max}_ Pre_Treatment_Test	tF_{max}_ Post_Treatment_Test _1	0.063	0.062	0.321
	tF_{max}_ Post_Treatment_Test _2	**-0.161***	0.050	**0.004**
	tF_{max}_ Post_Treatment_Test _3	-0.106	0.076	0.175
tF_{max}_ Post_Treatment_Test_1	tF_{max}_ Post_Treatment_Test _2	**-0.224***	0.054	**0.000**
	tF_{max}_ Post_Treatment_Test _3	-0.169	0.085	0.061
tF_{max}_ Post_Treatment_Test _2	tF_{max}_ Post_Treatment_Test _3	0.055	0.082	0.507

Based on estimated marginal means.

*. The mean difference is significant at the 0.05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 4 shows ANOVA with repeated measures in relationship to dependent variable tMVIC (tF_{max}). The results show that the least significant difference was found between tF_{max}_Post_Treatment_Test_2 and tF_{max}_Post_Treatment_Test_3 (Wilks' lambda Value = 0.482, F=7.151, p=0.002). The effect of individual test was calculated on the level of 51.8% explained difference of mean values (Partial Eta^2 = 0.518). These findings could suggest that signs of fatigue did occur.

CONCLUSION

It is necessary to establish the relationship between the tool being used for self-treatment, in this case vibrating foam roller and the expected acute effects derived from the application of that same tool. This research has found that the use of vibrating foam roller did not change the examined strength properties in terms of MVIC therefore it represents a safe technique for self-massage. Taking into consideration that the time needed to reach maximum isometric force during attempts did significantly change, between pretreatment test and post-treatment test 2, also between post-treatment test 1 and post-treatment 2, tMVIC has increased, these findings could be attributed to fatigue and not to the treatment itself, however definite answer remains unclear whether local or central fatigue mechanisms are responsible for this change or the experimental treatment procedure here applied, nevertheless caution should be taken when implementing this technique in exercise practice. Future experiments should apply different massage protocols and with more different muscle mechanical contractile variables as followed.

Conflict of Interest Statement

All authors declare no conflict of interest, or financial, or other interest in any product or product distributor. All authors read and approved the final manuscript and all data in the study were available to all authors. All authors take responsibility for the accuracy and integrity of the data and data analysis.

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PREVALENCE OF POSTURAL DISORDERS IN SAGITTAL PLANE AMONG SCHOOL-AGED CHILDREN IN SERBIA: A SYSTEMATIC REVIEW

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ABSTRACT

The aim of this study was to determine the prevalence of postural disorders in sagittal plane among school-aged children on the territory of the Repubic of Serbia in the past 10 years, based on the analysis of existing research. Initially, databases were used to search through more than 500 papers based on key words. The inclusion criteria identified 15 papers which were further analyzed in detail. The total sample of participants in the analyzed papers was 5329, all school-aged children of both genders. The analysis of existing research led to the conclusion that approximately 27% of school-aged children have a postural disorder in sagittal plane, that is, either kyphosis or lordosis, whereby kyphosis is more prevalent. The importance of this study lies in the fact that it provides information on the postural status of children and indicates the importance of proper focus and planned physical activity for the prevention of poor posture among school-aged children.

Keywords: lordosis, kyphosis, poor posture, deformity, exercise

INTRODUCTION

When human body assumes a vertical and balanced position in relation to a plane in which standing or movement takes place, with properly distributed body parts, whereby all the physiological processes in the body are maintained and stimulated, is known as proper posture (Bjeković et al., 2011). It includes an initial standing position where the physiological curvature of spinal column does not deviate from the perpendicular axis (Živković, 2009). Proper posture is not formed on its own, instead it is necessary to assist the formation of such posture from birth through proper development, and later through organized physical activity (Živković, 2009). Disrupted proper posture emerges due to poor habits, which include a decrease in movement activities and improper sitting, but also the habits imposed upon us by contemporary society, such as using a computer, playing video games, watching TV (Živković & Karaleić, 2006). Poor posture does not include only one disorder, i.e. the deformation, but several disorders, whose shared feature is that they disappear through active tension of the muscular system (Živković, 2009). Muscles play one of the most important roles in the formation and maintenance of proper body posture. If certain groups of muscles are weakened, or if the damage to them is too great and one-sided, various deformities could ensue. The formation of proper postural status among school-aged children is essential, due to the sensitivity of a child's body (Bala et al., 2006). The disruption of proper body posture leads to postural deformities. Postural deformities of the spinal column in sagittal plane include kyphotic, lordotic, kyphotic-lordotic poor posture, and flat back (Protić-Gava et al., 2010). Kyphosis is a deviation from normal body posture visible in the sagittal plane of the thoracic part of the spinal column, or a convexity of the spinal column (Živković, 2009). The basic clinical image of poor kyphotic posture includes the following elements: the head is bent forward and downwards; the thoracic curvature is increased and flexibility decreased; the rib cage is flat and bent inward; the shoulder blades are dislocated from the spine and the posterior wall of the thorax; the abdomen is flabby and protruding; the knees are in slight flexion and as a whole are protruding forward; and the feet display the first symptoms of weakness – insufficiency (Živković, 2009). The elements of lordotic posture are the following: the head is tilted back, behind the vertical line; the thorax is flat or somewhat protruding; the curvature of the lumbar spine is exaggerated, the inclination of the pelvis is greater, the abdomen is flabby and protruding, the knees are

hyperextended, and in some cases flat feet are also present. In the case of kyphotic-lordotic posture, there is an increase in the curvature of the spinal column both in the thoracic and lumbar part of the spinal column.

The aim of the study was to determine the prevalence of postural disorders in sagittal plane among school-aged children on the territory of the Republic of Serbia during the past 10 years based on an analysis of existing researches.

METHODS

The following databases were searched to find existing studies of a suitable type: Google scholar, PubMed, SCIndeks and KOBSON. Papers published from 2010 and 2020 were analysed. The identified papers (abstracts and full text) were read and analysed. In order for them to be included in the final analysis, they had to meet two criteria: that they were experimental, and that the participants were school-aged children. The key words included in the database search were: lordosis, kyphosis, poor posture, postural status, deformities, postural disorders, spinal column. The parameters based on which the studies were presented and analysed included: references (authors and year of publication), population (gender and age), measuring instruments and research results.

RESULTS AND DISCUSSION

Based on the key words we identified approximately 500 papers. Papers where participants were not school-aged children were excluded, along with papers based on their titles, abstracts, and topics which did not relate to the prevalence of postural disorders in sagittal plane among children on the territory of Serbia. The final analysis included 15 papers which were compiled and analysed based on the previously cited parameters. All of the papers were published from 2010 until 2020. The studies included both male and female participants; in order to fulfil the ascertained criteria, the participants had to be citizens of the Republic of Serbia, who took part in the assessment of postural deformities in sagittal plane among school-aged children. The parameters based on which the papers are presented in the table are: reference (first authors and year of publication), number of participants, gender (male and female), age categories, methods of measurement, and research results.

The study included 15 papers published from 2010 until 2020. The oldest publications were published back in 2010 (Bogdanović et al., 2010; Hodžić et al., 2010; Đokić et al., 2010), while the most recent paper is one authored by Vukićević et al. (2018). The studies included a total of 5329 school-aged participants. Most of the participants (n=1523) were included in the study Đokić et al. (2010), while the fewest participants (n=30) were noted in the study of Stanišić (2013). Based on the analysis of the papers shown in Table 1, we can see that the sample of participants in ten of the studies were male and female, while in some studies (Đurić et al., 2015; Jeremić, 2015; Marić, 2015) the sample of participants were female, and in other studies (Hodžić et al., 2010; Grabara, 2012) the participants were only male. The age of the participants ranged between 6 and 16 yrs. Based on the prevalence of the gender of the participants in the studies, it can be concluded that postural disorders in sagittal plane occur both among school age boys and girls. The youngest participants that took part in the study were aged 7yrs±6 months (Vukićević et al., 2018), while the oldest participants were 12-16 yrs of age (Đurić et al., 2015). Diagnosis of postural disorders in sagittal plane was carried out using the Napoleon Volansky method (Protić-Gava, Šćepović, & Batez, 2013), a somatoscopy and the somatometric method (Bogdanović et al., 2010; Đokić et al., 2010; Đokić et al., 2011; Miletić, 2017; Vukićević et al., 2018), the inspection method (Marić, 2015; Milić et al., 2015), and the clinical method (Beganović & Bešović, 2011; Grabara, 2012; Duvnjak, 2013; Jeremić, 2015; Đurić et al., 2015). The total number of participants in all of the selected studies was 5329. Among them, 905 were diagnosed with the postural disorder of kyphosis, while 510 participants were diagnosed with the postural disorder of lordosis. The results indicate that approximately 27% of the tested children have postural disorders in sagittal plane, that is kyphosis and lordosis, which is slightly more than one-fourth. The study did not include other postural disorders of the spinal column such as scoliosis which would certainly increase the percentage of children with postural disorders. This also indicates the high percentage of school-aged children with poor posture or postural disorders of the locomotor apparatus. In order to prevent the more frequent occurrence of postural disorders among children, it is necessary to take measures in the sense of prevention and correction of postural disorders. This can be achieved by including corrective gymnastics exercises during physical education classes, as well as by introduction of additional individual classes. Generally speaking, it is necessary to increase the level of physical activity of school-aged children.

Table 1. An analysis of the selected papers

FIRST AUTHOR AND YEAR OF PUBLICATION	SAMPLE OF PARTICIPANTS			EXPERIMENTAL TREATMENT	
	N	G	Age	*Methods of measurement*	*RESULTS*
Bogdanović et al., 2010	299	M, F	12 ± 6 yrs	Somatoscopy and somatometry	38.46% (114) of the participants have lordosis
Hodžić et al., 2010	125	M	7-12 yrs	The clinical method	Kyphosis 4.8% (6 school children) Lordosis 7.2% (9 school children)
Đokić et. al., 2010	1523	M, F	10 yrs	Somatoscopy and somatometry, using a pendulum, flexible ruler, and dermograph	Kyphosis 7.6% (115) Lordosis 1.0% (15)
Đokić et al., 2011	810	M, F	11-15 yrs	Somatoscopy and somatometry	Kyphosis was diagnosed in 14.9% (120) of the participants
Beganović et al., 2011	60	M, F	10-11 yrs	Measuring the curvature of the spine, measuring the side curvature of the spinal column	30% (18) of the school children have kyphosis
Grabara, 2012	151	M	11-14 yrs	Measuring the angles of the spinal column and the curvature in the sagittal plane	Spinal kyphosis was noted in 22% (33) of the soccer players
Stanišić, 2013	30	M, F	7-11 yrs	The clinical method	Kyphosis and lordosis are present in 33.3% of the boys (9 participants)
Protić-Gava et al., 2013	63	M, F	8 yrs	The Napoleon Volansky method	54% (34) of the participants have lordotic posture, while 22.3% (14) of the participants have kyphosis
Duvnjak, 2013	1739	M, F	7-10 yrs	A battery of tests with measuring instruments for the evaluation of postural disorders	Lordosis is present in 17.9% or 225 of the school children. Kyphotic posture and kyphosis were noted in 38.57% or 484 of the school children
Marić, 2015	56	F	7-8 yrs	An analysis of the postural status carried out via the method of inspection	The research results showed that 22 of the female participants have a postural disorder in the sagittal plane
Milić et al., 2015	67	M, F	10-11 yrs	An analysis of the postural status was carried out via the method of inspection	22 participants had kyphosis, while 18 participants had poor lordotic posture
Jeremić, 2015	40	F	7-8 yrs	The clinical method	Kyphosis 7.5% (3 female school children) Lordosis 7.5% (3 female school children) Winged scapula 2.5% (1 female school children)
Đurić et al., 2015	72	F	12-16 yrs	The clinical method	Kyphotic posture 1.4% (1 participant) Lordosis 16.6% (12 participants)
Miletić, 2017	174	M, F	11-15 yrs	Somatoscopy and somatometry	Kyphotic posture in 39 participants Lordotic posture in 33 participants
Vukićević et al., 2018	120	M, F	7±6 yrs	Somatoscopy	Kyphosis in 41 participants Lordosis in 38 participants
LEGEND	N– number of participants, **G-** gender of the participants, **M–** male participants, **F–** female participants, **Age–** age category.				

CONCLUSION

Based on the analysis of the existing studies it could be concluded that approximately 27% of school-aged children, or slightly more than one-fourth, have postural disorders in sagittal plane, i.e. have kyphosis or lordosis. Viewed individually, kyphosis is present in 905 participants (17%), while 510 participants (approximately 10%), have the postural disorder of lordosis. In order to improve postural

status among school-aged children, it is primarily necessary to work on the prevention, and then on the correction of postural disorders. This could be achieved with an increase in the number of physical education classes, the inclusion of corrective gymnastics exercises during physical education classes, depending on the postural status of children, as well as through organized sports clubs.

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DOES CAFFEINE HELP REACTIVE-AGILITY PERFORMANCE?

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ABSTRACT

It is well known that the effects of caffeine intake on the central and peripheral nervous system have positive effects on psychomotor function performace. However, studies examining the effects of caffeine on reactive agility are limited in the literature. The main purpose of this study was two fold: 1) to evaluate the effects of acute caffeine ingestion on reactive-agility performance, 2) to examine the effect of acute caffeine use on HRpeak values. A total of 49 healthy, physically active students (nM=25; nF=24) who were studying at Faculty of sports sciences attended the research ($\bar{x}$age = 21.8±2.3 years, $\bar{x}$H = 165.6±8.5 cm, $\bar{x}$BM = 60.1±10.2 kg). Following familiarization session, all participants was attended to Agility Star Drill Test (ASDT). ASDT was repeated three different times, 48h apart. During each trial, participants consumed 4 mg/kg either regular instant coffee (CAF), or a decaffeinated instant coffee (PLA). While measuring the baseline, the participants were not given any coffee or caffeine-containing food and beverage. Friedman test and Mann-Whitney U tests were used in the analysis of the data. The significance value was accepted as $p<0.05$. The primarly result of the study showed that caffeine was more effective in reactive-agility test reaction time (RT), than base results ($p<0.05$), but it was not different than PLA. Secondly, there were no differences in HRpeak values between the trials ($p>0.05$).

Keywords: agility, blazepod, caffeine, reaction time, reactive agility

INTRODUCTION

Caffeine is one of the most widely consumed psychoactive ingredient foods and supplements in the world (Frary, Johnson, & Wang, 2005; Ferré, 2008; Fulgoni III, Keast, & Lieberman, 2015). Caffeine has been of great interest for many years as it has been proven to support cognitive development. One of the most important cognitive effects is that it reduces reaction time (RT) in activities that require speed. (Grosch, 1998; Haskell, Kennedy, Wesnes, & Scholey, 2005; Childs & de Wit, 2006). The effects of caffeine on performance are linked to both central and peripheral mechanisms. Caffeine is associated with the blockage of adenosine receptors in the central nervous system, which prevents reduction of neural activity and increases muscle recruitment (Bazzucchi, Felici, Montini, Figura, & Sacchetti, 2011). Peripherally, caffeine inhibits phosphodiesterase activity, thereby promoting plasma catecholamine and glycolysis activity, increasing the energy availability of active muscles during exercise (Davis & Green, 2009). As a result of its central and peripheral effects, caffeine provides an increase in psychomotor function performance such as agility and attention (Brice & Smith, 2001; Gillingham, Keefe, & Tikuisis, 2004; Tikuisis, Keefe, McLellan, & Kamimori, 2004; van Duinen, Lorist, & Zijdewind, 2005).

Studies conducted today, reveal that cognitive factors such as visual scanning, intuition, perception and decision making are very important for agility, as well as physical characteristic such as speed, change of direction and strength. (Zemková, 2016; Armstrong & Greig, 2018). Agility, which is classified in different ways by researchers, argues that cognitive factors have a key role in this concept, especially in new approaches. (Zemková, 2016; Greig & Naylor, 2017; Armstrong & Greig, 2018). Researchers say that the methods used to evaluate agility performance mostly measure speed and change of direction performance, therefore they are insufficient to measure all factors that meet this concept, especially cognitive factors (Šimonek, Horička, & Hianik, 2016; Zemková, 2016; Zouhal et al., 2018). A model was created by Young, James, & Montgomery (2002) to represent the sub-components of agility performance.

This model was later adapted by Young & Sheppard (2006) with minor changes (Sheppard & Young, 2006).

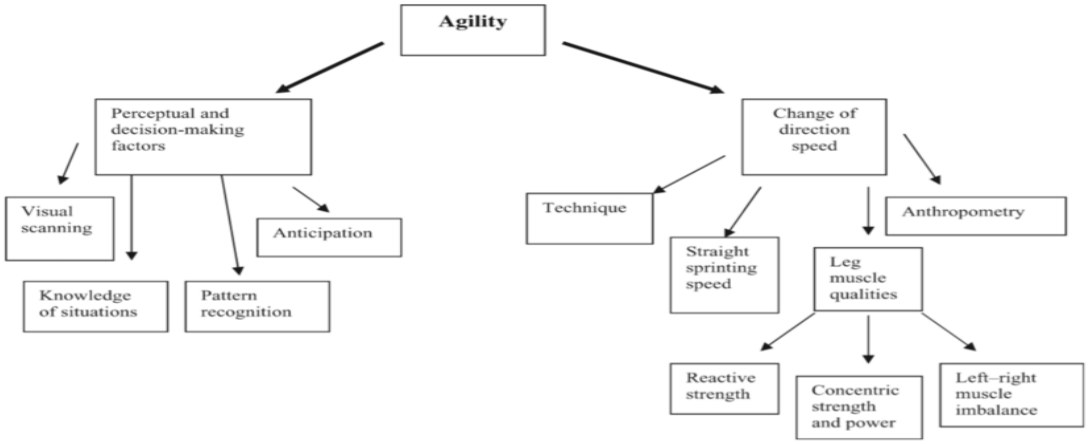

Figure 1. Universal agility components (Sheppard & Young, 2006)

According to The European Food Safety Authority, 75 to 150 mg caffeine intake increases alertness and attention (EFSA Panel on Dietetic Products & Allergies, 2011). There are many studies investigating the effects of caffeine on agility, RT and speed (Brice & Smith, 2001; Judelson et al., 2005; Lorino, Lloyd, Crixell, & Walker, 2006; Duvnjak-Zaknich, Dawson, Wallman, & Henry, 2011; Schuda, Thornton, Vitale, Wright, & Ameres, 2019; Egesoy & Öksüzoğlu, 2020;). However, as mentioned above, agility is not dependent on a single parameter, on the contrary, it is a feature consisting of many components. In this regard, to investigate the effects of caffeine on agility, the BlazePod-Agility Star Drill Test (ASDT), which simultaneously evaluates the RT, speed, visual scanning, and detection features that affect agility, was applied. In this study, we focused on examining the effect of caffeine on agility, using a higher amount of caffeine than EFSA claims. In this contex, the aim of this investigation was to find out whether ingestion of caffeine in the form of instant coffee exerts any influence on agility time performance and observe HR_{peak} values of participants during ASDT trials. We hypothesize that ingestion of caffeine in the form of instant coffee exerts improve reactive-agility performance in physically active individuals.

METHODS

Subjects

A total of 49 healthy, physically active students (n_M=25; n_F=24) who were studying at Faculty of sports sciences attended the research ($\bar{x}_{age}$=21.8±2.3 years, $\bar{x}_H$=165.6±8.5 cm, $\bar{x}_{BM}$=60.1±10.2 kg). Subjects were recruited by personal contact. Individuals regularly ingesting greater than 600 mg of caffeine per day were excluded. Prior to data collection, the University approved all procedures and subjects provided written informed consent. Throughout testing, procedures adhered to standard national and international regulations regarding the use of human subjects in research.

Procedure

The cross-over double-blind experiment included a familiarization day with the tests and three identical experimental trials. In familiarization day, before the study was conducted, participants were reminded to restrain from all caffeine sources and supplements 48h before the trials and until the end of the experiment. They were encouraged to train for, avoid alcohol consumption, be adequately hydrated and sleep at least 8h the day before the experiments. During each trial, participants consumed 4 mg/kg either regular instant coffee (CAF), or a decaffeinated instant coffee (PLA) from the same manufacturer (Nestle Nescafe Gold, Bursa, Turkey). While measuring the baseline, the participants were not given any coffee or caffeine-containing food and beverage. Upon arrival to the laboratory the anthropometric characteristics of the participants were measured. Participants were then requested to experiment ASDT for familiarization, one week before the trials and just one time. On the 1st day participants' baseline values of ASDT were measured. On the 2nd and 3rd trials, the participants applied the test after consuming

coffee with caffeine (CAF) or non-caffeinated (PLA). Heart rate (HR) were measured (Polar Team 2 telemetric system, Finland) before and during the ASDT. For measurement of resting HR, before the ASDT, participants were asked to lie comfortably in a supine position and HR was recorded. The highest HR value during the ASDT was recorded as HR_{peak}. On the days of CAF and PLA, the coffee were given to the participants 60 minutes before the test. Caffeine was mixed with 200 ml of hot water at a rate of 4mg/kg of participants and has been given as of sugar free. Decaffeinated coffee given as PLA was given in proportion to the amount of caffeinated coffee for each participant. Immediately after testing, participants wer asked to rate their perceived exertion (RPE).

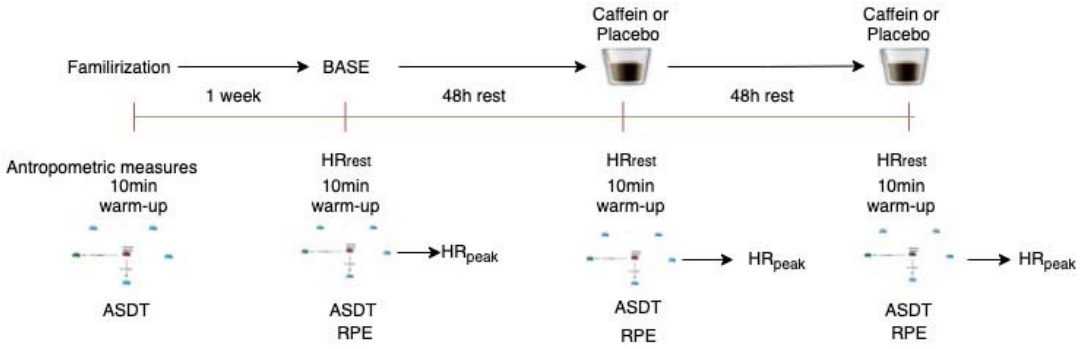

Figure 2. Test Protocol

Agility Star Drill Test (Reactive-agility Test)

RT of volunteers were measured using the BlazePod™ Trainer Device (Play Coyotta Ltd., Tel Aviv, Israel). The intraclass coefficient values displayed excellent reliability (r's ranging from 0.833 to 0.884). Five pods were placed around the home base pod on the floor. They were approximately 3 m from each surrounding pod to the base pod. For each participant the measurement started when the researchers manually touched the "start now" button on the BlazePod phone application. After the start command, with the end of the "3-2-1-go" warning sound, the sensors started to flash randomly for 60 sec. For the starting position, participants were asked to stand next to the home base pod and when a surrounding pod lights up run to tap it out and then run back as quickly as possible to tap out the home base pod. Participants repeated this action up to the end of the test time.

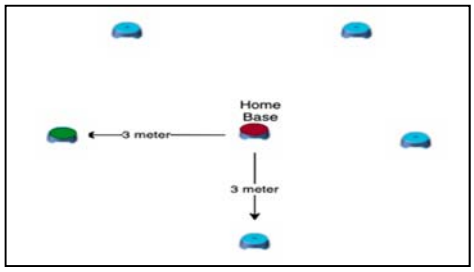

Figure 3. BlazePod-Agility Star Drills Test

Statistical analysis

Descriptive statistics for the variables used in the analysis of the data are shown as mean and standard deviation. Normality tests of the variables were performed with the Kolmogorov–Smirnov test and it was observed that the data were not normally distributed. Friedman test and Mann-Whitney *U* tests were used in the analysis of the data. The significance value was accepted as $p<0.05$.

RESULTS

In Table 1 the mean values of age, height, BM and BMI of the participants' by gender and total mean values are presented.

Table 1. Descriptive statistic of participants

Gender	N	$\bar{x}_{age}$±SD (years)	$\bar{x}_{H}$±SD (cm)	$\bar{x}_{BM}$±SD (kg)	$\bar{x}_{BMI}$±SD
Female	24	21.4±2.5	159.5±5.54	54.66±7.7	21.48±2.9
Male	25	22.1±2	171.6±6.53	65.4±9.5	21.96±2.3
Total	49	21.8±2.3	165.6±8.5	60.1±10	21.73±2.6

Legend: N- number, **H-** height, **BM-** body mass, **BMI-** body mass index

Table 2. Results of the participants in different variables for BASE, CAF and PLA trials

Variables	BASE	CAF	PLA	χ^2	p
	x̄±SD	x̄±SD	x̄±SD		
HR	74.4±13.2	73.7±14	70±11	2.65	.265
HR_{peak}	188.5±9.8	187.8±10	187±8.8	4.33	.114
NH	16.28±1.5	16.63±1.6	16.51±1.8	4.18	.123
RT	2.22± 0.20**	2.17±0.27**	2.21±0.26	8.61	.013*
RPE	7±1.7	7.3±1.7	7.3±1.5	2.10	.349

Legend: CAF- caffeine, **PLA-** placebo, **HR-** Heart rate, **HR_{peak}-** peak heart rate, **NH-** number of hits, **RT-** reaction time, **RPE-** rated perceived exertion
** Trials with a statistically significant difference

Table 2 shows that there is no statistically significant difference in HR, HR_{peak}, NH and RPE values of the participants between BASE, CAF and PLA trials (p>.05). However, in RT values of participants there is a statistically significant difference between trials (p<.05). This difference occurs between CAF and BASE in favor of CAF trial.

Table 3. Results of the participants by gender in different variables for BASE, CAF and PLA trials

		BASE			CAF			PLA		
Gender		x̄±SD	Z	p	x̄±SD	Z	p	x̄±SD	Z	p
HR	**F**	73.66±13.93	-.55	.582	69.58±13.63	-1.7	.076	68.83±12.84	-.96	.336
	M	75.24±12.79			77.73±13.54			71.15±10.5		
HR_{peak}	**F**	187.66±10.88	-.25	.802	186.54±12.86	-.42	.674	184.62±10.94	-1.7	.076
	M	189.3±8.86			189.±6.43			189.32±5.60		
NH	**F**	15.1±.9	-5.10	.00*	15.7±1.1	-3.8	.00*	15.3±1.2	-4.2	.00*
	M	17.4±1.2			17.5±1.4			17.6±1.7		
RT	**F**	2.37±0.16	-4.93	.00*	2.31±0.29	-4.1	.00*	2.34±0.22	-3.7	.00*
	M	2.08±0.13			2.03±0.14			2.07±0.22		
RPE	**F**	6.95±2	-.152	.87	7.37±1.71	-.05	.95	7.45±1.69	-.68	.49
	M	7±1.5			7.4±1.7			7.2±1.4		

Legend: CAF- caffeine, **PLA-** placebo, **HR-** Heart rate, **HR_{peak}-** peak heart rate, **NH-** number of hits, **RT-** reaction time, **RPE-** rated perceived exertion
* Trials with a statistically significant difference

In Table 3 the mean values of HR, HR_{peak}, NH, RT and RPE of the participants by gender and comparison of trials are presented. According to gender comparison there was not statistically significant difference in HR, HR_{peak} and RPE values (p>.05), while there was statistically significant difference in NH and RT values for BASE, CAF and PLA trials (p<.05). When the mean values are examined, it is seen that this difference was in favor of male participants.

DISCUSSION

The primary findings of this study are: CAF was more effective in RT during the ASDT than base results and there was no difference in HR_{peak} values between trials. Given the specific testing parameters and research frame of reference, these results suggest that in healthy, rested individuals, consumption of caffeinated foods and beverages may have an positive effect on reactive-agility.

In the study of Lee et al. (2014) in which they investigated the effect of caffeine on agility T-test result (6 mg/kg gelatin capsules), no statistically significant difference was found between the agility T-test results of CAF+PLA and PLA+PLA groups ($p>0.05$). In another study, in which participants were given 200 mg of caffeine and placebo (Kaczka et al., 2021), no significant difference was found between the trials in reactive Y-Agility test results ($p=0.06$). It is well known that caffeine ingestion in doses between 32 and 300 mg improves key aspects of cognitive performance such as attention, alertness, and RT (Snel, Lorist, & Tieges, 2004; Lorist & Snel, 2008; Nehlig, 2010). However, the limitation of most of the current studies which is investigating the effect of caffeine intake on agility performance is the use of preplanned stimuli. It is thought that the participants did not test the effect of reactive-agility in synchronization with a perceptual component that requires the initiation of movement in a game environment. It should be noted that while there is general consensus that caffeine improves "low" cognitive functions such as simple RT, caffeine's effects on "higher" cognitive functions such as problem solving and decision making are often debated (Gazzaniga, 2000). The ASDT used in the current study included speed, visual reaction and agility components together, which are the basic components that should be included in agility tests. Therefore, when compared with many studies in which reactivated agility is tested, it can be said that the current study tests agility ability similar to the game environment (reaction to unplanned stimuli).

RT values of the current study were examined according to the gender difference. A statistically significant difference was found for BASE, CAF and PLA trials, and this difference was in favour of male participants. However, the fact that this difference was seen in the base trial shows that there is a significant difference between both genders regardless of the CAF and PLA trials. For this reason, the mean values of CAF and PLA trials were compared with BASE to control the effect on genders. In this case, it was seen that female participants are more affected by CAF and PLA trials than male participants and RT decreases more than male participants (F vs. M respectively: CAF: -2.53% vs -2.40% PLA: -1.26% vs -0.48%).

Previous studies show that caffeine has the effect of promoting sympathetic stimulation (Corti et al., 2002), which also occurs during physical exercise (Nishijima et al., 2002). However, in this current study HR_{peak} results of the participants were examined, and there was not statistically significant difference between the trials. In the meta-analysis study by Benjamim et al. (2020) they report that the difference in HR_{peak} is due to CAF supplementation and not due exercise performance. On the other hand, Gonzaga, Vanderlei, Gomes, & Valenti (2017), Nelson, Biltz, & Dengel (2014) and Kliszczewicz et al. (2018), they reported that no difference was found in trials in HR_{peak} values. Considering the studies in which caffeine HR_{peak} changes were not observed, it is thought that adequate cardiovascular stress did not occur in the study protocols. In the current study, the reason why no difference was observed in HR_{peak} values between trials may be due to the absence of cardiovascular stress. Studies investigating the effects of caffeine on HR still seem to have not reached a consensus.

CONCLUSION

In a conclusion CAF was more effective in RT during the ASDT than base results and there was no difference in HR_{peak} values between trials and genders.

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MOTIVATION FOR ACHIEVEMENTS IN SPORTS- THEORETICAL FRAMEWORK AND RECOMMENDATIONS FOR PRACTICE

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ABSTRACT

Motivation is a set of processes that encourage, direct and maintain human behavior towards a specific goal. It represents a willingness to do something. Motivation can be defined as the readiness of an individual to take action to satisfy his need. The aim of this paper was to collect relevant data related to the motivation for achievement in sports and physical education, i.e. theories, as well as recommendations for practice. The analyzed works showed that athletes with a dominant trait of achievement express strong energy aimed at achieving the goal, perceive their competence as high and feel that the achievement is under their control, are willing to take risks that motivate them, are realistic and do not try to achieve the impossible. Numerous studies have shown that motivation, especially in conjunction with motor skills, has probably the most decisive influence on student success. The best motivation for student work is if the contents are adjusted to the possibilities, abilities and interests of each student individually. Students with intrinsic motivation stay attached to what they do longer, even in the absence of material reward. Research conducted on athletes has shown that motivation is especially present in the cadet age (age 14 to 16) of young football players. The decrease in intrinsic motivation is due to pressure and anxiety due to external recognition and success.

Keywords: motivation, theories of motivation, sport, physical education

INTRODUCTION

Motivation is a set of processes that encourage, direct and maintain human behavior towards a specific goal. It represents a willingness to do something. Motivation can be defined as the readiness of an individual to take action to satisfy his need. They reflect wishes and increase the desire to satisfy them. These are also the means by which priority is given and needs are ranked.

It is characteristic of today's psychology of motivation that we do not try to understand behavior only on the basis of a person's characteristics (instincts, instincts, etc.), nor only on the basis of situation characteristics (stimuli, objective stimuli, etc.). Instead, behavior is understood as the result of a relationship between the characteristics of the individual and the characteristics of the situation, i.e., the circumstances (Rheinberg, 2004).

Motivation itself has a number of theories to date. From motivation for work and achievement in work organizations, to motivation for achievement in sports and sports competitions. Motivation for participation in sports activities is often a researched topic with the aim of finding a model that will help maintain the level of quality in athletes, but also as an incentive for the general population to lead a physically active lifestyle (Biro & Nedimović, 2014).

Theoretical framework - Motive of achievement

According to the theory of motivation, a person's achievements differ in the way they set goals (Barić & Horga, 2007). The motive of achievement has been identified as a motive that contributes to the

development of personality and its potentials (Murrey, 1938; Schunk, 2004; according to Lazarević, 2008).

Motivation for achievement is characterized, in addition to competition with high standards, by behavior in situations that present a challenge and a sense of personal responsibility for those consequences. An unavoidable component of the achievement motive is self-awareness. These complex dimensions develop through the overall activity of the athlete, depending on different personal experiences (Vujanović, 2015).

Athletes with a dominant trait of achievement motives have the following characteristics of manifest behavior (Vujanović, 2015): they express strong energy aimed at achieving the goal, perceive their competence as high and feel that achievement is under their control, they are ready for risk that motivates them, they are realistic and do not try to achieve the impossible, they perceive success as something that is stable and depends on internal factors that are under control, they are task-oriented and are not satisfied with easily achieved goals, but with success that requires maximum effort. By achieving success they also increase the level of aspiration.

Achievement motivation theory by McCleland and Atkinson

McClelland, one of the pioneers in researching this motive, believes that behavior is determined by the motive of achievement when it seeks to check or prove their own competence in relation to a standard of success or excellence (McClelland et al., 1953; McClelland, 1989; according to Lazarević, 2008). The motive of achievement is expressed in the desire to do something well, better than others or earlier than others (Lazarević, 2008). The personal component of the achievement motive is the need for competence, and situations in which this component is manifested are those in which a person faces a standard of success or excellence (McClelland et al., 1953; McClelland, 1989; according to Lazarević, 2008).

The fundamental need of this theory is the need for achievement that is the result of the action of two forces, the desire to succeed and the desire to avoid failure. The original McClelland model expanded in 1961 and introduced two new needs, the need to belong and the need for power. Individuals who have expressed this need will look for a job that provides them with independence, responsibility and challenges (Šajatović, 2016).

In Atkinson's theory of expectations (Beljan, 2017), there are three basic motives that everyone tries to satisfy from the earliest age. These are: - to achieve something in life (motive for achievement), - to belong to someone and be accepted by others (affiliative motive) and to have a certain influence, not to be helpless, to have a certain control over the environment (motive for power). Motivation for achievement according to Atkinson (Beljan, 2017) is the result of a conflict between two opposite aspirations: the pursuit of success, and the pursuit of avoiding failure.

Motivation of sports achievement - Nichols' AGT theory

Achievement Goal Theory (AGT) is the most common theoretical framework for studying motivation in sport (Nicholls, 1992; Duda, 1992, 1993, 2001; Roberts, 1993, 2001, Kavussanu and Roberts, 1996; Newton, Duda, 1999; Treasure , 2001; Petherick and Weigand, 2002 and others; according to Trboglav, 2006).

The application of Nichols' theory of goals - AGT in sports was proposed by Duda, among the first authors (Duda, 1987; according to Vesković, 2012). The main idea of this theory was that each individual is goal-oriented and wants to demonstrate his own competence (Nicholls, 1992; Duda, 1993, 2001; Treasure, 2001, according to Trboglav, 2006; Vesković, 2012). As a result, the experience of success or failure will depend on the individual's interpretation of one's own efforts to achieve a certain achievement (Maehr and Nicholls, 1980; according to Roberts 2001; according to Trboglav, 2006).

Nicholls (1989, according to Duda & Ntoumanis, 2005; according to Vesković, 2012), believes that young athletes are more likely to experience positive feelings if they are more focused on learning than on achieving results. The experience of success and failure in activities and tasks can be based on different criteria, which are based on different conceptions of ability (Duda, 2001; according to Vesković, 2012).

Practical recommendations- How to raise motivation for achievement in physical education classes

"It is indisputable that sport is an ideal educational medium for the development of desirable psychosocial attributes such as cooperation, combativeness, independence, autonomy, leadership, motivation for achievement, self-affirmation, self-confidence, self-concept." (Bačanac, 2003; according to

Šekeljić & Stamatović, 2006). Numerous studies have shown that motivation, especially in conjunction with motor skills, has probably the most decisive influence on student success (Babiak, 2009).

One of the main problems concerning the teaching in the lower grades of primary school is the insufficient staff training of primary school teachers, stated Berković et al. (1982) and Stamatović (2001; according to Šekeljić & Stamatović, 2006).

Analyzing the situation in the upper grades of primary school and in secondary schools, Bokan believes that the teaching staff has a decisive role (Zdanski, 2002; according to Šekeljić & Stamatović, 2006). The authors point out that the stated approach to teaching physical education, provides mostly superficial and incomplete motor education, and contributes very little to the development of key motor, functional and other potentials, abilities and characteristics (Stamatović, 2001).

Based on the analyzes conducted in previous decades, it was concluded that it is first necessary to solve staffing problems and equipment of gyms, and then focus on individual characteristics of students and their motor, spatial abilities (Lazarević, 2005).

Praise and recognition as a verbal stimulation in physical education classes is a powerful motivating tool. For example. The teacher praises the student who has mastered the task of the class before the others and asks him to demonstrate this successfully mastered task in front of other students in the class, which has a motivating effect not only on that student but also on most others. Plaque, trophy and diploma as motivational means are awarded publicly and solemnly. Competition in the teaching of physical education and in extracurricular activities - sections can be considered in a special motivational sense, and that motivational power of the competition is important for all students.

The best motivation for student work is if the contents are adjusted to the possibilities, abilities and interests of each student individually (Međedović, 2006; Mehmeti, 2015).

Children with intrinsic motivation, longer remain attached to what they do even in the absence of material reward (Pelletier et al., 1995). When goal theory, ie. the theory of motivation for sports achievement (AGT) is applied to the teaching of physical education, its basic theoretical postulates, goal orientation, motivational climate and the state of goals get a new context, which refers to the approach of a person to an activity (class) with a specific goal.

How to raise motivation for achievement in football training

In order for a person to engage in team sports, it is necessary to possess many psychological characteristics that represent a good basis for success in team sports. (Mladenović, 2011). It turned out that motivation is especially present at the cadet age (age 14-16) among young football players. It is extremely important to keep in mind that it is necessary to work not only on improving sports potentials, but also on improving psychological qualities (Mladenović, 2011). Active athletes are systematically exposed to specific environmental requirements and situations and develop a disposition of personality that Havelka & Lazarević (1981, 1990; according to Mladenović, 2011) have determined as a motive for sports achievement.

The goal of the research that Mladenović conducted (2011) among young football players and basketball players of cadet selections, was to determine the structure of personality and the structure of motivation for sports achievement. The results show that active athletes, along with the development of motives for sports achievement and the establishment of emotional control and stability, show a decline in tendencies towards emotional inhibition and instability. and the development of cooperation in the team, leads to an increase in intrinsic motivation (Nicholls, 1989; according to Trboglav, 2006). External recognition and success are very likely to lead to increased pressure and anxiety and consequently lead to a decrease in intrinsic motivation (Nicholls, 1989; Ryan, 1982; according to Duda & Hall, 2001; according to Trboglav, 2006).

The results of the research on sports motivation of young football players from Russia, Serbia and Montenegro, which was conducted on respondents aged 12 to 15, indicate the complexity of sports motivation. The analysis of sports motivation in relation to the age and the country from which the respondents come, showed that only extrinsic motivation based on the mechanism of introjection was significant. The most age-significant differences, in terms of all aspects of extrinsic motivation, were obtained between thirteen-year-olds and fourteen-year-olds (Mladenović & Marjanović, 2011).

CONCLUSION

In this review analysis, the emphasis was on motivation for achievement in sports and physical education, ie theories, of which there are a large number to date, and recommendations for practice. The influence of motivation as the main driver of activity in general in the field of efficiency of physical

education is an unavoidable problem. In order for the teaching process of physical education to be as efficient as possible and to meet with as few problems as possible, it is necessary to have a higher staff qualification of physical education teachers. In addition to personnel problems, it is necessary to solve the issues of equipping gyms and all the necessary conditions for conducting physical education classes. All this would aim to raise the quality of teaching and raise motivation for student achievement. The quality of teaching, in addition to all the above, will largely depend on the attitude of students towards physical education.

In order for a person to engage in team sports, it is necessary to possess many psychological characteristics, such as: adaptability, willingness to cooperate, social sensitivity, but also dominance, emotional discipline and responsibility. Achievement in football is related to emotional stability, maturity, ego strength, the ability to adapt one's own impulsive reactions to the demands of the social situation, as well as a very high and stable motivation for achievement.

The recommendation to increase motivation for achievement in football coaching would be to develop internal motivation, followed by goal-oriented motivation, competition and coaching to focus on learning and develop a sense of belonging to the team, all with the goal of satisfaction they will feel when achieving results. This is certainly the task of the coach, but also of parental and school upbringing.

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IMPACT OF BODY DISSATISFACTION ON EATING DISORDERS DEVELOPMENT IN FEMALE ATHLETES

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ABSTRACT

In the world every third person is directly affected by insufficient body weight, lack of vitamins and minerals, or by overweightness, obesity and diet-related diseases. About 10 million women in the United States struggle with eating disorders such as anemia and bulimia, and mostly those women are dissatisfied with their appearance. The aim of this study was the assessment of body dissatisfaction in female athletes and whether this dissatisfaction leads to eating disorders. The sample consists of 36 respondents, active female basketball players, taken out from around the Serbia. The variables used were: age, body height, body mass, body mass index (BMI) as well as the duration of their active involvement in sports. Respondents completed an Eating Attitudes Test (EAT-26) questionnaire online and a modified Body Shape Questionnaire (BSQ-34) for the assessment of their dissatisfaction with the appearance. Based on the EAT-26 diet questionnaire, the results show that there are no eating disorders among respondents. In the sample, there are 31 well-nourished respondents, which makes 86.1% of the sample, while five (13.9%) are over-nourished. There are no malnourished and obese respondents. Among the respondents, eight of them (22.2%) said that they were satisfied, 25 (69.4%) expressed mild dissatisfaction, and three (8.3%) expressed moderate dissatisfaction with their body. There were no respondents completely dissatisfied with their body. Nonparametric correlation analysis (Spearman's correlation coefficient) shows that correlation between the absolute value of body dissatisfaction score and the results of the dietary attitude test is statistically significant ($p=0.412$, $p=0.012$, respectively). The results of the linear regression analysis indicate that an increase of absolute value of body dissatisfaction score leads to an increase in dietary attitude score. Body dissatisfaction reciprocally increases, increasing the interval of confidence, which is evident on the increase by 1, and this increase is statistically significant in $p<0.05$. The results of regression analysis showed that BMI is a significant predictor of body dissatisfaction, which was expected and previously reported. Numerous studies have shown that engaging in physical activity leads to increased satisfaction with one's own appearance, and physical activity is correlated with the attitude about the importance of engaging in physical activity.

Keywords: EAT-26, BSQ-34, eating disorder, body dissatisfaction

INTRODUCTION

The difference in the perception of one's own body and one's ideal physical appearance leads to dissatisfaction with own body, which is associated with undesirable outcomes and diseases, both mental and physical (Paxton, Eisenberg, & Neumark-Sztainer, 2006). Body image has a significant impact on the physical and mental health of young people. A positive attitude about one's appearance can be encouraged by teaching young people to focus on functionality rather than physical appearance, as well as providing health information that is not focused on body composition but as an essential component for a healthy life (Jensen, Savoie-Roskos, Neid-Avila, & Bingeman, 2018). During assessment of the health risk and nutritional status, body composition is considered relevant (Gómez-Ambrosi, Silva, Galofré, Escalada, Santos et al., 2012). Eating disorders belong to the group of mental and physical illnesses that affect an individual regardless of age, gender, ethnicity and socioeconomic group, resulting in anorexia and bulimia nervosa (Erskine, Whiteford, & Pike, 2016). One out of three people in the world are directly affected by underweight, vitamin and mineral deficiency, or overweight, obesity and diet-related diseases (IFPRI, 2016). About 10 million women in the United States struggle with eating disorders such as

anorexia and bulimia (Crowther, Hobfoll, Stephens, & Tennenbaum, 2013). According to the U.S. Department of Society and Social Services (DHHS), malnutrition may be a dietary change related to problematic eating behaviors, such as restrictive dieting and cleansing, and as a need to meet full criteria for diagnosing eating disorders. Implementing a diet is a very stressful process. Women who report eating disorders express much more dissatisfaction with their appearance compared to the increase in effort they put into controlling their weight. The attitude towards the body is formed during puberty when children begin to notice the first physical changes on their body. In many of the developed western countries 50-80% of girls want to be thinner, and 20-60% of girls follow a weight loss diet (Levine & Smolak, 2002). Research of Thompson (2004) indicates that dissatisfaction with own body is a predictive measure of eating disorders. The results of a study realized by Johnson, Powers, & Dick (1999) show that women have a more common disorder than men. Namely, 1.1% of women meet the criteria for bulimia compared to men (0%). Also, the research study of Gallagher, Sonneville, Hazzard, Carson, & Needham (2021) points out that the assessment of the risk of eating disorders is independent of gender, but is more common in women. Eating disorders in male athletes 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: by family, friends, team and coaches (Reel & Gill, 1996). The research on eating disorders can clarify the role of self-esteem, dissatisfaction with one's appearance as well as pressures from coaches, parents, the public and the media that influence the development of eating disorder symptoms. Also, research in this area can contribute to the development of eating disorder prevention programs, the development of education of future coaches, provide facts that confirm the importance of maintaining a positive attitude about one's appearance as well as its impact on an individual's health.

The aim of this study was to determine whether there is any presence of eating disorders as well as the assessment of dissatisfaction with one's own appearance in female athletes and whether dissatisfaction with the body leads to display of eating disorders.

METHODS

Subjects

The sample consisted of 36 respondents, female basketball players, taken from the whole of Serbia. The criteria for the selection of female respondents were: aged over 13 years and actively involved in sports. The youngest respondent was 17 years old, while the oldest was 33. Participation in the study was voluntary and each of the respondents could withdraw from the study at any time.

Procedure

Female respondents were informed and instructed about the research aim and the method as well as the work procedure. The variables used were: antopometric characteristics (body height, body mass), age, body mass index (BMI) as well as how long they have been actively involved in sports. Female respondents completed an EAT-26 (Eating Attitudes Test with 26 items) questionnaire online and a modified BSQ-34 (Body Shape Questionnaire with 34 items) for assessment of the dissatisfaction with their appearance. EAT-26 (Garner & Garfinkel, 1979), i.e. questionnaire on eating habits, is the most commonly used questionnaire in order to examine the risk of eating disorders. It contains three subscales that show the dimensions of eating habits: (1) nutrition, which describes eating habits; (2) food preoccupation- whether there are any deviations from normal eating habits; (3) oral control- whether any means are used to control food intake. A total score higher 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 a problem with an eating disorder. The results are interpreted together with the current BMI. For the assessment of the degree of body dissatisfaction, the modified BSQ-34, which measures concerns about one's own body appearance, uses a 5-point Likert scale (1=never, 2=rare, 3=frequent, 4=very often, and 5=always). Item scores are summed up, and the total score is calculated for each individual. A total score less than or equal to 67 is considered normal; that is, there is no distortion of the body image. A score between 68 and 92 points means a slight distortion of the body image; results between 93 and 117 indicate moderate distortion, and over 117 serious distortions of body image (Cordas & Castilho, 1994).

Statistical analysis

The program SPSS 20.0 was used for statistical data processing. The statistical method of analyse included descriptive statistics: arithmetic mean (Mean), standard deviation (SD), minimum (Min) and maximum (Max). The Wilcoxon test was used, based on the results of the Kolmogorov-Smirnov test (with Lilifors correction), so as nonparametric correlation analysis- Spearman's correlation coefficient and linear regression analysis.

RESULTS

Table 1 shows the parameters of descriptive statistics of the basic characteristics of the female respondents as well as the subscales of the EAT-26 questionnaire.

Table 1. Descriptive statistics of basic characteristics of female respondents

Variables	Mean	SD	Min	Max
Age	23.03	3.783	17	33
Years of playing sports	10.50	3.910	4	19
Body height (cm)	174.92	8.849	165	193
Body weight (kg)	67.61	10.784	51	95
Nutrition (1)	4.44	4.053	0	15
Food preoccupation (2)	1.06	1.351	0	7
Oral control (3)	1.86	1.885	0	8

The average age of 36 female respondents is 23.03±3.78 years, where the youngest respondent is 17, and the oldest is 33 years old. On average, they have been involved in sports for 10.5±3.91 years, with the shortest period of practice being 4 years and the longest 19 years. The mean value of the body mass of the respondents was 67.61±10.78 kg, while the one with the lowest body mass had 51 kg, and with the highest 95 kg. Based on the EAT-26 diet questionnaire, the results show that there are no eating disorders.

Table 2 shows the structure of female respondents based on BMI and the results of the BSQ-34. The average BMI of the female respondents is 21.99±2.26 kg/m^2, where the one with the lowest BMI has 18.73 kg/m^2, and the one with the highest 27.76 kg/m^2. In the sample, there are 31 normally nourished female respondents, which makes 86.1% of the sample, while five are over-nourished, which is 13.9% of the sample. There are no malnourished and obese female respondents. Among the female respondents, eight of them, which is 22.2% of the sample, said that they were satisfied, 25 of them, which is 69.4% of the sample, express mild dissatisfaction, and three of them, which is 8.3% of the sample, express moderate dissatisfaction with their body. There are no female respondents who are completely dissatisfied with their body.

Table 2. Structure of female respondents by nutrition and questionnaire on satisfaction with their body

Category	Frequency	Percentage (%)
Normally nourished	31	86.1
Over nourished	5	13.9
Satisfied with their body	8	22.2
Mild dissatisfaction with his body	25	69.4
Moderate dissatisfaction with your body	3	8.3
In total	36	100.0

Table 3 shows the distributions of frequency for each of the symptoms of eating disorders, i.e. weight control by forced vomiting, use of pills, laxatives or diuretics, exercise for more than 60 minutes and loss of more than 10 kg. Control of body weight by forced vomiting, use of pills, laxatives or diuretics was not used in 94.4% of the respondents. Female respondents who exercised for more than 60 minutes are 19.4% while 52.8% of the sample said they had never exercised for more than 60 minutes.

Table 3. Distributions of the frequency for each of the symptoms of eating disorders

Category	Taking pills, laxative or diuretic	Forced vomiting	Exercise more than 60min	Loss more than 10 kg
Never	34 (94.4%)	34 (94.4%)	19 (52.8%)	35 (97.2)
Rarely	1 (2.8%)	2 (5.6%)	5 (13.9%)	0
Often	1 (2.8%)	0	1(2.8%)	0
Sometimes	0	0	1(2.8%)	0
Very often	0	0	7(19.4%)	0
Always	0	0	3(8.3%)	1 (2.8%)
Total	36 (100%)			

Table 4 refers to the current, desired and ideal look for playing sports. Descriptive statistics for all three characteristics are presented.

Table 4. Descriptive statistics for body image characteristics and the result of dissatisfaction with their body image with minimum and maximum values

Characteristic	Mean	SD	Min	Max
Current look	4.89	1.304	2	7
Desired look	4.39	.803	3	6
Ideal look for sports	4.58	1.025	3	9
Results of dissatisfaction with body appearance	0.50	1.320	-3	3
Results of satisfaction with body appearance	-0.42	1.025	-2	4

To determine whether the results of dissatisfaction with physical appearance and the results of satisfaction with one's own appearance were, on average, statistically significant, the Wilcoxon test was used, based on the results of the Kolmogorov-Smirnov test (with Lilifors correction), samples for all three characteristics, with error probability of 5% (0.05), not normally distributed (p=0.001, p=0.000, p=0.000, respectively).

Table 5. Results of Wilcoxon's test for dissatisfaction with body perception in general and in sports

Variable difference	Z	Significance
Current look – Desired look	-2.270	0.023
Ideal look for sports – Control variable for ideal look for playing sports	-2.799	0.005

The Wilcoxon's test results indicate that the average result of dissatisfaction with body perception is statistically significant (Z=-2.270, p=0.023). The same applies to the result of dissatisfaction with body perception in sports (Z=-2.799, p=0.005). As the result of the body perception can be negative and positive, and both sides indicate a deviation from the ideal (0), its absolute values are calculated so that the correlation analysis is valid and such the measure of deviation from the ideal value is obtained. Nonparametric correlation analysis (Spearman's correlation coefficient) shows that the correlation between the absolute value of the results of body dissatisfaction and the results of the dietary attitude test is statistically significant (p=0.412 and p=0.012, respectively). The results of the linear regression analysis indicate that increasing the absolute value of the body dissatisfaction score by one 1 leads to the result of the dietary attitude test increasing by B=1.735 (with a 95% confidence interval from 0.318 to 3.152), and this increase is statistically significant (p=0.018). The coefficient of multiple determination R^2 is 0.154, which means that 15.4% of the changes in the result of the test of attitudes towards the diet of the female respondents were determined by the changes in the absolute value of the BSQ-34 test. However, using linear regression analysis we found that an increase in BMI by 1 results in an increase in dietary attitude test results by B=0.663 (with a 95% confidence interval from 0.032 to 1.295), and this increase is statistically significant (p=0.040). The coefficient of multiple determination R^2 is 0.118, which means that 11.8% of the changes in the result of the test of attitudes towards the nutrition of our female respondents were determined by changes in the BMI.

DISCUSSION AND CONCLUSION

Taking into account previous experiences, the basis of the problems, subjects and goals of the research, as well as the methodological approach in this research, the results showed that own body dissatisfaction leads to eating disorders and has an impact on the above mentioned, and increase of BMI results in eating disorder increase. The EAT-26 results show that there are no eating disorders in this research's respondents. The results of regression analysis showed that BMI is a significant predictor of body dissatisfaction, as indicated by previous research (Paxton et al., 2006; Matić, 2008; Matković, 2013). According to the problem, it is expected that the female respondents who are dissatisfied with their body perception wold have a higher BMI, and would attach more importance to their physical appearance. The results showed that 86.1% were normally nourished, while 13.9% of the sample was over-nourished. There are no malnourished and obese female respondents. Among the female respondents, 8 of them, which is 22.2% of the sample, said that they were satisfied, 25 of them, which is 69.4% of the sample, expressed mild dissatisfaction, and 3 of them, which is 8.3% of the sample, expressed moderate dissatisfaction with their body. There are no female respondents who are completely dissatisfied with their body. According to Novkovic (2003), adolescent girls are in a very sensitive developmental period in which the emphasis is on physical appearance and at the same time major physical changes lead them to procedures that could help in reducing the body mass and thus approach the desired ideal one. Attempts to lose weight by lose-weight diet and other weight control procedures may be associated with the opposite effect than expected, such as weight gain. This increases the frustration of the girls, their dissatisfaction with their physical appearance and the feeling of inefficiency in changing their own body. It is noticed that the female respondents show extremely low results in the ability to regulate and manage emotions. Research strongly emphasizes that the role of emotion regulation and management is great in overeating, i.e. such behaviour is preceded by high levels of stress and unpleasant emotions (Safer, Telch, Chen, & Linehan, 2009).

Numerous studies have shown that engaging in physical activity leads to increased satisfaction with one's own appearance, and physical activity is correlated with the attitude about the importance of engaging in physical activity (Berry & Howe, 2004; Dunlavy, 2008; Roberts, 2010; Carter-Parker, Edwards, & McCleary-Jones, 2012; Poobalan, Aucott, Clarke, & Smith, 2012), so it is to be expected that greater body satisfaction will be associated with more positive attitudes toward physical activity in individuals, who are physically active. In future longitudinal research could be applied to obtain information on various factors of body dissatisfaction over a longer period of time. Since there is a lack of data on the development of body dissatisfaction in men, it would be useful if future research included men. Future research could also include some hitherto unexplored variables, such as depression, fear of social rejection, and Internet influence. If the results show a developed dissatisfaction with physical appearance, it is necessary to apply exercise programs, promote a healthier lifestyle, as well as diet and how to influence self-respect.

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FAIR SPORTS LITERATURE DISCOURSE REPRESENTATION OF DISABILITY

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ABSTRACT

Each discourse community shares its unique system of communicating to effectively spread information and knowledge pertaining to that particular community. Generally speaking, scientific knowledge is shared through written communication deploying an argumentative language in different science domains, including sports sciences. To corroborate this fact Montgomery (1999, 32) claims that, "science would not exist if scientists were not writers". This means that science functions through linguistic forms and content. However, one particular Paralympic community despite the need to efficiently communicate scientific "facts" and proven "truths", also uses images or photographs to bring to light facts concerning Paralympians' ordinary, but also sporting life and achievements. Hardin (2007) analyzed photographs in 59 general physical education (PE) textbooks via content analysis and concluded that general PE physical textbooks do not usually include photographs of persons with disabilities, but just general physical education environment as non-inclusive. Táboas-Pais & Rey-Cao (2012) report implicit prejudice embodied in cultural representation patterns, language, and the socialization of individuals in a community. Analyzing 3,316 images published in 36 Spanish textbooks by 10 publishing houses, through the content analysis the authors verified Bhatia's (1993, 13) claim that "genres fulfill communicative purposes". However, the Paralympic community messages are usually distorted, misunderstood, downgraded, and the accomplishments of the disabled athletes are marginalized in mediated coverage, particularly through printed scientific literature. This coverage is scarce, incomplete, and misleading, thus perpetuating wrong images and wrong messages of the disabled personal and sporting life. Therefore, the need for more detailed content analysis of the focused disabled athletes' literature was felt.

Keywords: discourse, bias, Paralympics, disability, scientific literature

INTRODUCTION

Science functions through linguistic forms and content. However, one particular Paralympic community needs to efficiently communicate scientific "facts" through words, but also through images or photographs to bring to light Paralympians' ordinary and sporting life and achievements. Hardin (2007) analyzed photographs in 59 general physical education (PE) textbooks via content analysis concluding that general PE textbooks do not usually include photographs of persons with disabilities, but insist on the non-inclusive general PE environment. Táboas-Pais & Rey-Cao (2012) analyzed 3,316 images published in 36 Spanish textbooks reporting implicit prejudice embodied in cultural representation patterns, and language as well. However, printed mediated sports literature needs analyzing to reveal fair or biased reporting on the Paralympian sports and athletes. Generally speaking, scientific knowledge is shared through the written communication which enables argumentative discourse in different science domains, including sports sciences. Formal written scientific expression deploys six to eight lexical words per clause to alienate readers not belonging to a given specified discourse community (Halliday & Martin, 1993, 76) It seems that the specific discourse community of sports literature needs revising not only language units used, but whole discourses, to make them free from bias and prejudices. For example, when reporting on eating disorders in general, the topic covers much more than problems pertaining to

race and class, celebrities or ordinary people. Moreover, it is interesting to investigate how scientific literature report on the findings about societal factors contributing to women and men feeling differently about their body image both in the abled and the disabled population.

Physical excellence embodied in the able human body comes into the limelight particularly in the mega event such as the Olympic Games. The mighty human body is displayed in all its magnificence bringing messages typical for the competing and winning athletes such as physical and mental strength, effort, determination, stamina, and endurance. However, it seems that in the Paralympics as well stereotyping is perpetuated depicting men as strong, rational, dominant, independent, less concerned with appearance, whereas women are always described as weak, emotional, nurturing, dependent, and anxious about their appearance. Mass media, when tackling the topic of gender socialization on television ensure that male characters are typically more aggressive, constructive, and direct, while females use manipulation to get their way. By all means such negative phenomenon should be avoided in scientific literature. Some recent findings suggest that regardless of the linguistic interventions favoring the reporting on disability, real life proves that disability comprises many complex social, economic and political issues.

It is also far from certain that favoring is what Paralympians themselves prefer. Recently (Evening Standard, 20th Jan. 2011), Sophia Warner, a cerebral palsy runner claims her disability shows twofold characteristics: the full awareness of her limitations in performance, but also an immense determination to succeed at all costs, which probably proved vital for her triumphing sports performance. The achievements of all sportspeople can be immensely inspiring, but the achievement of the disabled athlete can prove tremendously encouraging. Therefore, the Paralympian's achievement can be used to emphasize virtues such as fortitude and determination. That is what the Olympics role is: to inspire, excite and arouse to achieve nothing less than excellence in all types of sports performances. Lack of attention to the Paralympians' achievements, or the foul language used to report or investigate these topics, lessens the performance and speaks more of the society than of the disabled medalists.

METHODS

In order to investigate possible unfair reporting and depicting of the disabled athletes a more detailed content analysis of the focused disabled athletes' literature was investigated through "Google Scholar", "PubMed", "Kobson", "SCIndex" and "Hrcak" using key words - *sports, Paralympic Games, sitting volleyball, quality of life,* published from 2006 to 2016. Research methods of selection, description and synthesis were applied. 25 papers have fulfilled research criteria and the content analysis was applied. Following most important Paralympians' sport participation factors were found: motivation, promoting war veterans, improving physical conditioning, improving functional abilities, changing attitudes and promoting positive attitudes to Paralympic sports in general. Terminology investigation has also revealed the need to use more standardized terms and a fair reporting discourse.

Wu & Williams (2001) claim that models of restoring social life of the disabled include the influence of friends and peers with disabilities as initial socialization agents which proved much more effective than the rehabilitation therapists. Moreover, education programs goals for rehabilitation therapists should include "participation"-oriented skills development as well as optimal function restoration. Twenty year later, Grover (2021) a conceptual model of disability is introduced locating itself on a spectrum between social and medical perspectives.

For our research study it is important to note that improving functional abilities of the disabled athletes still occupies the attention of the inclusion theoreticians so much so that out of 25 papers investigated 8 were focused on the restoration of the bodily functions which are feasible only through the better perception of the disabled athletes (Grenier, Collins, & Wright, 2014). Quite naturally, different bodily disorders or dysfunctions influence the way people and athletes perceive the possibility of inclusion in sports activities which is nicely described in Moola, Fusco & Kirsh (2011) who draw on the role of social barriers in full physical activity implementation. The participants offer their narrative stories to inform and warn of their sociocultural world and the inability to actively participate in physical activity due to the societal barriers, wither psychological or physical ones. The findings should engage researchers and general and physical educators to focus on the social and cultural patterns as well. Representation of the disabled is also investigated through the images or the lack of them in media, scientific literature or PE textbooks and other teaching materials.

Hardin (2007) examined textbooks used for PE teachers' education but his findings have only reinforced a notion that sport seems to be for the non-disabled since 59 textbooks with 2,455 photographic images had only 14 photographic images showing persons with disabilities. Publishers may print photographs of the disabled, but not more than 1.5% of their total photographic images included

persons with disabilities, with two thirds of them including no photos of persons with disabilities whatsoever. Táboas-Pais & Rey-Cao (2012) analyzed 3,316 images published in 36 Spanish textbooks reporting implicit prejudice embodied in cultural representation patterns. Results also showed a remarkable imbalance between people with disabilities and people without disabilities, dominantly less frequent representation of women with disabilities than men with disabilities. Also, sports participation of the disabled was very limited to the segregated, competitive, and elite sports activities.

Quality of life of the disabled athletes throughout their lifespan was also investigated by Coric & Ljubotina (2013) who investigated the quality of life of war veterans with physical disabilities playing sitting volleyball. 101 Homeland War veterans with physical disabilities actively playing sitting volleyball, cite their reasons and motivation for playing, perceived benefits from playing, the level of satisfaction with acknowledgement and appreciation of the society. The majority of players started playing volleyball after being invited by a friend and the main motives for participation are friendship and socialising as well as care for personal health. Between 75% and 85% of veterans estimate that sitting volleyball to a higher degree helps them to improve their physical and mental health, social life and the feeling of general purposefulness.

Molik, Laskin, Kosmol, Skucas, & Bida (2010) focus more on the relationship between functional classification levels and anaerobic performance of wheelchair basketball athletes. They were investigating the relationship between upper extremity anaerobic performance (AnP) and all functional classification levels in wheelchair basketball. Their findings provided some evidence that the IWBF functional classification system should be re-examined and that a consolidation of the current eight levels might be in order.

Perret, Labruyère, Mueller, & Strupler (2012) investigated the correlation of heart rate at lactate minimum and maximal lactate steady state in wheelchair-racing athletes. They have found out that there is a close relationship between LMHR and HR at MLSS in wheelchair racing. This allows the prediction of MLSS based on a single exercise test in this special group of athletes. For practical use during daily training, routine HR at MLSS can be assumed to be 8-9 b.p.m. above the LMHR in wheelchair-racing athletes.

Braye (2016) in his paper 'I'm not an activist': an exploratory investigation into retired British Paralympic athletes' views on the relationship between the Paralympic games and disability equality in the United Kingdom enumerates the London 2012 Paralympic Games aftermaths for the disabled athletes. He cites that the Games 'improved attitudes to disability and provided new opportunities for disabled people to participate in society'. In addition, the International Paralympic Committee's strategic plan suggests that the Paralympic Games is a vehicle for achieving 'a more equitable society'. A group of retired British Paralympic athletes gave their opinions on the relationship between the Paralympic Games and disability equality in the United Kingdom. Narrative interviews were conducted with five male retired British Paralympians and one female retired British Paralympian who had participated in a total of 22 Summer Paralympic Games events. Their conclusion is that some Paralympic athletes who are not obvious 'activists' can still contribute to equality for the disabled people.

Discourse of the disabled or language and naming matter. Throughout history the terminology has reflected our stereotypes about those not created to the image of the majority. Society still feels in the dark for more socially acceptable terminology: physically challenged, visually impaired, differently abled, disAbled, etc. Able-bodied individuals *do* exercise, workout, and have personal *fitness trainers*, while individuals with disabilities *get* rehabilitation, therapy, and have *physiotherapists.* Able-bodied children *take* music lessons, children with disabilities *receive* music therapy. Able-bodied children *do* swimming lessons, children with disabilities *get* hydrotherapy. Such language still implies a sense of dependency and inferiority; a sense that the experiences are happening to the individual, rather than that the individual is being actively involved. For example, there is still doubt if the labels Olympians and Paralympians are viewed equally as having the same high-quality of athleticism, determination, and commitment. From the terminology point the question is posed if this differentiation between athletes is really necessary? What purpose does this distinction serve? What stereotypes are reinforced?

RESULTS

Content analysis of the sports literature totalling 25 scientific papers focusing on the Paralympians, regardless of the sport in question, has revealed following Paralympians' sport participation factors: motivation, promoting war veterans, improving physical conditioning, improving functional abilities, changing attitudes and promoting positive attitudes to Paralympic sports in general. Motivation was found in nine papers as a leading topic, four papers focused on the war veterans and their sports participation, four papers were dealing primarily with functioning abilities, all other papers combined the

above-mentioned elements. Arbitrary terminology related to disability was mostly used, showing a pressing need to standardize disability terminology since domestic scientific literature heavily relies on the Anglophone Paralympians literature. Most representative papers were analyzed in detail for the predominant factors covered and the terminology used. Out of 25 papers 20 have explicitly favored the use of the social, or the conceptual model of perceiving the disabled athletes over the medical model. All the papers have stressed the need to conduct further research and to enlarge the literature on the sports participation of the disabled athletes. 15 papers have tackled the problem of gender discrimination but mostly in the area of the availability of sports conditions and facilities.

DISCUSSION AND CONCLUSION

From the analysed literature we find out that Paralympian sports (sitting volleyball, wheelchair basketball, wheelchair volleyball, etc.) emerge as a new approach to the treatment of patients where sport is presented equally as part of a medical treatment and a complete rehabilitation of persons with physical disabilities. All the more important is the component of general resocialization of such persons-athletes which helps erasing all religious, racial and other differences, thus alleviating their already damaged health status.

Impartial and fair reporting language in scientific literature was shown to be equally important. Modern terminology in this area points to at least two things. First, it points to the power of culturally dominant groups to control a group of people by categorizing it according to the characteristics that the ruling culture considers important for its goals. Second, it points to the ideological position and broader philosophical-anthropological view of the possessors of that power on human nature. Regarding the first, Gergen says that we name some phenomena in a certain way not because they really exist, but because some linguistic categories are socially useful to us, thus showing the connection between linguistic and social practice (Gergen, 1994, 50). The term disability, support the relationship between inequality and power that seeks to present itself as natural. Although people have always noticed the specificity of the "mentally retarded", it has not always been an obstacle for them to be equal members of a society. Only in the late 19th century did the perception of the "retarded" begin to change their nature due to major social changes- technical-technological and information-transport innovations and their social consequences.

The key argument in favour of terminological reform is not so much that depersonalizing terms ("handicapped", "disabled", "damaged", "retarded", "physically challenged", etc.) are simply replaced by politically correct ones ("person with disabilities", "person with special needs") which cynics call euphemisms, as much as the change of social practice towards these persons. In this manner, the change of perception must really take place. Persistent proponents of the old classification point out that labelling helps explain strange behaviour, better understanding, and greater sensitivity to “disruptions”! Were it not for such labels, the school would, for example, consider such students lazy, and it would be more difficult for them to understand how the population of the disabled differ from others (Hallalian & Kauffman, 1994, 502). These authors seem to forget that it is precisely this difference, which has been singled out for its dysfunctionality in relation to the almost harsh demands for high economic productivity, is the basis of oppressive practice.

The paths to adequate terminology are the paths to rediscovering the forgotten and repressed humanity of the “hindered” that has been lost in the language of deficits in overemphasizing shortcomings. One should not naively believe that the lives of those "hindered" in the new appointment will immediately take a different direction. Proponents of the old names claim that the new names are mere euphemisms that smell of calculation and compromise and that do not have much influence because they quickly acquire old meanings (Barnes, Mercer, & Shakespeare, 1999, 8). But these conservatives lose sight of the power of the influence of language and symbols on individual and collective consciousness, and of their ability to be a reflection of the nature of social relations in society and their creation at the same time. Conceptual oppression or “symbolic violence,” as Bonvin & Bourdieu (1993) would say, is becoming an excellent substitute for physical coercion in the modern world. It is clear, therefore, that a complete solution cannot be found only in new labels unless they are accompanied by structural, profound social changes. Changing the labels from negative to positive is one of the conditions for changing the treatment of the "disturbed" in society. Although language often obscures more than it clarifies, at the same time it has the potential to conceptualize a better world and to begin the process of its reconstruction.

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ANALYSIS OF SERBIAN MEDIA REPORTING ON NATIONAL MALE AND FEMALE BASKETBALL PLAYERS DURING THE OLYMPIC GAMES 2016

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ABSTRACT

This paper aimed to gain new insights into how and to what extent the domestic media reported on basketball players at the 2016 Rio de Janeiro Olympic Games, as well as to identify reporting differences by gender of athletes. The subject of this article was basketball newspaper articles in electronic newspaper publications, which influence the formation of a media image of female athletes and which can contribute to the affirmation or marginalization of women in sport. The method used in the research is the content analysis of the selected articles. This method is widely accepted in these types of research and enables a large number of texts to be viewed by systematic quantification of media content, using predefined categories and data to be analysed statistically. Content analysis as a quantitative method, counts and measures categories such as words, phrases or pictures. This is a popular method for studying gender differences in media representation, as it can reveal recurring patterns that can shape our attitudes, values and beliefs. The sample of the research material was based on the Serbian media in the electronic edition: Politika, Kurir, Večernje Novosti, as well as the portal of RTS media public service, from 5th to 21st of August, 2016. The data included information on the number of articles dedicated to male and female basketball players; the number of words in the text; the number of photos and gender of the actors in the photos; the active or passive representation of basketball players, as well as representation of basketball players on and off the field; the camera's shooting angle; the emotions in the photos and the level of the exposure of the bodies in the photographs. The results showed that the surveyed media paid almost twice as much attention to male basketball players, but that texts on male basketball players were slightly shorter on average. Basketball players were also visually represented with more photos (52% men, 37% women, 4% both, 7% something else about basketball). Male basketball players were more off-field (50%) in the photos, while female athletes were more represented on the field (27%). Overall, the obtained results showed that there is still an imbalance in the way men and women are portrayed by media and that there is a need for some changes regarding this topic.

Keywords: basketball, women, Olympic Games, Serbia

INTRODUCTION

One of the features of the modern twentieth-century Olympic Games was male dominance, both in terms of the range of sports and disciplines involved, and in terms of the total number of players. Sports media coverage in that period was also based on a strong male dominance (Messner, Duncan, & Jensen, 1993; Coakly, 2003; Huffman, Tuggle, & Rosengard, 2004). However, male dominance at the Olympics, as well as the promotion of gender stereotypes, has decreased significantly over time. Given that the participation of male and female athletes in the 2016 Olympic Games was 55% vs. 45%, in favour of men, the quantitative difference is not very significant. However, there is still an imbalance in the qualitative sense in the media coverage of male and female athletes (Godoy-Pressland, 2014; Živković, Ranđelović, Piršl, & Nejić, 2016). Showing the higher frequency of males compared to female athletes, as well as minimizing the significance of the women's sports through the differences in quality of the media report amplifies the stereotype that sport is specific to men and limits women to stereotypical gender roles (Bernstein, 2002; King, 2007). Due to the great importance of the media in modern society, the imbalance

in reporting on male and female athletes can lead to the creation, preservation, and strengthening of gender stereotypes. Feminist-oriented media researchers argue that sports media are a bastion of male dominance where male hegemony is represented through the marginalization and trivialization of female athletes (Krane, 2001; Van Zoonen, 2004; Boyle & Haynes, 2009). Previous research on this topic can be generally systematized into two groups: papers emphasizing the quantitative predominance of men in the media (in terms of number of articles, words per individual article, number of photos or videos), and papers emphasizing qualitative differences in media sports reporting. To depict this imbalance, a study conducted in the United States (The Global Media Monitoring Project 2010 - North America Regional Report) states that men are represented by 67% of the total television broadcast time in sports television news. Regarding printed media, sports covers about 7% of all articles, and it should be noted that women are in focus only in the context of their success in sports such as tennis, volleyball, basketball (86%). Very little is written about female athletes in other sports (football, kickboxing, judo, karate, chess, swimming, etc.), although female athletes from these disciplines have brought equally important awards and recognitions. The success of a women's team is almost exclusively commented on by their male coaches as experts (92%). In recent years, more and more texts can be found on the pages of sports about famous women athletes, but also about their families, and finally about their beauty (Jones, 2006). On the other hand, readers of sports papers have the opportunity to see a significantly higher number of male photographs and articles about sportsmen (Duncan, Messner, Williams, & Wilson, 1991; Koivula, 1999; George, Hartley, & Paris, 2001). In most cases, the number of photographs showing female athletes is more than half the number of photos showing their fellow athletes. Also, one part of the photos of the athletes does not even refer to their participation in sports (Alston, 1996).

A survey conducted in the Balkan region on "Equality between men and women in sports programs by audio-visual media" conducted by the Electronic Media Agency (AEM), in co-operation with the Balkan Regular Research Network (BIRN), has shown devastating results. The program of three national televisions - RTS 1, RTL, and Nova TV - was analyzed during one week in February, March, and April 2016. Sports news were analyzed as part of informative shows on the three most-watched TV channels with a national concession. Altogether, there were 63 sports news shows, which included 370 articles. Of these 370 broadcasts, only 14 were dedicated to women's sports, representing less than 4% of the total, and 86% of them are men, and slightly less than 10% of both sexes. In research that studied media coverage of Serbian athletes at the Olympic Games held in London (Živković et al., 2017) out of 305 articles, 248 referred to men's sports and 57 to women's sports. The Olympic Games are suitable for research on the media representation of male and female athletes since the number of participants and sport disciplines of both sexes is almost equal nowadays. Media coverage of the Serbian women's and men's basketball national teams at the 2016 Olympic Games in Rio de Janeiro is an exceptionally suitable case for research since both basketball teams achieved great success winning medals. The men's national team won a silver and the women's team a bronze medal, and that is why this case offers great opportunities to see the influence of the media on the social construction of gender.

This paper aimed to gain new insights into how and to what extent the domestic media reported on basketball players at the 2016 Rio de Janeiro Olympic Games, as well as to identify reporting differences by gender of athletes. Based on general assumptions, the following specific hypotheses were derived: H_1- A larger number of articles are about male athletes; H_2- More words in articles are referring to male athletes; H_3- There are a larger number of photos of male athletes; H_4- Women are more often shown in photographs in an environment other than a sports field; H_5- Women are more often shown in photos in "inactive position"; H_6- Women appear in photographs more than men when photographed from an angle "below eye level"; H_7- Women are more often shown in photos in "more emotional states".

METHODS

The content analysis method was used for qualitative and quantitative data analysis. By using the content analysis it is possible to conclude how the media cover so as represent male and female athletes. The sample of research material is based on the Serbian electronic media. Three daily newspapers (Politika, Kurir, Večernje Novosti) were selected, as well as the RTS media public service portal. The data sample is made from articles downloaded from the websites of these media. This decision is based on the fact that more and more people are reading news online. A large number of mobile users who access news websites via phone or tablet contribute to this. That is why newspapers achieve great readership through their online services, which makes them a relevant subject of research. All articles were published in the period from 5th to 21st of August, 2016 and were taken from the archives of the sports section of these media, and then only those that referred to the men's and women's basketball national

teams of Serbia were singled out. These dates coincide with the dates of the opening and closing ceremonies of the 2016 Olympic Games.

Procedure

All the coding was performed by one coder. The gender of the athlete, the gender of the author of the text, the level of activity, and the content of the photographs are variables coded for this research. The athlete's gender is coded: (a) male, and (b) female; place of depicting the athlete: (a) on the field, (b) off the field activity level: (a) active (that is, the athlete is clearly performing some physical movement), (b) passive; camera shooting angle: (a) below eye level, (b) at eye level, (c) above eye level; emotions in photographs: (a) sadness, (b) crying, (c) joy, (d) anger, (d) disappointment, (f) a hug; body exposure level: (a) first level, (b) second level, (c) third level, (d) fourth level (the highest degree of body exposure).

Statistical analysis

The following methods were used in the research: descriptive method and quantitative-qualitative content analysis.

RESULTS

The results of the analysis (Table 1) showed that there were almost twice as many articles in which the main actors were men (57%) compared to women (29%).

Table 1. Number of articles in relation to gender

Male athletes	Female athletes	Both genders in the article	Neither one of them (the article is about something else)
178 (57%)	89 (29%)	37 (12%)	6 (2%)

Table 2. Number of words per article in relation to gender

	Average number of words
Male athletes	347
Female athletes	362
Both genders in the article	1248
Neither one of them (the article is about something else)	1934

The results of the analysis of the number of words (Table 2) showed that the texts about men were on average shorter than those about women. The total volume of texts dedicated to men is significantly higher (61849 words, compared to 32199 words), but concerning the number of articles, the average size of the text is still smaller.

Table 3. Number of photographs per article in relation to gender

Male athletes	Female athletes	Both genders in the article	Neither one of them (the article is about something else)
328	231	27	43
52%	37%	4%	7%

Based on the number of photographs (Table 3), male athletes attract more attention (52%, 328 photographs) than female athletes (37%, 231 photographs) in the electronic media.

Table 4. On- and off-field display of the athletes

	on-field	%	off-field	%
Male athletes	181	46	64	50
Female athletes	106	27	30	25
Both genders in the article	104	27	30	25
Total:	391		124	

Table 4 shows that female athletes are more represented on-field than off-field (106:30). Male athletes were also shown more on-field than off-field (181 vs. 64 %).

Table 5. Active and inactive representation of athletes in photographs

	active representation	%	inactive representation	%
Male athletes	219	62	89	54
Female athletes	135	38	76	46

Both male and female athletes were portrayed more in active than in inactive depictions (Table 5).

Table 6. Shooting angle

	below eye level	%	in eye level	%	above eye level	%
Male athletes	91	66	175	59	85	73
Female athletes	46	34	124	41	31	27
Total:	137		299		116	

Both male and female athletes were portrayed the most at eye level. Female athletes were shown fewer times in "below eye level" (66 vs. 34 %), but also "above eye level" (73 vs. 27 %).

Table 7. Display of emotions in photographs

	sadness	%	crying	%	joyfulness	%	hug	%
Male athletes	4	57	2	40	71	56	17	46
Female athletes	3	43	3	60	55	44	20	54
Total:	7		5		126		37	

Table 7 shows that there were more photographs of men showing sadness or joyfulness, while more photographs showed female athletes crying or being hugged. The results showed (Table 8) that all the athletes were most shown in the second and third levels of body exposure, and the least in the fourth.

Table 8. Level of body exposure in photographs

	Level of exposure 1	%	Level of exposure 2	%	Level of exposure 3	%	Level of exposure 4	%
Male athletes	37	53	197	69	114	60	5	83
Female athletes	33	47	89	31	76	40	1	17

DISCUSSION

To test hypotheses H_1 – H_3, using quantitative analysis, the number of articles, words, photographs, and proportionality of the observed variables concerning gender was determined and based on them, an appropriate analysis was performed. The results of the analysis of the number of articles showed that there were almost twice as many in which the main actors were men (57%) compared to women (29%), with both men and women athletes in 12% of the photos, and the remaining 2% of the photos were related to something else. This result was expected and it confirmed the set hypothesis H_1. Obtained results confirm the previous research where male athletes are more dominantly represented in the media than female athletes (Billings & Angelini, 2007; Bruce & Wensing, 2012). The results of the analysis of the number of words (volume of texts) showed that the texts about men were on average shorter than those about women, so hypothesis H_2 was not confirmed. The total volume of texts dedicated to men is significantly higher (61849 words, compared to 32199 words), but concerning the number of articles, the average size of the text dedicated to men is still smaller. However, the texts of the largest volume were, on average, those that wrote about topics of a general nature unrelated to athletes. Other research confirms that more text space is devoted to male athletes per individual article (George, Hartley, & Paris 2001), which is in contradiction with the obtained results. In previous studies, female athletes were most often portrayed in a way that stands out, primarily their physical appearance. In considering the importance attached to certain sporting events, but also the actors of those events, the number of photographs is a significant element. Within this research, and based on the number of photographs, it is concluded that male athletes are more perceived and paid more attention (52%, 328 photographs) when photographing than female athletes (37%, 231 photographs), which is why the hypothesis H_3 is confirmed. This fact is also consistent with other research (Jones, 2006). According to some research, during media coverage of sporting events, female athletes are more often represented in photographs in an environment outside the sports field. Within this research, it came to the fact that both athletes were shown much more on the field in photographs than off the field (ratio 27% - 25%). Athletes are slightly more represented and shown on the field than off the field (27% - 25%), so this hypothesis H_4 was not confirmed in this study. Athletes were shown more off the field than on the field (50% - 46%).

Duncan (1990) finds that men are framed as active subjects, while women are framed and more often presented as inactive or passive objects. Such findings exist in some other studies (George, Hartley, & Paris 2001). However, there are studies in which different results have been obtained. Studies in Canadian, South African, British, and American newspapers report that men and women are most often portrayed in action or sports, and these percentages differ very little by gender (Lee, 1992). Hardin et al. (2002) found that 78% of women and 81% of male athletes were represented in "active photographs" in American newspapers. Comparing the media coverage of the United Kingdom, the United States, and Canada, Vincent et al. (2002) state that both women and men are most often represented in active (competitive) situations (women, 51%; men, 52%). Women were shown more often in inactive, but men were more often in photographs in photo poses. Within this research, the results showed that men were portrayed more in active than inactive displays (ratio 62% - 54%), while the display of women in an inactive position was more represented compared to the active display (46% - 38%), so that hypothesis H_5 is confirmed. One of the conclusions of Duncan (1990), who tried to offer interpretations of sports photographs based on different communicative characteristics of photographs, was that cameras placed women below eye level and men in elevated positions, suggesting positions of inferiority and superiority, respectively. On the other hand Hardin & Hardin (2005) came up with results that showed that a higher percentage of men were shown in photographs from the lower corner, and in all newspapers men were more likely to be shown from the lower than from the upper. The most common angle of shooting with the camera was at eye level, and the least above eye level. Both male and female athletes are significantly higher than the other two angles shown at eye level. The largest difference between male and female athletes in the number of photographs was above eye height (46%) and the smallest in eye height (18%). Athletes were shown in a fewer number of photos compared to men "below eye level" (66% men and 34% women), but also "above eye level" (73% men and 27% women). Based on these results, it can be concluded that hypothesis H_6 is partially confirmed.

Some previous research has resulted in the notion that women are often infantilized, presented in highly emotional contexts, and unable to control their feelings. Petca, Bivolaru, & Graf (2013) performed a photo analysis as part of their research, with the aim of determining certain emotional states (sadness, crying, joy, hug). According to the expression on the athlete's face in the photo, each of them was assigned one of the previously mentioned emotions established in the coding scheme. If none of these emotions could be identified, it was marked as indeterminate. The results showed that the most common emotion in the photos was joy in both men and women. There were more photos of men showing sadness or joy,

while more photos showed female athletes crying or being hugged. Based on this, it can be concluded that hypothesis H_7 is partially proven. Another category considered in this research is based on traditional stereotypes but also on the results of some research. Within our research, the results show that athletes were most shown in the second and third levels of body exposure, the least in the fourth. The reason for this is the larger number of articles about Serbian water polo players who achieved good success, and because of that they were more present in the photos, and due to the nature of the sport, they belong to this category. Based on this, it can be concluded that this hypothesis has not been confirmed in this case.

CONCLUSION

This research has led to interesting findings about the portrayal of male and female basketball players in Serbian media. The results showed that male athletes are twice as present in sports texts, but that the texts of articles about them are somewhat shorter. Basketball players are also visually presented with a larger number of photos (52% men, 37% women, 4% both, 7% something else related to basketball). Basketball players of both sexes were shown more on-field in the photos. The results show that both male and female athletes were shown in active performances in the pictures. The most common angle of shooting with the camera was at eye level, and the least above eye level. Both male and female athletes are significantly higher than the other two angles shown at eye level. The results showed that the most common emotion in the photos was joy in both men and women. There were more photos of men showing sadness or joy, while more photos showed female athletes crying or being hugged. Within our research, the results show that athletes were most shown in the second and third levels of body exposure, the least in the fourth.

Overall, the findings of this research showed that there is still an imbalance in the way men and women athletes are portrayed, with a significant positive shift in terms of gender equality, and that there is a need for some changes in the quantity of female athletes media presentation.

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THE IMPACT OF ELECTROMYOSTIMULATION ON THE ATHLETES VERTICAL JUMPING PERFORMANCE: A SYSTEMATIC REVIEW

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ABSTRACT

Electromyostimulation (EMS) represents an artificial muscle stimulation with a well-defined protocol that is precisely designed to reduce discomfort during unnatural muscle activation. The main goal was to find new information on the basis of systematic review of many studies which examined the impact of EMS on athletes vertical jumping performance, as well as to expand the already known conclusions. Electronic databases (Google Scholar, Pub Med, Web of Science and ResearchGate) were searched for the original scientific research projects on the topic of the impact of EMS on athletes' vertical jumping performance. The last search was conducted in June 2020 with a limitation to study published in English. As many as 415 scientific studies were indentified and only 15 of them were selected and then systematically reviewed and analyzed. The results of the research projects with the total sample size of 445 athletes showed that the treatment of global and local EMS, in combination with another types of training, is an effective method for the development of explosive strength, such as vertical jumping. It has been proven that the EMS represents an effective strategy for improving vertical jumping performance, as well as for improving physical performance of athletes in general.

Keywords: athletes, electromyostimulation, jump performance, physical performance

INTRODUCTION

The ability to generate contractile muscle activity, under the influence of neuromuscular electrical stimulation, has been known since the 18th century (Bax et al., 2005; Vanderthommen & Duchateau 2007; Kaçoğlu & Kale 2016). The number of research projects on the topic of electromyostimulation (EMS), as a significant factor in the development of different performances of athletes, has significantly increased in the last 30 years. During the last decade, local and global electrostimulation has been used as an adjunct method in many rehabilitation centers to strengthen the muscular system due to long immobilization (Lake, 1992). On the other hand, during the last couple of years EMS has become one of the most popular method for development of strength in healthy individuals, as well as in professional athletes (Maffiuletti et al., 2002; Malatesta et al., 2003; Taifour et al., 2013). Neuromuscular electrostimulation or EMS represents an artificial muscle stimulation with a well-defined protocol that is precisely designed to reduce discomfort during unnatural muscle activation (Seyri & Maffiuletti 2011). Local EMS is based on stimulation of one or two muscle groups, whereas global EMS emerged due to modernization of technology, which made it possible to connect multiple alternating current or two-phase current channels at the same time with the help of wireless electrical receivers that have a strong battery (Pano-Rodriquez et al., 2019). In comparison with the standard methods of training, EMS is different because it allows the creation of greater muscle contraction than naturally develope ones (Nosaka et al., 2011).

Research projects that have been conducted in the past 20 years have proven the EMS' positive effect on certain parameters of physical components, especially when it comes to lower limbs' muscles of amateur and recreational athletes (Kayvan & Maffiuletti, 2011). In the systematic review research

Filipović et al. (2011) aimed to find out what are the ideal conditions for more efficient application of EMS to the strength training, especially in sports. Pano-Rodriguez et al. (2019), by systematic analysis of 21 scientific study on the topic of the impact of global or whole body electrostimulation on health and physical performance, came to confirmation of the fact that EMS is a relatively unexplored topic, and therefore concluded that more analysis and research projects were necessary. However, no research project has aimed to examine the impact of EMS on athletes' vertical jumping performance.

Based on previous findings and the recommendations of previous researchers, the objective of this study was formed. It was based on a systematic review of large number of studies on the impact of EMS on vertical jumping performance of athletes. The objective is to obtain new information, as well as to expand already known conclusions.

METHODS

This research project has been conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines (Moher et al., 2009).

Search strategy and study selection

The following databases have been searched: Google Scholar, PubMed, Web of Science and Research Gate, by using all the available studies without time limit, but with a limitation to the English language. In accordance with the prescribed rules of every database, the following keywords, combined or individually, have been searched: “EMS”, “electromyostimulation”, “jump performance”, “athletes”, “physical performance”. The search strategy of using conjunctions “OR” and “AND” have also been used. The relevance of the titles and abstracts were checked, and only complete studies have been taken and have been considered for inclusion. In addition to all that has been said, review of all the references and collected studies was done, in order to reach greater number of studies on this topic.

In order to identify all the relevant studies, all the titles were reviewed by the author during the electronic searches. All the titles that were of topic were excluded. The initial review identified 415 potentially acceptable studies (the study selection process is shown in Diagram 1). Full texts of the remaining papers, which met the inclusion criteria, were involved in the procedure and reviewed by the authors in order to make the final decision on inclusion in the systematic review.

Inclusion and exclusion criteria

For the selection of studies which were going to be included in the final analysis, the following inclusion criteria were defined: (1) original scientific studies, (2) studies based on longitudinal design, (3) studies written exclusively in English, (4) sample of respondents- active athletes, (5) duration of experimental treatments for at least 14 days, (6) experimental treatment conducted using local or global electromyostimulation, (7) a minimum of two groups of respondents (1 experimental - 1 control or 2 or more experimental groups), (8) monitored variables: squat jump (SJ), countermovement jump (CMJ), drop jump (DJ), Abalakov jump (AJ).

Other studies were excluded on the basis of the following criteria: (1) studies based on transversal design, (2) studies written in non-English language, (3) inadequate sample of respondents (non-athletes, obese, older than 45 years, etc.), (4) studies with a lack of a control group or other experimental group, (5) experimental treatment lasted less than 14 days, (6) studies in which the method of electrical stimulation was not used, (7) studies in which the results are not adequately presented or the parameters required for further analysis were missing, (8) studies where testing was conducted on animals, (9) case study scientific papers.

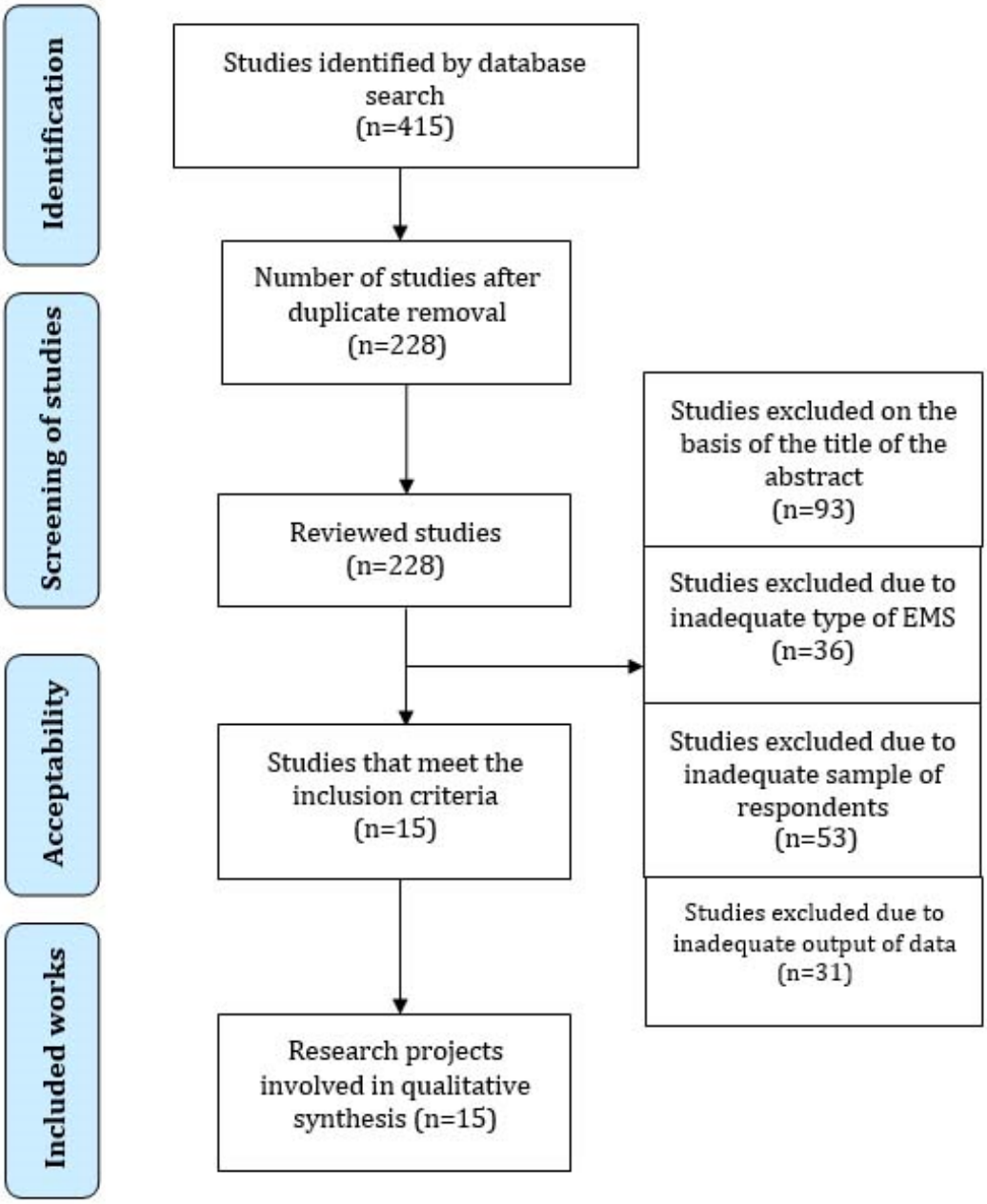

Diagram 1. Schematic representation of the studies search strategy

Data extraction

The collected research projects used for this paper are shown in Table 1. For each research the following parameters are shown: (1) study characteristics including author(s) and year of publication, (2) information about respondents such as sample size, gender, age, number of groups and sports they play, (3) a description of the experimental procedure, which includes the type of electromyostimulation, training conditions, duration and the protocol of the program, (4) monitored variables and (5) obtained results of the study.

Author (Year)	Sample size		Intervantion			Results			
	N	*Gender, years groups, sport*	*Type of EMS*	*Program duration*	*Program protocol (contraction; rest; frequency; intensity)*	*SJ*	*CMJ*	*DJ*	*AJ*
Willoughby & Simpson (1998)	20	F=20 20±1.9 TG (n=5) EG (n=5) E+TG (n=5) CON (n=5) athletics	Local (knee extensors)	6 w 18 t	Dynatron 500 (-; -; 50 Hz; -;) + weight training	/	TG: ↑; EG: ↑; E+TG: 9.54±1.73 cm↑* CON: ↑	/	/
Maffiuletti et al. (2000)	20	M=20 24.7±3.9 EG (n=10) CON (n=10) basketball	Local (knee extensors)	4 w 12 t	16min (3s; 17s; 100 Hz/400 ms; 0-100mA) + basketball training	EG: 14%↑**; CON:→	EG:→; CON:→	/	/
Maffiuletti et al. (2002)	20	M=20 21.8±2.8 година E/PG (n=10) CON (n=10) volleyball	Local (knee extensors, plantar flexors)	4 w 12 t	~80 min (3s; 17s; 115–120 Hz/400 ms; 0-120mA) + plyometric jumps)	E/PG:~21%↑**; CON: ↑	E/PG:~13%↑**; CON:→	E/PG:~12.5%↑ **; CON:↑	/
Brocherie et al. (2004)	17	M=17 22.6±4.5 EG (n=9) CON (n=8) hockey	Local (knee extensors)	3 w 3 t	12 min (4 s; 20 s; 85 Hz/250 ms)	EG: 8.4±6.9%↓*; CON: ↓	EG: 6.1±6.0%↓*; CON: ↓	EG: 5.2±4.6%↓*; CON: ↓	/
Herrero et al. (2005)	40	M=40 EG (n=10) (19.4±0.4) PG (n=9) (20.8±0.6) E/PG (n=10) (21.4±0.9)	Local (knee extensors)	4 w 16 t	~34min (3 s; 30 s; 120 Hz/400 ms; 0-120 mA) + plyometria	EG: ↑; PG: ↓; E/PG: 7.5%↑*; CON: →	EG: →; PG:↑ ; E/PG: 6.7%↑*; CON: →	/	/

		CON (n=10) (20.6±0.6) athletes							
Babault et al. (2007)	25	M=25 22±1 EG (n=15) CON (n=10) rugby	Local (knee extensors, plantar flexors, glute muscles)	12 w 24 t (6x3, 6x1)	~36 min (5 s; 15 s; 100 Hz/400 ms; 0-100 mA) + rugby training	EG: 11.8±9.9%↑***; CON: ↑	EG: ↑; CON: ↑	EG: 7.6±5.7%↑*; CON: ↑	/
Billot et al. (2010)	20	M=20 EG (n=10) (20.1±2.1) CON (n=10) (21.7±3.4) football	Local (knee extensors)	5 w 15 t	12 min (3 s; 17 s; 100 Hz/400 ms; 60-120 mA) + football training	EG:↑ CON:↓	EG: 6.7±6.3%↑*; CON:↓	/	/
Marqueste et al. (2010)	15	F=15 20.6±1.3 EGBF (n=5) EGVL (n=5) CON (n=5) volleyball	Local (knee extensors)	4 w 10 t	30 min (11 s; 19 s; 4-75 Hz/400 ms) + volleyball training	EGBF: 16.4±2.4%↑*; EGVL: 26.9±3.8%↑*; CON: ↑	EGBF: 30.2±2.1%↑*; EGVL: 23±4.2%↑*; CON: 6.9±3.8%↑*	/	/
Benito-Martinez et al. (2011)	78	M=40, F=38 E/PG (n=20) (17.65±1.47) P/EG (n=19) (16.16±1.72) E+PG (n=19) (17.7±1.49) CON (n=20) (17.05±1.47) athletics	Local (knee extensors)	8 w 16 t	12 min (3 s; 17 s; average 26.39±7.11 mA) + plyometric jumps	/	/	/	E/PG: 13.51%↑***; P/EG: 1.23%↑*; E+PG: ↑ CON: 3.57%↑**;

Deley et al. (2011)	16	F=16 (12.4±1.2) EG (n=8) CON (n=8) gymnastics	Local (knee extensors)	6 w 18 t	20 min (4 s; 20 s; 75 Hz/400 ms 65-120 mA) + gymnastics training	EG: 20.9±8.3%↑*; CON: ↑	EG: 10.1±10.0%↑*; CON: ↑	/	/
Martinez-Lopez et al. (2012)	98	M=51, F=47 E+PG (n=27) (17.7±1.3) E/PG (n=23) (18.2±1.4) BOTH (n=24) (18.1±1.5) CON (n=24) (18.0±1.6) athletics	Local (knee extensors)	8 w 16 t	12 min (3 s; 12 s; 85-150 Hz/350 ms; average 25.22±7.21 mA) + plyometria	E+PG: 28.02%↑***; EG/P: 8.93%↑**; BOTH: ↑; CON: ↑;	E+PG: 13.67%↑**; EG/P: ↑; BOTH: ↑; CON: ↑;	E+PG: 4.08%↑**; EG/P: ↑; BOTH: ↑; CON: ↑;	/
Amaro-Gahete et al. (2016)	12	M=12 EG (n=6) (27.0±7.5) CON (n=6) (27.0±6.1) athletes	Global	6 w 6 t	<20 min (12-90 Hz/350 ms) + running	/	EG: 0.33±0.06 m↑*; CON: →	/	EG: 0.38±0.06 m↑*; CON: →
Filipović et al. (2016)	22	M=22 EG (n=12) (24.9±3.6) CON (n=10) (26.4±3.2) football	Global	14 w 28 t	15 min (4 s; 10 s; 80 Hz/350 ms; -) + football training	EG: 35.9 cm↑*; CON: ↑	EG:~40 cm↑*; CON: ↑	EG: ↑**; CON: ↑	/
Wirtz et al. (2016)	20	M=20 E+TG (n=10) (22.1±1.9) CON (n=10) (21.9±1.6) athletes	Local (trunk & leg muscles)	6 w 12 t	(5 s; 1 s; 85 Hz/350 ms; 0-120 mA) + squats (4x10)	E+TG: 37.6±5.2 cm↑*; CON: 40.3±5.8 cm↑*	E+TG: 41.1±4.4 cm↑* CON: 43.0±5.3 cm↑*	/	/

Dörmann et al. (2019)	22	F=22 20.5±2.3 EG (n=11) CON (n=11) athletes	Global	4 w 8 t	45 min (85 Hz/350 ms; 0–120 mA) + jumping exercises	EG: ↑; CON: ↑	EG: 5.6%↑*; CON: 5.0↑*	EG: 11.6%↑*; CON: 11.7%↑*	/

Legend: **N**- number of participants; **EMS**- electromyostimulation; **n**- subsample; **SJ**- squat jump; **CMJ**- Countermovement jump; **DJ**- Drop jump; **AJ**- Abalakov jump; **M**- Male; **F**- Female; **w**- week; **t**- training; **CON**- control group (without intervantion); **TG**- weight training group; **EG**- electromyostimulation group; **E+TG**- combination of electromyostimulation and weight training group; **PG**- plyometric training group; **E/PG**- electromyostimulation before plyometric training group; **P/EG**- plyometric training before electromyostimulation group; **EGBF**- electromyostimulation of biceps femoris group; **EGVL**- electromyostimulation of vastus lateralis group; **E+PG**- combination of electromyostimulation and plyometric training group; **BOTH**- both trainings.

Note: → without change; ↑ progress without significance; ↑* $p<0.05$; ↑** $p<0.01$; ↑*** $p<0.001$

RESULTS

The selection of studies

By searching various electronic databases, 415 relevant studies were identified in total. After removing the duplicates, 228 studies remained. Based on titles and abstracts, 93 studies were excluded. Because of the inadequate types of EMS, 36 studies were excluded, while 7 studies were excluded on the basis of inadequate number of respondents. Finally, due to inadequate data output, 97 studies were excluded from further analysis. Fourteen studies met clearly defined inclusion criteria and have been included in the final systematic review research.

Characteristics of the studies

All of the included studies were published in English before June 2020. The total sample size was 445 respondents, of which 158 females and 287 males. Nine studies were based on examining only the male gender (Maffiuletti et al., 2000; Maffiuletti et al., 2002; Brocherie et al., 2004; Herrero et al., 2005; Babault et al., 2007; Billot et al., 2010; Amaro-Gahete et al., 2016; Filipović et al., 2016; Wirtz et al., 2016), four studies included female respondents (Willoughby et al., 1998; Marqueste et al., 2010; Deley et al., 2011; Dörmann et al., 2019), while two studies included respondents of both genders (Benito-Martinez et al., 2011; Martinez-Lopez et al., 2012). The age of the respondents ranged on average from 16.16±1.72 to 27.0±7.5 years of age. One study examined the impact of EMS on physical performance of basketball players (Maffiuletti et al., 2000), hockey players (Brocherie et al. 2004), rugby players (Babault et al., 2007) and female gymnasts (Deley et al., 2011), while two studies examined this impact on football players (Billot et al., 2010; Filipović et al., 2013) and volleyball players (Maffiuletti et al., 2002; Marqueste et al., 2010). Four studies used athletes of different orientations as a sample of respondents (Herrero et al., 2005; Amaro-Gahete et al., 2016; Wirtz et al., 2016; Dörmann et al., 2019). The duration of the experimental program was from three weeks and three trainings, (Brocherie et al., 2004) up to 14 weeks and 28 training sessions (Filipović et al., 2016). In three studies (Filipović et al., 2016; Amaro-Gahete et al., 2016; Dörmann et al., 2019) the impact of global EMS was examined, while all the other studies examined the impact of EMS on the lower extremities.

The longest single EMS, of approximately 80 minutes, appeared in the study of Maffiuletti et al. (2002), while the shortest session lasted 12 minutes (Brocherie et al., 2004; Billot et al., 2010; Benito-Martinez et al., 2011; Martinez-Lopez et al., 2012). The lowest frequency was used in the study of Marqueste et al. (2010) and it was 4-75 Hz which lasted 400 ms, while the highest was 150 Hz and which lasted 350 ms (Martinez-Lopez et al., 2012). If the load intensity is observed, the average was 0-120 mA (miliAmpers) in all researches. In most studies, the contraction period lasted three seconds, with a break of 17-20 seconds. However, the longest contraction period was five seconds, with a one-second break (Wirtz et al., 2016). If the load intensity is observed, the average was 0-120 mA in all of the studies. In most studies, the contraction period lasted 3 seconds, with a break of 17-20 seconds.

All of the selected papers aimed to examine the statistical significance ($p<0.05$, $p<0.01$ and $p<0.001$) of the influence of local and global EMS on the vertical jumping performance of athletes, with the help of, in total four monitored variables: SJ, CMJ, DJ and AJ. The number of monitored variables, by study, ranged from one (Willoughby & Simpson 1998; Benito-Martinez et al., 2011) to three (Maffiuletti et al., 2002; Brocherie et al., 2004; Babault et al., 2007; Martinez-Lopez et al., 2012; Filipović et al., 2016; Dörmann et al., 2019).

The results of the studies

Observing the objectives of individual studies, in 13 papers the influence of EMS was examined with the help of the monitored variable SJ (Maffiuletti et al., 2000; Maffiuletti et al., 2002; Brocherie et al., 2004; Herrero et al., 2005; Babault et al., 2007; Billot et al., 2010; Marqueste et al., 2010; Deley et al., 2011; Martinez-Lopez et al., 2012; Filipović et al., 2016; Wirtz et al., 2016; Dörmann et al., 2019). The positive impact of this method is evident in all the studies, except for one, where there was a statistically significant deterioration of the results at the final measurement (Brocherie et al., 2004). However, a statistically significant progress of one of the groups was found in ten studies (Maffiuletti et al., 2000; Maffiuletti et al., 2002; Brocherie et al., 2004; Herrero et al., 2005; Babault et al., 2007; Marqueste et al., 2010; Deley et al., 2011; Martinez-Lopez et al., 2012; Filipović et al., 2016; Wirtz et al., 2016). The largest statistically significant progress of as much as 28% ($p<0.001$) appeared in the study Martinez-Lopez et al. (2012), in a group that applied EMS at the same time as plyometric training. Changes in vertical jumping

performance, with the help of CMJ test, were monitored in 14 studies included in this systematic review. This variable was not monitored only in the work of Benito-Martinez et al. (2011). Observing statistically significant differences, the negative impact of EMS also appeared in the work of Brocherie et al. (2004) where the test was performed on a sample of hockey players, and the results showed a deterioration of 6.1±6.0% ($p<0.05$). Changes were not found in one study out of total 14 studies included in the systematic review (Maffiuletti et al., 2000), 10 studies found positive statistical impact at the level of significance $p<0.05$, while the largest and most significant statistical progress of 13.67% ($p<0.01$) was presented in Martinez-Lopez et al. (2012).

Statistically significant progress in respondents occurred in five out of six studies that aimed to examine the effect of EMS on vertical jumping performance measured by DJ test (Maffiuletti et al., 2002; Babault et al., 2007; Martinez-Lopez et al., 2012; Filipović et al., 2016; Dörmann et al., 2019). In the study of Brocherie et al. (2004), hockey players who in addition to regular training were connected to the electrostimulation treatment of the neuromuscular system, showed statistically worse results than 5.2±4.6% ($p<0.05$). Maffiuletti et al. (2002) got the statistically best progress of nearly 12.5% ($p<0.01$).

The smallest number of the included studies, a total of two, aimed to examine the impact of EMS on explosive strength, such as vertical jumping, using the AJ test (Benito-Martinez et al., 2011; Amaro-Gahete et al., 2016). The results obtained from these studies indicated a statistically significant progress of the entire sample of respondents. In Benito-Martinez et al. (2011), the group that underwent EMS treatment prior to plyometric training, obtained the highest improvement of 13.51% ($p<0.001$). On the other hand, the group that was included in the treatment of neuromuscular electrostimulation after plyometric training, showed an improvement of 1.23% ($p<0.05$). Global EMS, used in the work of Amaro-Gahete et al. (2016), led to a statistically significant progress of the experimental group (0.38±0.06 m, $p<0.05$).

DISCUSSION

The objective of this systematic review study was to determine the impact of local or global EMS on explosive strength, such as vertical jumping in athletes. Given that this method has become very popular in recent years, it was necessary to do additional systematic review of the so far findings in order to clarify the present one and obtain some new conclusions about the impact of this type of treatment on athletes' performance, such as vertical jump.

Although the field of research related to neuromuscular electrostimulation is a relatively young and unexplored area, the number of research studies engaged in examining the impact of this treatment on some physical performance of athletes does not stop growing. Even though it is very effective this training method can also have negative consequences if used incorrectly. In this regard, a guide for timely and appropriate use has been developed (Allen & Goodman 2014; Kemmler et al., 2016).

By observing the most commonly monitored vertical jumping variables in this systematic review study, where a better percentage of progress of the experimental groups over the control ones is evident (Maffiuletti et al., 2002; Herrero et al., 2005; Billot et al., 2010; Marqueste et al., 2010; Deley et al., 2011; Martinez- Lopez et al., 2012; Dörmann et al., 2019), it was difficult to compare the obtained mean values of individual studies, because there are different program protocols. When it comes to the remaining seven studies, four indicated statistically significant progress in the results obtained by at least one group (Willoughby et al., 1998; Filipović et al., 2013; Amaro-Gahete et al., 2016; Wirtz et al., 2016), two did not show statistically significant changes (Maffiuletti et al., 2000; Babault et al., 2007), while in a study by Brocherie et al. (2004) the achievements of the respondents worsened in comparison to the initial measurement by 6.1±6.0% after the implemented program.

The second modality of vertical jumping which appears the most in this study is SJ, where a percentage of statistically significant progress of at least one experimental group, appeared in eight studies (Maffiuletti et al., 2000; Maffiuletti et al., 2002; Brocherie et al., 2004; Herrero et al., 2005; Babault et al., 2007; Marqueste et al., 2010; Deley et al., 2011; Martinez-Lopez et al., 2012), in the range from 7.5% to 28.02%. The authors of two studies presented the statistically significant progress of their respondents in centimeters (Filipović et al., 2016; Wirtz et al., 2016), in two studies there was no statistically significant change (Billot et al., 2010; Dörmann et al., 2019), and only one study showed a negative impact on this monitored variable, which is 8.4±6.9% in the experimental group (Brocherie et al., 2004).

The progress of the respondents in the monitored variable DJ was examined in six studies and only one study indicated a negative impact of electromyostimulation (Martinez-Lopez et al., 2012). Although some authors have argued that EMS is more dominant and effective than classical strength training, most studies in this systematic review have shown that an appropriate combination of EMS treatment with additional training brings better improvements in jump height (Maffiuletti et al., 2002; Babault et al., 2007; Martinez-Lopez et al., 2012; Filipović et al., 2016; Dörmann et al., 2019). The authors of two papers

(Benito-Martinez et al., 2011; Amaro-Gahete et al., 2016) indicated a positive effect of EMS treatment, when combined with an additional exercise program, on the jump height, performed by the AJ procedure. Benito-Martinez et al. (2011) used a combination of 12-minute EMS, and a plyometric training of athletes discovered great improvements in each group of respondents. The greatest progress occurred in 15th group that was connected to local EMS treatment before plyometric jumps (13.51%).

It is an obvious fact that the local or global EMS, with a specially programmed training, had a positive effect on the vertical jumping of athletes in most studies. However, Brocherie et al. (2004) found a negative effect on their sample of hockey players in all monitored variables. The reason for this result can be seen in the characteristics of the sport. Compared to other research projects included in this systematic review, where the sample of respondents consisted of basketball, volleyball and football players, whose specific movement is jumping, hockey players are not trained for jumping, and they encountered the "unknown". Given that such research is mainly conducted on healthy individuals, it is concluded that the conclusions reached should be taken with a dose of skepticism. Based on this, it can be concluded that the choice of frequency in some of the included studies is not recommended for every sample of respondents. Such study limitation leads us to the fact that properly determined load intensity and frequency is one of the key factors. In this regard, in their systematic review, Filipovic et al. (2011) stated that there is a large correlation between the intensity and effects of EMS. Although most devices provide an average frequency of 85 Hz, Filipovic et al. (2012) concluded with their research that a frequency of 50 Hz is sufficient for the strength development. Thus, it is necessary to lower the frequency, since its increase also leads to faster muscle fatigue (Gregory et al., 2007). Another limitation of this study are the differences in the protocols used. Therefore, the program protocol, type and parameters of EMS, as well as the monitored variables, should be precisely defined in order to avoid heterogeneous results, which would certainly facilitate comparisons between individual research projects.

CONCLUSION

After analyzing all of the selected studies it can be conclude that EMS had a positive effect on the development of vertical jumping performance of all of the respondents in experimental groups, especially in the groups that used EMS in the correct combination with additional training. Based on the reviewed studies and analysis of the obtained results, it has been proven that the treatment of electromyostimulation is more efficient strategy to improve explosive strength and type of jumping of athletes. However, the selection of respondents, the selection of program protocols, types and more clearly defined parameters of EMS are also of great importance. In addition to all mentioned above, it is necessary to try to find greater number of studies on a similar topic, in order to get additional knowledge and new conclusions, which in the period to come, researchers, as well as experts in the field of sports and rehabilitation, could use for additional education.

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THE INFLUENCE OF MORPHOLOGICAL CHARACTERISTICS AND BODY COMPOSITION ON STRENGTH PARAMETERS OF PHYSICALLY ACTIVE WOMEN IN FITNESS

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ABSTRACT

Morphological characteristics and body composition, to a greater or lesser extent, can influence certain anthropological characteristics and abilities. The aim of the research study was to determine whether there is any influence of the morphological characteristics and body composition on strength parameters in physically active women in fitness. The sample consisted of 94 female subjects of average age 32.8±10.6 years, who are physically active and engaged in fitness. A set of 21 measures was used for the assessment of morphological characteristics (14) and of body composition (7) which was determined by the indirect method, i.e. by using bioelectric impedance (InBody 720). Strength assessment was determined using countermovement jump and squat jump. Data processing was performed by SPSS 20.0. Regression analysis was applied to determine the influence of the morphological characteristics and body composition on strength parameters. The obtained results have shown that there is a statistically significant influence of the morphological characteristics on strength parameters (p=.000), as well as body composition (p=.000).

Keywords: fitness, strength, body composition, morphological characteristics, women

INTRODUCTION

The strength of sport lies in its ability to motivate, move the individuals and the masses. Therefore, it is possible to understand that taking part in physical exercise is mostly motivated by competing with oneself and that physical exercise helps oneself and those who need help (Живановић, Станковић, Ранђеловић, Павловић, 2010).

The term "fit" in a narrower sense, is a term that refers to the coordinated action of different human abilities and body composition during physical activity with a certain degree of nervous muscle tension (Костић, 2009).

Body composition is made up of the relative values of muscle, fat, bone, and other anatomical components that contribute to a person's overall body weight (Solway, 2013). Body composition is a special component of fitness. Many people start exercising just because of their body composition. To use exercise to control body weight, as an indicator of body composition, it is important to know the physical activities, health, and abilities of the person. There are numerous methods for determining body composition, the most common being BMI, anthropometric measurements, skin folds, hip and waist ratio (Росић, Станишић-Стојић, 2012).

One of the modern concepts of understanding physical activity and exercise is fitness. Both as a term, but also as something self-evident, "fitness" is more and more present and popular. Fitness includes exercise in the gym and aerobics and proper nutrition - in a word, fitness is a way of living, which is usually understood as being healthy. The health effect of fitness is associated with increased physical activity. By doing fitness, a person reaches the world of new feelings, positive emotions, good mood, and increases in energy. The word fitness itself exists without translation in many languages and has become very popular. This term came from an English expression "to be fit" - to be in shape. Most people would

answer without thinking that fitness primarily means performing physical exercises with the goal of losing weight. Statistically, the largest number of people starts exercising having in mind that goal. However, the term fitness has acquired a much broader content and represents a life concept, an active lifestyle that includes various physical activities and proper nutrition, and for some people, it represents a life motto (Живановић, Станковић, Ранђеловић, Павловић, 2010). Muscle strength as an integral part of fitness is nothing but the ability of muscles to work against resistance and is achieved by gradually increasing the load when conducting resistance training (weight training). The structure of the body composition, above all, refers to the distribution of muscles and fats in the body. Determining body composition plays a significant role in sports and health. Excessive body fat can lead to obesity, which increases the risk of other diseases. Excess fat in sports affects performance and interferes with the production of muscle strength because extra weight requires extra energy to move. There are numerous methods for determining body composition: body mass index (BMI), anthropometric measurements, skin folds, waist and hip ratio (Костић, 2009).

Morphological characteristics are a set of characteristics that make up the constitution, body composition, and structure. Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec (1975) formed a model of the latent structure of morphological characteristics that contains four dimensions: longitudinal, transversal, circular dimensionality and body mass as well as subcutaneous adipose tissue dimension.

The research was conducted to determine whether there is an influence of body composition and morphological characteristics on strength parameters in the physically active women.

METHODS

Subjects

The research was conducted on a sample of 94 respondents, who were engaged in fitness, aged 18 to 60 years. The training status of these respondents was over a year. Each respondent was included in the research, where at the time of the examination each was healthy and each voluntarily agreed to participate in the research.

Procedure

For the assessment of morphological characteristics the following sample of anthropometric tests were used: AVIST– Body height; TMAS– Body mass; AONAD– Upper arm volume; AOGRK– Chest circumference; AOSTR– Waist circumference; AOTRB– Abdomenon circumference; AOKUK– Hip circumference; AOBUT– Thigh circumference; AOPOT– Lower leg volume; KNNAD– Upper arm skin fold; KNLE– Back skin fold; KNTRB– Abdomenon skin fold; KNBUT– Thigh skin fold; KNPOT– Lower leg skin fold. The latest generation InBody 720 was used for the aasessment of following body composition parameters: Body_Fat_Mass (*BFM*), Soft_Lean_Mass (*SLM*), Fat_Free_Mass (*FFM*), Skeletal_Muslce_Mass - in kg (SMM), Body_Mass_Index (BMI), Percent_Body_Fat (%PBF), Percent_Skeletal_Muscle_Mass (%*PSMM*). The strength assessment tests used were CMJ- Counter Movement Jump and SJ- Squat Jump (Sudarov & Fratrić, 2010).

Statistical analysis

Descriptive and regressive statistical data processing were performed. All obtained data were processed in the statistical program Statistica 6.0. For all variables, the basic parameters of descriptive statistics were calculated: Mean-arithmetic mean, SD-standard deviation, Max-maximum result, Min-minimum result, Range-range, Skewness-curvature coefficient and Kurtosis-roundness coefficient. Regression analysis was also used to determine the system of variables, and the following statistical parameters were calculated: multiple correlation coefficient (R), determination coefficient (R^2), F-test result (F) and statistical significance (Sig). To determine the influence of each individual variable in the regression analysis, the following were calculated: standardized partial regression coefficients (Beta), T-test results (t) and statistical significance (Sig). A significance level of up to 0.05 ($p \leq 0.05$) was used for statistical significance setting.

RESULTS

Table 1. Basic statistical indicators of morphological characteristics

	N	*Mean*	*SD*	*Min*	*Max*	*Range*	*Skewness*	*Kurtosis*
Age	94	32.80	10.67	13.00	63.00	50.00	.520	.035
Body_height	94	166.95	6.37	154.00	185.00	31.00	.238	-.056
Body_mass	93	66.12	9.28	50.00	101.00	51.00	1.135	2.165
Upper_arm_volume	93	26.66	2.63	21.60	35.90	14.30	.447	.867
Chest_circumference	93	88.36	7.80	76.60	117.50	40.90	1.398	2.495
Waist_circumference	93	72.89	8.82	57.50	117.00	59.50	2.075	7.002
Abdomenon_circumference	93	82.45	8.99	69.00	118.50	49.50	1.382	2.836
Hip_circumference	93	96.16	8.85	75.80	131.00	55.20	.518	2.103
Thigh_circumference	92	55.73	5.64	45.00	75.00	30.00	.797	.508
Lower_leg_volume	92	36.23	2.96	28.00	47.00	19.00	.497	1.834
Upper_arm_skinfold	94	20.33	5.35	6.20	35.80	29.60	.158	-.039
Back_skinfold	94	15.85	6.63	7.40	37.60	30.20	1.305	1.574
Abdomenon_skinfold	94	22.92	9.00	7.00	41.20	34.20	.231	-.843
Thigh_skinfold	94	28.21	8.37	12.00	46.20	34.20	.291	-1.007
Lower_leg_skinfold	94	22.00	6.53	8.20	37.20	29.00	.308	-.518

Legend: Mean- average value, **SD-** standard deviation, **Min-** minimum value, **Max–** maximum value, **Range-** range of results, **Skewness-** coefficient of curvature, **Kurtosis-** coefficient of roundness

Table 1 shows the basic descriptive statistical parameters of 14 features of morphological characteristics. The obtained results show that there are no significant deviations of the results from the normal distribution, except for the variable waist circumference (2.075), which deviates from the normal distribution. The results of the roundness coefficient are below the normal value of the distribution, which makes the distribution platicurtic.

Table 2. Basic statistical indicators of body composition

	N	*Mean*	*SD*	*Min*	*Max*	*Range*	*Skewness*	*Kurtosis*
Body_Fat_Mass	94	27.39	7.31	11.20	51.40	40.20	.244	.574
Soft_Lean_Mass	94	35.24	6.80	24.20	49.40	25.20	.501	-.895
Fat_Free_Mass	94	38.53	6.47	27.60	52.50	24.90	.525	-.664
Skeletal_Muslce_Mass	94	23.52	2.64	19.00	31.90	12.90	.754	.105
Percent_Body_Fat	94	36.72	6.73	20.80	54.60	33.80	.140	-.010
Percent_Skeletal_Muscle_Mass	94	35.89	3.61	27.01	48.04	21.03	.463	.833

Legend: Mean- average value, **SD-** standard deviation, **Min-** minimum value, **Max–** maximum value, **Range-** range of results, **Skewness-** coefficient of curvature, **Kurtosis-** coefficient of roundness

Table 2 shows the basic descriptive statistical parameters of body composition. The obtained values show that there are no significant deviations of the results from the normal distribution. The results of the rounding coefficient are below the normal value of the distribution, which makes the distribution platicurtic.

Table 3. Descriptive statistics of power parameters

	N	*Mean*	*Std. Dev*	*Min*	*Max*	*Range*	*Skewness*	*Kurtosis*
CMJ	94	0.16	0.04	0.08	0.30	0.22	.580	.066
SJ	94	0.16	0.04	0.10	0.28	0.18	.613	-.426

Legend: Mean- average value, **SD-** standard deviation, **Min-** minimum value, **Max–** maximum value, **Range-** range of results, **Skewness-** coefficient of curvature, **Kurtosis-** coefficient of roundness, **CMJ-** Counter Movement Jump, **SJ-** Squat Jump

Table 3 shows the results of descriptive statistics of power parameters- CMJ and SJ tests from the measurements of samples of 94 respondents. The curvature coefficients are below the normal value of 1.00 and show the normal distribution, and the curvature coefficient values show the platicuric distribution.

Table 4. Significance of multiple correlation results and coefficient of determination of anthropometry regression analysis - CMJ

Model	***R***	***R²***	***F***	***Sig.***
1	.711[a]	.506	5.623	.000

Legend: R- multiple correlation coefficient, **R²-** determination coefficient, **F-** F, test, **Sig.-** significance

In Table 4, based on the significance (Sig.= .000) and the percentage explanation of this influence of about 51% (R^2=.506), it can be stated that changes in the variables from the regression model cause significant changes in the value of the dependent variable. The remaining 49% can be attributed to other influences.

Table 5. Significance and t-test regression analysis (*CMJ*)

Coefficients[a]			
Model		**t**	**Sig.**
	Body_height	.629	.531
	Body_mass	1.114	.269
	Upper_arm_volume	-.551	.583
	Chest_circumference	.837	.405
	Waist_circumference	-1.178	.243
	Abdomenon_circumference	.193	.847
	Hip_circumference	-.636	.527
	Thigh_circumference	.507	.614
	Lower_leg_volume	.122	.904
	Upper_arm_skinfold	.231	.818
	Back_skinfold	-.725	.471
	Abdomenon_skinfold	1.169	.246
	Thigh_skinfold	-2.937	**.004**
	Lower_leg_skinfold	-3.868	**.000**

Legend: t- t-test, **Sig.-** significance

Table 5 shows the results of regression analysis of anthropometry of CMJ parameter 14 features of morphological characteristics. Based on the analysis of the regression coefficient and its significance obtained from the t-test value, it can be concluded that all variables affect the test performance, and that individually, the largest projections on the criterion have predictor variables for assessing skin fold of thigh and skin fold of lower leg.

Table 6. Significance of multiple correlation results and coefficient of determination of anthropometry regression analysis – SJ

Model	***R***	***R²***	***F***	***Sig.***
1	.641[a]	.411	3.942	.000

Legend: R- multiple correlation coefficient, **R²-** determination coefficient, **F-** F, test, **Sig.-** significance

In Table 6, based on the significance (Sig.= .000) and the percentage explanation of this influence of 41% (R^2 .411), it can be stated that changes in the variables from the regression model cause significant changes in the value of the dependent variable. The remaining 59% can be attributed to other influences.

Table 7. Significance of t-test regression analysis (*SJ*)

Coefficientsa			
Model		t	Sig.
	Body_height	.936	.352
	Body_mass	.517	.606
	Upper_arm_volume	-.434	.665
	Chest_circumference	.945	.348
	Waist_circumference	.575	.567
	Abdomenon_circumference	.467	.642
	Hip_circumference	-.622	.536
	Thigh_circumference	-.988	.326
	Lower_leg_volume	.256	.798
	Upper_arm_skinfold	-.203	.840
	Back_skinfold	-.498	.620
	Abdomenon_skinfold	.255	.800
	Thigh_skinfold	-1.292	**.200**
	Lower_leg_skinfold	-2.273	.026

Legend: t- t-test, **Sig.-** significance

Table 7 shows the results of regression analysis of anthropometry and SJ of 14 features of morphological characteristics. Based on the analysis of the regression coefficient and its significance obtained from the value of the t-test, it can be concluded that all variables affect the performance of the test, and that individually, the largest projections on the criterion are variables for estimating thigh skin fold.

Table 8. Significance of multiple correlation results and coefficient of determination of regression analysis of body composition – *CMJ*

Model	***R***	***R²***	***F***	***Sig.***
1	.508[a]	.258	4.266	.000 [b]

Legend: R- multiple correlation coefficient, **R²-** determination coefficient, **F-** F, test, **Sig.-** significance

In Table 8, based on the significance (Sig.= .000) and the percentage explanation of that influence of 26% (R^2=.258), it can be stated that changes in the variables from the regression model cause significant changes in the value of the dependent variable. The remaining 74% can be attributed to other influences.

Table 9. Significance of t-test (CMJ) regression analysis

Coefficients[a]			
Model		t	Sig.
	Body_Fat_Mass	.624	.534
	Soft_Lean_Mass	-2.637	**.010**
	Fat_Free_Mass	1.112	.269
	Skeletal_Muslce_Mass	2.239	**.028**
	Body_Mass_Index	.115	.909
	Percent_Body_Fat	-3.629	**.000**
	Percent_Skeletal_Muscle_Mass	-2.779	**.007**

Legend: t- t-test, **Sig.-** significance

Table 9 shows the results of the analysis of body composition and CMJ test of 7 variables from the measurement of a sample of 94 subjects. Based on the analysis of the regression coefficient and its significance obtained from the value of the t-test, it can be concluded that all variables affect the test performance, and that individually, the largest projections on the criteria have variables to estimate: net lean mass (SLM) Sig.= .010 , muscle mass (SMM) Sig.= .028, body fat (PBF) Sig.= .000 and percentage of muscle mass (% PSMM) Sig.= .007, but also that in the results of the t-test we can see negative coefficients in the tests: (SLM) t= -2,637, (PBF) t= -3,629 and (% PSMM) t= -2,779 and therefore they have the most negative impact on performance.

Table 10. Significance of multiple correlation results and coefficient of determination of regression analysis of body composition –*SJ*

Model	*R*	*R²*	*F*	*Sig.*
1	.578[a]	.334	6.171	.000 [b]

Legend: R- multiple correlation coefficient, **R²-** determination coefficient, **F-** F, test, **Sig.-** significance

In Table 10, based on the significance (Sig.= .000) and the percentage explanation of this influence of 35% (R^2= .334), it can be stated that changes in the variables from the regression model cause significant changes in the value of the dependent variable. The remaining 65% can be attributed to other influences.

Table 11. Regression analysis of body composition – *SJ*

Coefficients[a]		
Model	**t**	**Sig.**
Body_Fat_Mass	.388	.699
Soft_Lean_Mass	-.779	.438
Fat_Free_Mass	-1.033	.305
Skeletal_Muslce_Mass	2.253	**.027**
Body_Mass_Index	.908	.366
Percent_Body_Fat	-3.718	**.000**
Percent_Skeletal_Muscle_Mass	-.680	.498

Legend: t- t-test, **Sig.-** significance

Table 11 shows the results of the analysis of the body composition of the SJ test of seven variables from the measurement of a sample of 94 subjects. Based on the analysis of the regression coefficient and its significance obtained from the t-test value, it can be concluded that all variables affect the test performance, and that individually, the largest projections on the criteria have variables to assess: muscle mass (SMM) Sig.= .027 and body fat (PBF) Sig.= .000, but that with the variable (PBF) in the t-test we have a negative result PBF> t= -3.718, which proves that increasing the percentage of body fat negatively affects the performance of this test.

DISCUSSION AND CONCLUSION

The results of this research could serve as a model for further research and obtaining answers to questions that this research did not cover. This also applies to the selection of tests that seek to influence the morphological characteristics of strength parameters in women. The results will also be able to serve as a choice of sport or direction in which women should go to achieve the desired results.

The influence of measuring instruments of morphological characteristics on power estimation was determined by regression analysis. The values of the regression analysis indicate a significant influence of the applied body volume variables on the strength results. From the structure of morphological characteristics, it can be seen that CMJ and SJ have a statistically significant effect on anthropometric measures of the skinfold of the thigh and the skinfold of the lower leg.

When comparing the results in the research, we found that according to the indicators of regression analysis from previous research, it was determined that the results in body composition tests depend on the applied parameters of morphological characteristics. First, the higher the fat mass, the higher the total body mass, so the respondent achieves a higher result on the strength test. Secondly, less fat probably goes together with better physical condition and better preparation, so the result on the strength test is better, which is confirmed by the research of Stamenković et al. (2020). The best results related to weight loss were obtained in studies that combined restrictive diet and optimal exercise (Wood, Stefanick, Drion, et al., 1988; Wood, Stefanick, Williams, & Haskell, 1991; Bouchard, Despres, & Tremblay, 1993; Stefanick, 1993). Therefore, special attention should be paid to the development of muscles, because it allows you to perform those types of activities that are of primary importance for strength development and better nutrition in everyday life, because it allows better body composition, which means that emphasis should be placed on intake as much protein as possible, because of the muscles themselves, and as little fat and carbohydrates as possible, because all the factors are important in building the muscles themselves, strength and a healthy lifestyle in general. However, the authors (Bonney, Ferguson, & Smits-Engelsman,

2018) found that BMI is negatively associated with cardiorespiratory fitness and strength in the muscles of the lower extremities.

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THE INFLUENCE OF SOME PSYCHOSOCIAL FACTORS ON PHYSICAL AND SPORT ACTIVITIES IN STUDENTS 11 TO 15 YEARS OF AGE WHO SHOWED DEVIATION IN BEHAVIOR

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ABSTRACT

Study was conducted on a sample of 321 students of both sexes (169 male and 152 female) divided into two sub-samples (group of students who did not show deviation in behavior and a group of students who showed deviation in behavior) aged 11 to 15 years. The purpose was to determine the impact of phychosocial factors on physical and sport activity in two municipalities in the Republic of North Macedonia. To meet the objectives of the test, 5 variables were used to assess physical and sports activity. The primary interest is the causal analysis of the relationship between the psychosocial factors, sport participation and behavior, as well as the even bigger question about the role of sports participation in the socialization process among students from fifth to eighth grade.

Keywords: physical activity, sports activity, students, behavior, psychosocial factors

INTRODUCTION

The health benefits of regular physical activity have been studied and are well described in the literature (Rowland, 1990). The psychosocial benefits of regular physical activity, which are considered to be as important as the health benefits, are less clear (Calfas & Taylor, 1994). Determining the psychosocial factors that influence behavior when using physical and sports activities can help a lot from a sociological, educational, health and social point of view. The current data regarding the impact of physical activity on children's psychosocial health confirm an associative, rather than a causal link in many studies (Brown, 1990). There are several theoretical models that explain physical activity and the factors that affect it. Social learning theory (Bandura, 1977) begins from the fact that personal characteristics (knowledge, belief, self-efficacy and intention), environment (physical and social) reciprocally affect each other (Bandura, 1977). The model of social status (Model of social stratification) constructed by Saksida & Petrovič (1972) is a hierarchical model with a negative essence and is defined as a second-order stratification subsystem (institutional, socialization and sanction subsystem arranged as a combination of some first-order subsystems).

In the literature, theoretical and empirical, however, there is a general consensus that recreational education programs are necessary and useful, both for preventive and rehabilitation purposes (Perry & Jessor, 1983). Engaging in regular physical activity effectively alleviates a stress, improves self-efficacy, and results in higher levels of quality of life (Gill, Hammond, Reifsteck, Jehu, Williams, & Adams, 2013; Mailey & Mcauley, 2014). If the recreation process can reach its peak purpose, i.e. to fill free time in a useful way, then we have a significant opportunity to prevent delinquents and potential delinquents from abusing their free time. The primary interest in this research was to explore and understand the possible connection between psychosocial factors, sports participation and delinquent behavior of young people. Given the fact that interdisciplinary topics in which the impact of physical and sports activity on behavior were not included or very little studied, this topic is an additional challenge and of great interest: the

impact of psychosocial factors on the physical and sports activity and behavior in students from 11 to 15 years of age. The purpose of this study was to determine the impact of phychosocial factors on physical and sport activity in two municipalities in the Republic of North Macedonia.

METHODS

Subjects

Study was conducted on a sample of 321 students of both sexes (169 male and 152 female) divided into two sub-samples (group of students who did not show deviation in behavior and a group of students who showed deviation in behavior) aged 11 to 15 years.

Procedure

To meet the objectives, a set of five variables was used to assess physical and sports activity: Variables for assessing delinquent deviant behavior- Personal scale of delinquent/deviant behavior (psychopathy, neuroticism, immature behavior, inappropriate behavior in education); Scale for deviant behavior (acts against persons, acts against property, acts involving the use of substances, traffic violations, other delinquent acts); Social support/desirability assessment variable- Scale of social support/desirability; Variables for assessing social support- Scale that assesses social support from parents and a Scale by which social support from friends is assessed.

Statistical analysis

The obtained results are processed with appropriate statistical methods, i.e. multivariate and univariate parametric analyzes (Analysis of variance, Discriminant, Regression and Univariate analysis), while the non-parametric ones applied were Kruskal-Wallis X-test and Man-Whitney *U* test.

RESULTS

Table 1. The influence of some psychosocial factors on physical sports activity in students who showed deviation in behavior

Wilks'Lambda	Rao's R	df 1	df 2	Q
.853	1.678(a)	12.000	117.000	.080

	Have not shown		Have shown		F	Sig.	Partial Eta Squared
	Mean	*SD*	*Mean*	*SD*			
Psychopathy	44.61	4.19	44.84	3.62	0.11	.74	.00
Neuroticism	43.68	4.50	43.82	4.13	0.04	.85	.00
Immature behavior	13.96	1.30	14.13	1.34	0.51	.48	.00
Education	20.53	2.26	20.61	1.69	0.05	.83	.00
Scale 3	39.51	4.84	39.43	4.08	0.01	.92	.00
Against people	9.49	2.55	10.04	3.22	1.18	.28	.01
Against property	9.97	2.71	10.77	4.62	1.51	.22	.01
Traffic violation	4.72	2.45	5.36	2.65	2.03	.16	.02
Substances	7.74	2.01	8.27	3.12	1.35	.25	.01
Other	9.61	3.85	10.21	3.48	0.86	.36	.01
Support from parents	23.45	6.76	28.27	6.71	16.33	.00	.11
Support from peers	19.65	5.90	22.95	6.10	9.66	.00	.07

The results of students with deviation in behavior are shown in Table 1. From the review of the table it can be seen that at the multivariate level there are no statistically significant differences between psychosocial factors and physical activity. At univariate level of the arithmetic mean values and the level of statistical significance (Table 1) it can be seen that the variables (scales) for assessing social support from parents and social support from friends have a statistically significant impact on students who

showed deviation in behavior same as in the first group of students. The other scales and variables did not have a statistically significant effect on physical activity in this group of participants. The partial effect of the variables that have a statistically significant impact ranges from .113, for the scale of social support of parents, and .070 for the peer social support assessment scale.

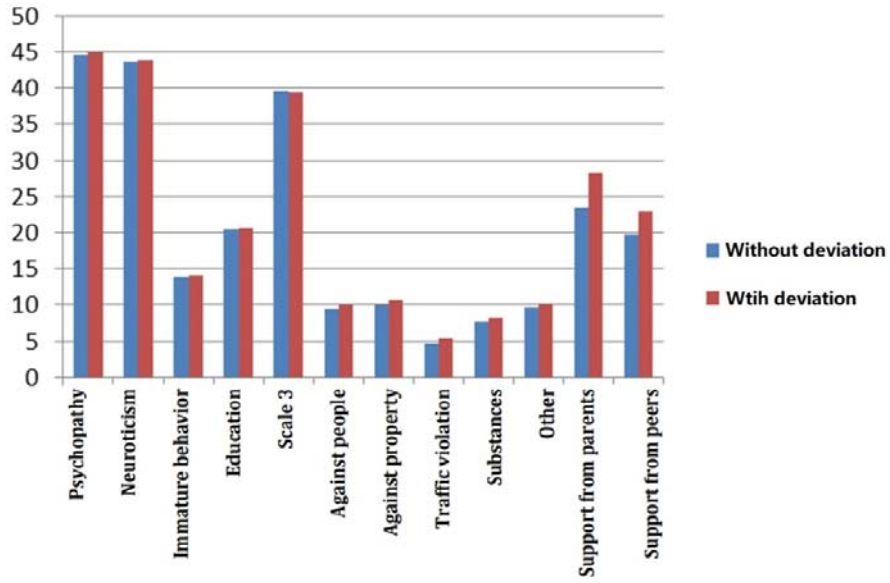

Figure 1. The influence of some psychosocial factors on physical sports activity in students who showed deviation in behavior

The influence of psychosocial factors on physical activity in the male participants who showed deviation in behavior are shown in the Table 2. From the review of Table 2 it can be seen that at the multivariate level there are no statistically significant differences between psychosocial factors and physical and sports activity in the male subjects who showed deviation in behavior.

Table 2. The influence of some psychosocial factors on physical sports activity in male students who showed deviation in behavior

Wilks'Lambda	Rao's R	df 1	df 2	Q
.843	1.354(a)	12.000	87.000	.204

	Have not shown		Have shown		F	Sig.	Partial Eta Squared
	Mean	*SD*	*Mean*	*SD*			
Psychopathy	44.19	4.56	44.89	3.84	0.69	.41	.01
Neuroticism	43.24	4.79	43.87	4.35	0.47	.50	.01
Immature behavior	13.96	1.32	14.22	1.38	0.89	.35	.01
Education	20.30	2.49	20.50	1.72	0.22	.64	.00
Scale 3	39.15	5.21	39.70	4.25	0.32	.57	.00
Against people	9.80	2.83	10.00	3.20	0.11	.74	.00
Against property	10.22	3.12	10.57	4.75	0.19	.67	.00
Traffic violation	5.15	2.51	5.65	2.72	0.93	.34	.01
Substances	7.98	2.29	8.28	3.08	0.31	.58	.00
Other	9.98	4.41	9.76	2.88	0.08	.77	.00
Support from parents	23.39	7.31	28.17	6.83	11.31	.00	.10
Support from peers	19.30	6.29	22.80	6.37	7.64	.01	.07

The results of the univariate analysis of variance (Table 2) indicate that only the variables such as social support from parents and social support from friends have a statistically significant impact. The

partial effect of the variables that have a statistically significant impact ranges from .103 for the scale of social support of parents and .072 for the scale of assessment of social support of friends. Other scales (personal scale of delinquent/deviant behavior, scale of social desirability, scale of deviant behavior) do not have a statistically significant impact on physical and sports activity in male participants who showed deviation in behavior.

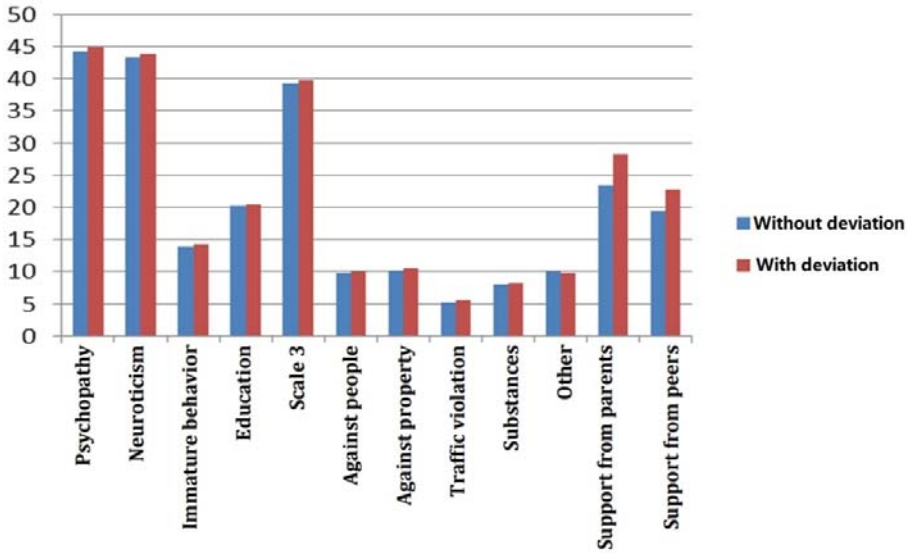

Figure 2. The influence of some psychosocial factors on physical sports activity in male students who showed deviation in behavior

From the review of Table 3 it can be seen that at the multivariate level there are no statistically significant differences between psychosocial factors and physical activity in female participants who showed deviation in behavior. At the univariate level the variables of against property and other variables that are part of the scale of social behavior show a statistically significant impact. The other variables do not show a statistical effect in this group of participants.

Table 3. The influence of some psychosocial factors on physical sports activity in female students who showed deviation in behavior

Wilks'Lambda	Rao's R	df 1	df 2	Q
.525	1.206(a)	12.000	16.000	.357

	Have not shown		Have shown		F	Sig.	Partial Eta Squared
	Mean	*SD*	*Mean*	*SD*			
Psychopathy	45.75	2.79	44.44	2.60	1.41	.25	.05
Neuroticism	44.85	3.42	43.44	3.24	1.08	.31	.04
Immature behavior	13.95	1.28	13.78	1.09	0.12	.73	.01
Education	21.15	1.35	21.00	1.58	0.07	.80	.00
Scale 3	40.50	3.59	38.33	3.20	2.41	.13	.08
Against people	8.65	1.27	9.89	3.55	1.96	.17	.07
Against property	9.30	0.66	11.00	3.64	4.24	.05	.14
Traffic violation	3.55	1.88	3.44	0.73	0.03	.87	.00
Substances	7.10	0.45	7.11	0.33	0.00	.95	.00
Other	45.75	2.79	44.44	2.60	1.41	.25	.05
Support from parents	44.85	3.42	43.44	3.24	1.08	.31	.04
Support from peers	13.95	1.28	13.78	1.09	0.12	.73	.01

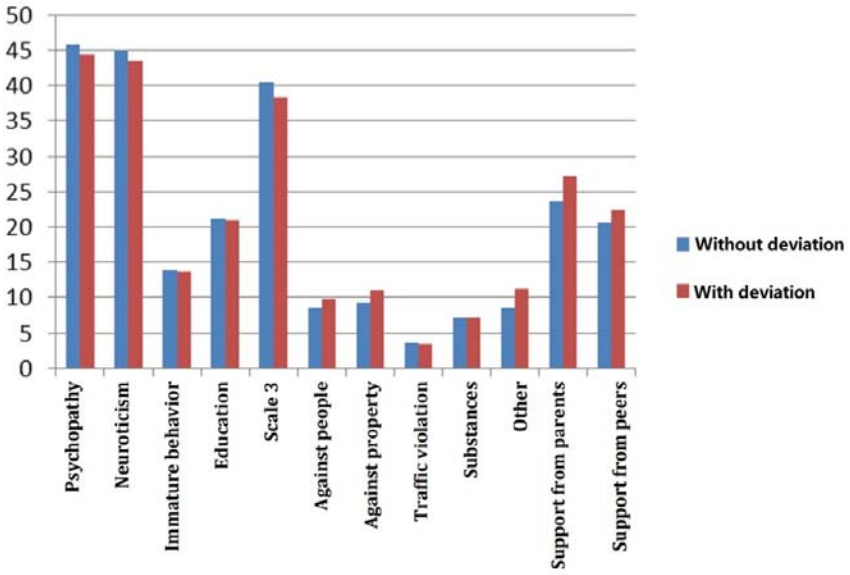

Figure 3. The influence of some psychosocial factors on physical sports activity in female students who showed deviation in behavior

CONCLUSION

In order to determine which elements or aspects of the sports experience are relevant to the relationship that concerns us, an assessment should be made of those elements and aspects whose importance is emphasized in the literature of sports sociology and psychology. That is why the relationship between physical activity, sports activity and student behavior was explored. Information was also obtained on how some socio-demographic factors affect the behavior and physical- sports activity of students in the regular education system of both sexes. Based on the obtained results it can be concluded that the perceived social support from the parents is a very important determinant that affects the physical activity and probably the other types of behavior in students who show deviation in behavior. This suggests that parents should pay more attention to their children, encourage them to participate in sports activities, provide transportation to the place where they can exercise, play sports with their children and thus indirectly it is likely to improve their children's behavior.

The research, which was of a multidisciplinary nature, came to a number of scientific findings that will be applied in practice and theory and that will help to better understand the behavior of young people and what factors influence it. Based on the obtained data, strategies and programs for prevention of youth behavior should be developed.

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EFFECT OF RESISTANCE TRAINING ON HORMONAL STATUS: A HISTORICAL REVIEW

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ABSTRACT

The cult of good physique and symmetrical body image dates back to the ancient civilizations of Greece and Egypt. Greeks gave great importance to physical exercise, and this was a significant aspect of their educational, economic, social, and political life. By exercising in the gymnasium (an institution where young Greeks trained and also a place where all the free citizens of Athens gathered) and palestra, young Athenians strengthened their body and spirit and prepared for important events, such as the Olympic Games and the military profession. With the development and availability of technology in the early 1970s, the potential effects of weighted training on the endocrine system intrigued scientists to examine this problem more thoroughly, based on the assumption that strength training can have inherent significance on cell homeostasis, metabolism, and tissue architecture. The first research in strength training focused on hormonal response, which personifies the body's anabolic-catabolic status. To a certain extent, this was established on an already known anabolic effect in developing muscle strength. As a result, there was a desire to learn more about our own endogenous anabolic and catabolic systems in order to attain the desired results of strength training. The following databases were used to gather adequate literature for this research: Google Scholar, PubMed, Cobson, SCIndeks. In total, 24 studies met the inclusion criteria for the review. A search terms included 'resistance training', 'testosterone', 'growth hormone', 'cortisol', 'muscle hypertrophy', 'hormonal responses'. The works that were sought were published between 1973 and 1980, all until 2014. The selected books or summaries were read and analyzed thoroughly. The basic requirements that needed to be completed for detailed analysis were that the research was published as original or systematic examination research or as theoretically application (historical). The outcome of this study suggests that the volume and intensity of training have a significant impact on hormone secretion. In addition, hormonal responses vary significantly depending on the gender and age of the respondents. Some researches show noteworthy impacts and changes in the level of anabolic hormones. However, not so significant changes in the hormone cortisol have also gone under observation. Hormone secretion responses also vary depending on the type of training load and the length of the training protocol. Experts in the field of sports science strive to explore signaling pathways and Acuna responses in hormone secretion. However, there is no clear evidence that indicates a difference in acute responses in hormone concentration in athletes and recreational athletes. Further researches are required in this field. The importance and role of anabolic hormones, associated with muscular hypertrophy and the impact on acute changes, are a significant strategy to improve sports performance.

Keywords: history, resistance training, hormonal responses, testosterone

INTRODUCTION

About 5000 years ago, endeavours that emphasized muscle strength were recorded in different forms. In ancient Egyptian tombs from approximately 2500 BC, forms of art were discovered on the walls depicting various forms of strength competitions. Meanwhile among the ancient inhabitants of Ireland, 3800 years ago, there was a well-known game of competitive throwing of a certain weight. On the other side of the world strength tests were used for military purposes, during the reign of the Chou dynasty in China as early as 1122-255 BC (Fry & Newton, 2008).

In Mesopotamia, activities such as wrestling and fist-fighting were an integral part of the culture of the time, where the participants in these games had to be physically well prepared. In addition, numerous historical sources explain, that the term "athletes" which is abovementioned, means: "those who are strong". It is believed that the Sumerian royal families attached great importance to both good physical and mental preparation, which they sometimes had to demonstrate through various competitions

(Lamont, 1995). Olympic weightlifting first appeared in the 1896 competition program. In 1932, the International Olympic Committee standardized a total of three lifting techniques that were used until 1972. The techniques included snatch, two-handed clean and press, and clean and jerk. However, ince 1972, Clean and press has been eliminated from the Olympic program, but the remaining techniques have withstood the test of time and remained unchanged (Silvester, 1992).

The first significant research, which refers to physiological changes under the influence of strength training, dates back to the beginning of the twentieth century. That muscle strengthening affects the increase in volume, i.e. muscle hypertrophy, and not the increase in the number of muscle fibers (hyperplasia), was pointed out by Morpurgo in 1897 (according to Tesch & Larsson, 1982), who suppressed the formerly founded myth. After thirty years of research, it has been confirmed that the cause of muscular hypertrophy is an external weight load (Radovanović & Ignjatović, 2013). Not later than 1920 and 1930, it became apparent that health, and the improvement of physical appearance were closely related, and that weight training was an undoubtedly effective way to build the body in the shortest amount of time (Schwarzenegger & Dobbins, 1998).

Acute neuromuscular and hormonal responses affected the extent and intensity of strength and rest exercises between sets. These acute responses should be the primary stimulus for neuromuscular and hormonal adaptation, leading to hypertrophy of muscle tissue and this fashion to the development of strength during prolonged exercise training (Ahtiainen, Pakarinen, Kraemer, & Hakkinen, 2004). It follows that the problem of this study was to examine the impact of strength training on the change in hormonal status, and whether it has a positive effect on adaptation in terms of increasing the ability and work capacity of athletes and recreational athletes. Nonetheless, it was necessary to use the historical method to determine certain patterns in the training of strength development throughout history, in order to draw adequate conclusions from the aspect of improving training practice.

METHODS

The following databases were used to collect adequate literature for this research: Google Scholar, PubMed, Cobson, SCIndeks. Papers that were searched were published in the period from 1973 to 2014. Gathered papers and summaries were read and analyzed. The basic criteria that needed to be met due to the detailed analysis is that the research was published as original and systematic review, research or as theoretically befitting work (historically). In addition, all studies had to meet the criterion of the influence of strength training over the change in hormonal status. The key words used in the database search are: 'resistance training', 'hormonal responses', 'testosterone', 'growth hormone', 'cortisol', 'strength training'. Researches that met all the conditions and criteria were presented as follows: references (authors and year of publication), population (age and sex, athletes and non-athletes), duration of the experimental protocol, type of study, research results. The historical methods were used in the paper accordingly.

RESULTS AND DISCUSSION

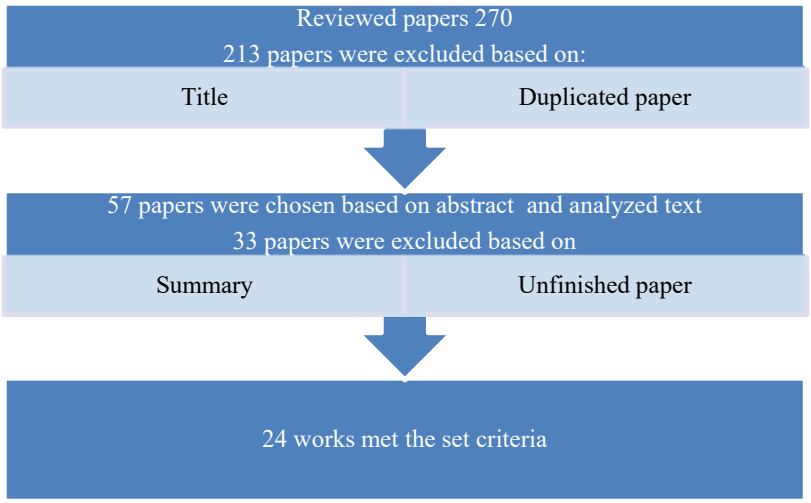

Diagram 1. Schematic diagram of the work search strategy
Table 1. Summary of main characteristics of the included studies

Reference	Age	Training experience	Protocol duration	Type of study	Conclusions
Sutton et al. (1973)	24±4	Active athletes	1 day	Transversal study	The authors point out the changes in the level of androgens (growth hormone, testosterone, as well as cortisol) caused by physical activity. They also emphasize the potential correlation between changes in androgen in serum and the intensity of activity.
Fahey et al. (1976)	Male: 20±2.7 Female: 21±1.2	Most of the participants had no previous experience in training with load.	1 day	Transversal study	Significant differences were observed in serum testosterone, where in men there was an increase accompanying weight training, while in women it remained the same.
Häikkinen et al. (1985)	26.3±3.8	Participants had some previous experience in training with load.	The protocol lasted 24 weeks of active training and 12 weeks of declining load and form training	Longitudinal study	The results of this study indicate a change in the level of testosterone and cortisol during training, while in the period of declining form there is a correlative decrease between the maximum strength and the ratio of the hormones testosterone and cortisol.
Guezennec et al. (1986)	33±5	Participants had experience in training with loads.	4 months	Longitudinal study	The authors point out that the values of the insulin, testosterone and cortisol did not change significantly after both protocols with exercise. However, changes at the level of metabolites (lactate, glycerol, triglycerides) were observed.
Häkkinen et al. (1988)	23±3	The group of participants was made of elite weight lifters.	1 week	Transversal study	The results of this study indicate an acute increase in total serum and free testosterone in weightlifters during an afternoon training session. Serum testosterone concentration varied, however after one day of rest the values were at pre-workout levels. Acute changes were also observed in the levels of the cortisol and somatotropin.
Kraemer et al. (1990)	24.66±4.27	Participants had previous experience in recreational training with load.	2 weeks	Transversal study	Significant changes were observed in growth hormone, but the parameters of the hormone testosterone were also higher than at rest.
Kraemer et al. (1991)	Male: 24.7±4.5 Female: 23.1±3.3	All participants had previous experience in recreational training with load.	Each experimental test was performed at the same time of day, but on different days with a minimum of 72 hours of rest between experimental sessions.	Transversal study	The authors point out the higher serum concentration of the hormone testosterone in men before training, while in women the higher level of growth hormone before training was recorded in relation to men.
Häkkinen & Pakarinen (1995)	8 young women and men under the age of 30 (25±1.4 and 27.1±2.1), 7 middle aged women and men 50 (48±3.7 and 47.9±3.0) and the group of elderly women and men under the age of 70 (8.9±3.2 and 68±3.1).	None of the participants had previous experience at competitions but all of them lived a healthy lifestyle.	The experiment consisted of a control day (rest) where blood samples were taken and after one week a load protocol was applied where samples were also taken.	Transversal study	Significant increases in testosterone concentration were observed in the group of young men and middle-aged men, as well as changes in cortisol levels in the group of older men. In women, there were no changes in the levels of the testosterone and cortisol for all groups. Growth hormone serum increased in young and middle-aged women, while no changes occurred in the older group. In men, growth hormone increased in the younger and middle groups.
Kang et al. (1996)	25.3±0.3	Participants had 5 years of experience in weight-lifting.	2 weeks	Transversal study	Significant acute changes were observed in growth hormone in the blood, but not at the high intensity of work, the authors point out. The squat exercises (25 repetitions) and leg presses (10 repetitions) cause significant acute changes compared to the rest of the repetition range.

Gotshalk et al. (1997)	25.4±4.14	Participants had previous experience in training with load.	2 weeks	Transversal study	The results of the research indicate a significantly better increase in growth hormone, testosterone and lactate after three sets, i.e. a larger volume compared to one set. Also, a larger protocol has a significant effect.
Kraemer et al. (1998)	Male: 25.3±3.2 Female: 20.6±1.5	Participants had no previous experience in training with load.	9 weeks	Longitudinal study	The concentration of the hormone testosterone is significantly higher in men than in women. There are no significant differences between men and women in serum cortisol. With growth hormone, it has been noticed that women have higher values before training.
Kraemer et al. (1999)	Two groups of participants of different age; younger 29.8 ± 5.3 and older 62 ± 3.2	No previous experience in training with load.	1 day	Transversal study	Higher values of total testosterone and IGF were observed in the younger group. In the older group, a jump in testosterone was detected during training in response to stress, but also a decrease in resting cortisol levels.
Häkkinen et al. (2000)	Middle age group: Male: N=10, age 42±2, Female: N=11, age 39±3 Older group: Male: N=11, age 72±3 Female: N=10, age 67±	Participants were well-trained and with healthy lifestyles.	6 months	Longitudinal study	During the experiment, no systematic changes occurred in the mean concentrations of total and free testosterone, growth hormone, cortisol, DHEA, DHEAS, and SHBG. A correlation between serum free testosterone and strength-related testosterone was also observed during training in the older women's group and in other women's groups.
Hansen et al. (2001)	Group A: 24.4±3.1 Group B: 23.3±4.6	The participants had no previous experience in working out at all.	9 weeks	Transversal study	The authors point out a significant increase in hormones (cortisol and testosterone) in group B, which had a larger overall volume of exercise and muscle activation. The hormone testosterone was also significantly higher in group B compared to group A. A larger relative increase in isometric strength was observed in the group that showed better hormonal responses.
Smilios et al. (2003)	23±4	Participants had experience in weight lifting.	1 day	Transversal study	The results of this study indicate that there were no acute changes in testosterone hormone levels, while there were significant changes in growth hormone and cortisol.
Ahtiainen et al. (2004)	26.0±4.3, 27.0±4.8	Participants were divided in the groups of experienced and non-experienced in training with loads.	2 weeks	Transversal study	The concentration of measured hormones changed significantly after both load protocols in both groups. However, the responses were more pronounced in the group that performed forced repetitions, while the results also indicate that the concentration of growth hormone in both protocols was better in subjects with experience.
Willoughby & Taylor (2004)	19.36±2.17	Participants with no previous experience in training with loads.	The length of this study was not explained.	Transversal study	The results of this research indicate changes in the level of the hormone testosterone, after training with load, but also in the control group that did exercises without load. Blood samples showed that training with load causes more noticeable results compared to exercises without load, in the secretion of the hormone testosterone in men.
Ahtiainen et al. (2005)	28.7±6.2	Recreational athletes with no previous experience in training with loads.	6 months	Longitudinal study	The authors point out that no statistically significant changes were observed in the concentration of basal hormones or in the profiles of acute hormonal responses during the entire six-month experimental training period.

Linnamo et al. (2005)	Male: 27.1±0.7 Female: 23.3±0.5	Participants had no previous experience in training with loads.	The three load protocols were performed separately, where there was a rest period of at least two weeks after one of the load protocols.	Transversal study	The results indicate that the protocol with maximum load causes more noticeable changes in new hormones (testosterone and growth hormone) in men and women compared to the protocol with sub-maximal and maximally explosive mode of operation.
Ratamessa et al. (2005)	24.3±4.4	Participants had previous experience in training with load. (at least 3 years with the exercise back squat)	1 day	Transversal study	The results of this study suggest that more sets in the training unit cause significant changes in the level of the hormones testosterone and cortisol, compared to a smaller volume or single set.
Izquierdo et al. (2009)	33±4.4	Participants had no experience in training with loads.	7 weeks	Longitudinal study	Training with load has led to significant changes in the level of anabolic hormones, however, not so significant changes in the hormone cortisol have been observed.
Charro et al. (2010)	26±6	Participants had previous experience in training with loads.	14 days	Transversal study	The authors point out significant changes in the levels of growth hormone, cortisol and lactate after both protocols (multiple series and pyramidal form of work). The results of the hormones insulin and testosterone remained unchanged. The results of both protocols show identical acute responses when the overall load range is equal.
Leite et al. (2011)	24.5±7.6	Participants had previous experience in training with loads.	1 week	Transversal study	The authors emphasize that there have been significant changes in cortisol levels and testosterone/cortisol ratios before and after the load protocol. The larger volume group showed higher values of growth hormone and cortisol, while testosterone remained unchanged for both groups.
Shaner et al. (2014)	25±3	Participants had previous experience in training with loads.	4 weeks	Transversal study	The results of this study, the authors point out, indicate that free weight exercise for the lower extremity causes significantly better acute responses to the levels of the hormones testosterone, cortisol and growth hormone compared to machines.

From the very beginning of the human species until today, work has been the basis of human survival on the planet Earth. The first forms of human labour, as well as the first forms of physical exercise, are related to activities necessary for human life, such as hunting, fishing and fruit gathering. In addition to making primitive tools at the time, man had to rely on his biological abilities. Skills such as running, jumping, climbing, throwing and wrestling had to be developed, because they were essential for the survival of the social community (Radan, 1981). Before 1890, information about weight training was anecdotal, and "experts" were the same people who performed weight training. Since the early 1950s and 1960s, weight training has been a topic of interest in the scientific, medical, and athletic communities (Kraemer, Adams, Cafarelli, Dudley, Dooly et al., 2002). Exercise and sport scientists were actively involved in research to better understand the processes that control the body's physiological reactions to acute bouts of exercise, as well as adaptations to training and detraining. The majority of this study was carried out at large research institutions, medical facilities, and specialized institutes, employing standardized research methods and exercise physiologist-developed equipment (Kenney, Wilmore, & Costill, 2015).

With increasing of age, seniors experience various changes in their body, including decreased hormone secretion, muscle atrophy, and decreased bone density (Fleck & Kraemer, 2014). Scientists in their study (Kraemer, Häkkinen, Newton, Nindl, Volek et al., 1999) came to the conclusion that the younger group of participants has significantly more noticeable results in hormone secretion (testosterone and IGF-1) compared to the senior, after weight training. In addition, the older group showed significant acute increases in the hormone testosterone, as a response to stress induced by loads tension. Research of Häkkinen & Pakarinen (1995) indicates that the concentration of growth hormone on the same relative training with a load significantly decreases with age in both men and women, while the acute responses of the hormone testosterone are significantly reduced. The six-month work out program did not show systematic changes in the experimental period with the mean values of total and free testosterone, growth hormone and cortisol, the authors point out (Häkkinen, Pakarinen, Kraemer, Newton, & Alen, 2000). Low testosterone levels, especially in women, can be a limiting factor in the strength development.

When we take all the results in consideration, acute hormonal increases in response to training with load significantly decrease with the increasing of age. Based on the beforementioned statement, we can look for the cause of this observation in the process of biological aging. The number of sets is closely related to the range of training, overall work, where training practice has shown that more sets compared to one set have a better effect on optimal strength development and local muscle endurance, as well as muscle hypertrophy (Fleck & Kraemer, 2014). Intensity is a term that can be used for the condition. Accordingly, it determines more closely the level of exhaustion during exercise with load. An intensity of 45-50% of 1 RM (one-repettion maximum) in people who do not posses training experience can have benefits in strength development, while in overtrained athletes the intensity should not be less than 80-85% in order to develop strength (Ratamess, 2012).

Ratamess, Kraemer, Volek, Maresh, VanHeest et al. (2005) came to a conclusion that multiple sets cause significant increase in total serum testosterone (16-23%) only 15 to 30 minutes after protocol. Cortisol from plasma was also elevated (31-49%) following a more set protocol after exercise, while androgen receptor content did not change for one hour following a single set protocol, but decreased significantly by up to 46% following a multi set protocol series. The cause of this response may be higher protein, catabolism associated with higher levels of fear due to higher training volume. Research conducted by Gotshalk, Loebel, Nindl, Putukian, Sebastianelli et al. (1997) discusses the comparison of two load-based protocols (1 set and 3 sets) and their impact on acute hormonal responses. Both protocols caused significant acute changes in hormone secretion (testosterone, growth hormone, and cortisol), however, the 3 sets protocol showed significantly better results. The authors point out that a larger volume produces significantly more noticeable anabolic increases in circulation during such a resting phase, followed by exercises. It was pointed out by the authors that intensity played a bigger role (Linnamo, Pakarinen, Komi, Kraemer, & Häkkinen, 2005). Furthermore, the authors conducted research with the aim of determining acute changes in three different load protocols. The protocol with maximum load (5 sets, 10 repetitions), showed the best results in the secretion of growth hormones and testosterone. Due to the anabolic effects of growth hormones and testosterone, acute responses stimulated by training may have an important effect in the process of muscle hypertrophy and strength development, the authors emphasized.

After training with load, there are changes in the concentration of anabolic hormones (testosterone and various molecular forms of growth hormone), as well as the hormone cortisol, where 30 minutes after training and standard values are elevated in men. These values stabilize over time due to both adaptation to acute training load and after long-term application of training with load (Haff & Triplett,

2015). Based on the above-stated claims of the authors, it is important to observe carefully the influence of acute changes in the level of anabolic hormones associated with muscle hypertrophy.

Research conducted by Travison, Vesper, Orwoll, Wu, Kaufman, Wang et al. (2017) indicates that normal values of the hormone testosterone, in healthy individuals, in the period between 19 and 39 years, are from 264 to 916 ng/dl. The influence and effect of testosterone is evidenced by research of Bhasin, Storer, Berman, Callegari, Clevenger et al. (1996), where the main goal was to examine the effect of a supraphysiologic dose of testosterone on muscle size and strength in men. Subjects were divided into four groups, of which two groups received 600 mg of testosterone per week, for a total of 10 weeks. The results of the research of the former mentioned authors indicate that the level of testosterone in the group that did not exercise and received a dose of testosterone in concentration drastically increased to 2828±417 ng/dl, while in the group that exercised and received a dose of testosterone the value was 3244±305 ng/dl. In both groups, there was an increase in muscle mass. On the other hand, one research (Fahey, Rolph, Moungmee, Nagel, & Mortara, 1976) reports acute testosterone values after the static strength protocol, which were 581±146.8 ng/dl in men before training, while the values after the protocol were 692.8±175.4 ng/dl.

Considering the fact that both testosterone and growth hormone are anabolic hormones, Linnamo et al. (2005) hypothesize that acute responses elicited by the maximal exercise protocol may play an important role in the process of long-term anabolic adaptation associated with muscle hypertrophy and maximal overall strength. However, based on the obtained results (West, Kujbida, Moore, Atherton, Burd et al., 2009; West & Phillips, 2012), we can conclude that acute responses to anabolic hormones caused by exercise training have a very small share in muscle hypertrophy and cannot be used as proxy markers in potential skeletal muscle growth and strength development.

CONCLUSION

Since the very beginning and the first forms of training with load, and with the progress of science in the field of sports as well, until today, it is known that training with load has many and varied positive effects, for both athletes and recreationists, if dosed correctly. Research on age and hormone secretion induced by exercise training clearly indicates that there is a significant decrease in concentration (growth hormone and testosterone) with increasing of age. The importance and role of anabolic hormones, associated with muscle hypertrophy and the impact on acute changes, represent an important strategy in order to improve sports performance. However, the results suggest that acute responses are not sufficient to drastically increase muscle mass, and therefore strength, and cannot be taken as significant indicators. Whether it is an athlete or a coach, it is important to understand that the endocrine system plays a very important role in training. Therefore, in order to plan and program, it is important to take all the important segments that can affect the secretion and action of hormones, in order to preserve health and achieve the best possible sports results. If we look at researches from the beginning of 1970 until today, we can see that the development of technology, as well as science in the field of sports is advancing rapidly, so we can expect more reliable and accurate data in the field of sports science and medicine in the future.

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