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<b>Nevenka Zrnzević &amp; Toplica Stojanović</b> <i>Morphological characteristics and functional abilities in elementary school students.....</i>	<b>1</b>
<b>Željko M. Rajković, Darko N. Mitrović, Vladimir K. Miletić &amp; Petar M. Spaić</b> <i>Kinetic indicators of training methods and selection of young rowers.....</i>	<b>13</b>
<b>Raid Mekić, Merisa Mekić, Zana Dolićanin, Adem Mavrić, Ilma Čaprić, Emir Biševac &amp; Armin Zećirović</b> <i>Influence of exercise program content on elderly persons with diabetes melitus tip 2. ....</i>	<b>25</b>
<b>Saša Jovanović, Snežana Bijelić, Adriana Ljubojević, Dalibor Fulurija &amp; Aleksandra Belić</b> <i>Relations of motor ability of balance and success of performance of gymnastic elements on the floor exercise.....</i>	<b>34</b>
<b>Mariia Roztorhui, Alina Perederiy, Khrystyna Khimenes &amp; Olexandr Tovstonoh</b> <i>Assessing the effects of different training programs for physical preparation and sport performance in powerlifters with visual impairments of high qualification.....</i>	<b>44</b>
<b>Dinko Kolarić, Ana Kolarić, Drago Ambroš, Siniša Popek, Zoran Vrbanac &amp; Lana Ružić</b> <i>Influence of external risk factors on alpine skiing injuries in recreational skiers.....</i>	<b>58</b>
<b>Zvezdan Savić, Nikola Stojanović, Miloš Tomić &amp; Đorđe Savić</b> <i>Chronological age of alpine ski medal winners in the 2015-2018 Olympic cycle .....</i>	<b>72</b>
<b>Aleksandar Gadžić, Aleksandar Živković &amp; Tamara Stojmenović</b> <i>Influence of Covid-19 on morphological and cardiovascular status of professional handball players.....</i>	<b>83</b>



**MORPHOLOGICAL CHARACTERISTICS  
AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**  
*MORFOLOŠKE KARAKTERISTIKE I FUNKCIONALNE SPOSOBNOSTI  
UČENIKA OSNOVNE ŠKOLE*

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**ABSTRACT**

*The main aim of the study is to establish whether there are any differences in growth and development of functional abilities between boys and girls. For the evaluation of functional abilities, growth and development in students the following parameters have been used: height, body mass, body mass index, vital lung capacity, resting heart rate, active heart rate and modified Harvard step test index. The results of multivariate analysis (MANOVA) have shown that there is no statistically significant difference between male and female students. A statistically significant difference has been found by means of univariate analysis of variance (ANOVA) in active hearth rate variables ( $F=8.36$ ;  $p=.004$ ) and modified Harvard step test index ( $F=6.67$ ;  $p=.011$ ) in favor of male students. Comparing the results obtained in the earlier and recent studies it can be concluded that the current physical exercise program does not produce desired results, furthermore it does not contribute nor does it improve functional abilities of male and female younger elementary school students.*

**Key words:** *Morphological characteristics, functional abilities, physical exercises, younger students, Harvard step test.*

## **MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**

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### **INTRODUCTION**

Physical education is part of general upbringing and plays a significant role in the educational system of young people as well as their upbringing. It is realized through a series of general and specific tasks. It starts in preschool institutions and finishes in the institutions of higher education. During this process there should not be any room left for improvisation, nor accidental influence, especially the kind of influence that may have a negative impact on the personality development (Milanović, 2011). Bearing in mind the fact that 97% of children attend elementary school and have physical education classes on regular basis, it is the obligation of the school to promote physical activity as an important social institution. Teachers are also obligated to constantly stress the importance and value of physical exercises, and develop a habit in students to take care of their body and improve their abilities so that physical exercises become a part of their daily needs.

The development of our civilization, besides its positive aspects for the progress of our humanity, has negative aspects as well. Life without sufficient time spent in nature and without enough movement

decreases the development of motor and functional abilities. In addition, it leads to various diseases among which cardiovascular diseases take the first place (Đurašković, 2002). V. Pelagić (1952) stressed the importance of exercises by stating the following: "Thousands who by their own weakness and gloom represent a burden to their beloved ones and spend miserable lives without any joy, could have been happy, diligent and healthy people, had they exercised their bodies in their youth. Do not ever forget that the happiness of our children depends on their exercise. "Even though cardiovascular diseases are not common in children, children who are less active have a predisposition to cardiovascular diseases (Armstrong, Williams, Balding, Gentle, & Kirby, 1991; Wedderkopp, Froberg, Hansen, Riddoch, & Andersen, 2003). Serbia takes the first place based on the mortality rate caused by cardiovascular diseases in Europe. It is especially alarming that health threats begin in an early childhood (Đokić, Međedović & Smiljanić, 2011). The situation is similar worldwide because 60 to 70% of the population in the developed countries does

## **MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**

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not engage in the minimum level of physical activity (Trost, Owen, Bauman, Sallis, & Brown, 2002).

Research conducted on students 7 to 9 years of age during the period from 1995 to 2016 (Gajević, 2009; Zrnzević, 2007; Zrnzević N. & Zrnzević J., 2015) shows that the number of obese children is gradually increasing. Obese children have a great chance of staying obese even as adults (Strong, Malina, Blimkie, Daniels, Dishmann et al., 2005; Schlegel-Zawadzka, 2013).

Since growth and development are the best indicators of general health in children, the increase in height and body mass are the most sensitive indicators of health and living standards of the examined population (Smajić, Marinković, Đorđić, Čokorilo, Gušić et al., 2017). This especially refers to younger elementary school students as one of the most important elements in the process of upbringing and education. In the past, a healthy and capable child used to be the one with good motor skills essential for a certain sport, today a child with good "physical endurance" which means optimal functioning of all physiological systems within a body, especially cardiovascular,

respiratory and skeletal system (Committee on Sports Medicine, 1987).

There is a relatively small number of studies and published papers which deal with the functional abilities of younger school children in Serbia (Stojanović, 1977; Đurašković, 2002; Kragujević & Rakić, 2004; Zrnzević, 2007; Radovanović, Aleksandrović, Stojiljković, Ignjatović, Popović et al., 2009; Mitrović & Stević, 2017). The authors who dealt with the efficiency of school curriculum state that the program of physical education does not cause significant changes in any segment of anthropological status of children, and therefore does not have a positive influence on the increase of functional abilities (Zrnzević N., Lilić, & Zrnzević J., 2013).

The main aim of this research is to establish whether or not there are any differences in morphological characteristics and functional abilities of the examined students of both sexes, for the purpose of curriculum revision, as well as the size of the morphological characteristics and functional abilities of the analyzed age in the region of Kosovo and Metohia, due to insufficient information about the given sample in a long period of time.

## **MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**

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### **METHODS**

The sample comprised 71 male (G1) and 63 female (G2) first-grade students, age 7.0 ± 6 months, from Zvečan and Leposavić (Kosovo and Metohia, the Republic of Serbia). The testing was performed on healthy students who regularly attend physical education classes. Their teachers were present during the tests. The school principal as well as the parents had given their consent to the testing and agreed that the measurements of morphological characteristics and testing of functional abilities of students be conducted during the regular PE classes.

Measures used for the assessment of morphological characteristics included: body height (BH), body mass (BM) and body mass index (BMI). Morphological characteristics were measured according to IBP protocol (Weiner & Lourie, 1969).

Body response to the physical load during physical education classes is best monitored by means of respiratory and cardiovascular system (vital lung capacity, heart rate at rest, active heart rate and heart rate after exercise). The following parameters were used for the assessment of

cardiovascular system function and general functional ability of the students who participated in the study: VLC – a spirometer was used to measure the vital lung capacity up to 7500cm<sup>3</sup>. Vital capacity measurement is of great value and represents screening for the general health of respiratory system, the same way as blood pressure gives general information of the state of the cardiovascular system (Miller, Hankinson, Brusasco, Burgos, Casaburi et al., 2005); RHR - resting heart rate in beats per minute was measured by a stethoscope placed on the chest of students in the projection of the heart top; HRAE – heart rate after exercise was measured by a stethoscope placed on the chest of students in the projection of the heart top and HAST – Harvard step test for the evaluation of cardiovascular and respiratory system adaptability to physical exertion expressed in index points (Mazur & Woynarowska, 2003), which is acceptable in mass examination, easy for measuring, does not require expensive instruments, equipment and special conditions.

Tests used for the assessment of

## **MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**

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functional abilities of children should: engage large muscle groups, the effort must be measurable and repeatable, conditions must be comparable and repeatable, children should be able to perform the test and it should not be harmful to their health, the necessary physical exertion should be easy and children with different levels of physical ability should be familiar with it (Đurašković, 2002).

Descriptive parameters are shown as arithmetic mean (Mean), standard deviation (Std.Dev.), minimum results (Min.), maximum results (Max.), skewness (Skew.), kurtosis (Kurt.) and Kolmogorov-Smirnov coefficient (K-S). The differences between

the male and female students for all morphological measures and physiological characteristics were measured by means of the analysis of variance and multivariate analysis of variance (MANOVA/ANOVA). Percentage difference (Difference %) between male and female students for all variables was calculated by the following formula:  $[(G1-G2)/G1] \times 100$ . Statistical package STATISTICA 10.0 for Windows (StatSoft, Inc., Tulsa, OK, USA) was used for the analysis of the obtained results and statistical significance of difference was established at  $p < 0.05$ .

### **RESULTS**

Observing the obtained results of basic statistics of morphological characteristics and functional abilities of male and female students we can observe that the results are normally distributed, given that the values of

Kolmogorov-Smirnov test coefficient are lower than the limited values. It is observed that there are numerical differences between the male and female students regarding all the variables in favor of boys (Table 1 and 2).



## MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS

**Table 1.** *Descriptive parameters of morphological characteristics and physiological abilities in first grade male students*

Variable	N	Mean	Std.Dev.	Min.	Max.	Skew.	Kurt.	(K-S) d
<b>BH</b> (cm)	71	126.08	5.47	112.10	141.00	0.44	1.16	.083
<b>BM</b> (kg)	71	26.96	5.48	18.50	46.50	1.89	3.83	.209
<b>BMI</b> (kg/m <sup>2</sup> )	71	16.98	3.38	12.32	31.38	1.84	4.47	.212
<b>VLC</b> (cm <sup>3</sup> )	71	1267.61	169.68	900	1800	0.24	0.73	.157
<b>RHR</b> (o/min)	71	95.87	5.68	84	116	0.80	1.30	.167
<b>HRAE</b> (o/min)	71	131.01	6.92	119	146	0.38	-0.60	.118
<b>HAST</b>	71	41.73	2.19	37.36	45.84	-0.17	-0.75	.114

**Legend:** Mean - arithmetic mean; Min. - minimum recorded result; Max. - maximum recorded result; Std.Dev. - standard deviation; Skew. - inclination of distribution of results; Kurt. - elongation of distribution of results; (K-S) d - Kolmogorov-Smirnov coefficient.

**Table 2.** *Descriptive parameters of morphological characteristics and physiological abilities in first grade female students*

Variable	N	Mean	Std.Dev.	Min.	Max.	Skew.	Kurt.	(K-S) d
<b>BH</b> (cm)	63	125.13	114.00	135.20	4.22	0.19	0.46	.092
<b>BM</b> (kg)	63	26.66	20.00	39.50	3.96	0.93	1.52	.122
<b>BMI</b> (kg/m <sup>2</sup> )	63	17.09	11.75	25.04	2.87	0.93	0.78	.122
<b>VLC</b> (cm <sup>3</sup> )	63	1225.40	700	1700	185.76	-0.21	0.63	.164
<b>RHR</b> (o/min)	63	96.94	88	108	4.81	0.31	-0.21	.196
<b>HRAE</b> (o/min)	63	134.62	120	152	7.51	0.43	-0.44	.120
<b>HAST</b>	63	40.75	36.36	45.45	2.16	-0.18	-0.55	.095

Based on the results of multivariate analysis we can conclude that there is no statistically significant difference in terms of morphological characteristics and functional abilities between male and female students at a multivariate level ( $Q=.186$ ) (Table 3).

**Table 3.** *Multivariate differences in morphological characteristics and functional abilities between first grade male and female students*

Wilks Lambda	F	Effect - df	Error - df	Q
0.925	1.46	7	126	0.186

**Legend:** Wilks lambda - the value of the coefficient of the Wilks test for the equality of group centroid; F - value of the F-test coefficient for the significance of the Wilks lambda; Df effect, Error df - degrees of freedom; Q - coefficient of significance of centroid differences.

Statistically significant differences have been established regarding heart rate after exercise (HRAE) ( $p=.004$ ) and Harvard step test (HAST) ( $p=.011$ ) by means of univariate analysis, in favor of boys (Table 4).

## MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS

**Table 4.** *Univariate differences in morphological characteristics and functional abilities between first grade male and female students*

Variable	Mean G1	Mean G2	Difference	Difference %	F (1; 132)	p
<b>BH</b> (cm)	126.08	125.13	0.95	0.8	1.24	0.267
<b>BM</b> (kg)	26.96	26.66	0.3	1.1	0.13	0.721
<b>BMI</b> (kg/m <sup>2</sup> )	16.98	17.09	-0.11	-0.6	0.04	0.840
<b>VLC</b> (cm <sup>3</sup> )	1267.61	1225.40	42.21	3.3	1.89	0.172
<b>RHR</b> (o/min)	95.87	96.94	-1.07	-1.1	1.35	0.247
<b>HRAE</b> (o/min)	131.01	134.62	-3.61	-2.8	8.36	<b>0.004*</b>
<b>HAST</b>	41.73	40.75	0.98	2.3	6.67	<b>0.011*</b>

**Legend:** Mean G1– arithmetic mean of a male group students; Mean G2 - arithmetic mean of a female group students; Difference - the difference in the arithmetic means of male and female group of students; F - value of F-test for testing the significance of differences in arithmetic means; p - coefficient of significance of differences of arithmetic means.

### DISCUSSION

Body height is one of the most stable indicators of physical development and reflects the process of longitudinal growth. Unlike body height, body mass and subcutaneous adipose tissue are susceptible to transformation under the influence of external and internal factors (Đurašković, 2002). Physical activity decreases subcutaneous adipose tissue to a great extent and increases muscle mass (Zrnzević, 2007; Pejčić, Malacko, & Muvrin, 2014; Malacko, Stanković, Doder, & Pejčić, 2015). In this case, by analyzing the average body height (BH) and mass (BM) results in male and female students we can observe that the values of body height are somewhat lower and body mass higher in comparison with the results obtained in the studies conducted

so far (Zrnzević, 2007; Malacko et al., 2015).

The values of vital lung capacity (VLC) depend on the general physical development of a child (Stojanović, 1977). Vital capacity at the beginning of the younger elementary school age is 1450cm<sup>3</sup> in boys and 1400cm<sup>3</sup> in girls (Kragujević & Rakić, 2004; Zrnzević et al., 2013) and until the end of this age period 2250cm<sup>3</sup> in boys and 2100cm<sup>3</sup> in girls (Kragujević & Rakić, 2004) because of the relatively weak muscle structure involved in the process of breathing. Male and female students of this study have lower values of vital lung capacity (VLC) in comparison to the values obtained in the earlier studies (Kragujević & Rakić, 2004; Zrnzević, 2007). This only

## **MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**

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confirms the observation that the functional abilities are at a low level of development and that after finished school they either stay at the same level as at the beginning or decrease (Marković & Findak, 1997). Physical activity can greatly improve vital lung capacity (Radovanović et al., 2009). School activities should be exclusively performed in aerobic conditions (Janssen & Le Blanc, 2010). Aerobic capacity is developed most successfully by fast and slow running in nature, long distance running of moderate intensity 60-70%, with the heart rate around 150-160 beats per minute (Brown, Ferrigno & Santana, 2000; Malacko & Rađa, 2004).

The intensity of exercises should be at least 50% of the maximum intensity in order for it to lead to positive changes and satisfactory results

(Donnelly, Blair, Jakicic, Manore, Rankin et al., 2009).

The values of heart rate at rest and after exercises in male and female students are greater than the ones obtained in the earlier studies conducted on the same population which is considered as negative (Đurašković, 2002; Kragujević & Rakić, 2004; Zrnzević et al., 2013). In trained people, there is a decrease in the values of the heart rate at rest and after exercises (Radovanović et al., 2009).

Results of a Harvard step test (HAST) indicate that male and female students are at an intermediate level of functional abilities (Mazur & Woynarowska, 2003). The obtained values are lower than the ones obtained in the studies conducted earlier (Kragujević & Rakić, 2004; Zrnzević et al., 2013).

## **MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS**

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### **CONCLUSION**

The results of this research have shown that there are no statistically significant differences between male and female first-grade students in terms of growth and functional abilities. No significant difference has been established regarding the growth and development variables (height, body mass and body mass index) by univariate analysis. By analyzing variables for the assessment of functional abilities of male and female students there is statistically significant difference at the univariate level in heart rate after exercises and Harvard step test in favor of boys. These results are expected, given that boys at this age are more active than girls in physical activities that significantly improve aerobic capacity

(sports games such as football and basketball), while girls are more oriented to games that are not demanding in terms of engaging aerobic capacity (rubber bands skipping, hopscotch, etc.)

Teachers should pay special attention to the development of functional abilities of their male and female students. They should gain a lot of knowledge in this field especially concerning the application of appropriate learning and exercise methods, selection of the appropriate amount of physical load, selection of exercises and methods used for the analysis of exercising effects. Requirements should be raised to another level as well as the motivation for work.

## MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS

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## MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN ELEMENTARY SCHOOL STUDENTS

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### SAŽETAK

Osnovni cilj je bio utvrditi da li postoje razlike u rastu i razvoju i funkcionalnim sposobnostima između učenika i učenica. Za procenu rasta i razvoja i funkcionalnih sposobnosti učenika primenjeni su sledeći parametri: telesna visina, telesna masa, indeks telesne mase, vitalni kapacitet pluća, puls u miru, puls posle opterećenja i index modifikovanog Harvardskog step-testa. Rezultati multivarijantne analize (MANOVA) pokazali su da ne postoji statistički značajna razlika između učenika i učenica u analiziranim varijablama za procenu rasta i razvoja i funkcionalnih sposobnosti. Statistički značajna razlika univarijantnom analizom varijanse (ANOVA) utvrđena je samo u varijablama puls posle opterećenja ( $F=8.36$ ;  $p=.004$ ) i indeksu modifikovanog Harvardskog step testa ( $F=6.67$ ;  $p=.011$ ) u korist učenika. Upoređujući rezultate nekih ranijih i sadašnjih istraživanja, može se zaključiti da aktuelni program fizičkog vežbanja ne daje željene rezultate i ne doprinosi u dovoljnoj meri poboljšanju funkcionalnih sposobnosti učenika i učenica mlađeg školskog uzrasta.

**Ključne reči:** morfološke karakteristike, funkcionalne sposobnosti, fizičko vežbanje, mlađi školski uzrast, harvardski step-test.

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# KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

KINETIČKI POKAZATELJI METODA TRENINGA I SELEKCIJA MLADIH VESLAČA

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## ABSTRACT

*Modern diagnostics in rowing enables more and more possibilities for recording, and comparing numerous stroke variables. At the same time, many coaches fall into the trap of strict respect for the prescribed norms, ratios, and temporarily results, which the athlete must achieve if he wants to stay in the world of competitive rowing. On the example of the comparison of rowing schools RC "Danubius" and RC "Partizan", descriptive indicators are on the side of RC "Danubius" at a time of 2000m, average force and average power. No significant differences were found in average force ( $sig = 0,167$ ) between rowers of RC "Danubius" and RC "Partizan", while statistically significant differences were recorded in time at 2000m ( $sig = 0,036$ ) and power ( $sig = 0,02$ ) in favor of rowers of RC "Danubius". On the other hand, a higher correlation of average force (-0,955) and power (-0,928) with time on 2000m was achieved by RC "Partizan" than RC "Danubius" (-0,931) and (-0,896). The correlation between the average force, and the average power within one team shows a higher correlation for RC "Partizan" (0,95) compared to RC "Danubius" (0,755). The obtained results are not enough for single rower or crew elimination from competition to recreational section in the process of too frequent and strict selection of rowers, considering different possible ways of building rowing techniques and numerous parasitic factors that may affect measured variables, specially at the age under 14 and novice rowers in general.*

**Key words:** rowing, rowing ergometer, speed, force, power.

# KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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## INTRODUCTION

Rowing is a sport of endurance, but also represents one of cyclic sports, because the movement of rowers is based on repeating the cycle of identical movements (Macanović, 1975). Rowing involves cyclic movements and, above all, it shows the force of the flexor, the arm of the torso extensor and the extensor of the lower extremities (Farfelj, 1972). Rowing belongs to a group of sports that is mainly characterized by the development of endurance with optimal investment of power of different intensity. The technique is aimed at saving the consumption of physical power and increasing the effects of optimal investment of force (Harre, 1973). Rowing is a sport in which a combination of several skills and characteristics (technique, endurance, rhythm, balance, etc.) is required to achieve a sport result. The length of the rowing race is 2000m, which lasts between 5 and 7 minutes. This fact has the consequence is that only persons of a certain genetic predisposition have the ability to achieve top sporting results in rowing (Lukač et al., 1999).

The cyclical character of the rowing technique enables the construction of a rowing ergometer that faithfully simulates the movement in a boat, of all components except balance (Liquori, 1986). The first patents for rowing trainers date back to 1871. As early as 1901, a hydraulic rowing machine was constructed. The company "Concept II" from Morrisville (USA) modernized the rowing trainer in 1981 by making a special aluminum disc with fins (for loading) and installing a mini computer. With constant training, the rowing machine "Concept II", through models "B", "C" (1994), "D" (2003) becomes the most common and adequate device for training and checking the physical and functional abilities of competitors in rowing (Dreissigacker, 2003).

Training machines have a great contribution in training programming, evaluation of training effects and evaluation of results (Group of authors, 1976). The study

found that neuromuscular coordination in imitation of stroke movements on a rowing ergometer is approximately equal to that in a boat (Nowicky et al., 2005). The manufacturer of the ergometer, Concept, made it possible for the achieved speed and other values of biomechanical variables on the rowing ergometer to correspond to the conditions of rowing in a coxless four (Dreissigacker 2003).

A high correlation was observed between water rowing and the "CONCEPT II" rowing ergometer (Lamb, 1989). This ergometer showed certain advantages over the others, but the differences are insignificant from the point of view of kinematics (Steer et al., 2006) and electromyography (Nowicky et al., 2005). Ergometers differ from training machines in that they can measure the work done (Rajković, 2015). The force and power variables are usually monitored on the ergometer display during training and testing, in addition to pace and speed. Proper distribution of force and power enables sufficient and proper muscle relaxation during the passive phase of the stroke (Mitrović, Rajković, 2020).

Periodic control of rowers is necessary to obtain feedback on the reaction of athletes to training, as well as to accurately determine the intensity of subsequent loads in training (Grujić et al., 1988). In sculling and sweep rowing, we can talk about a unique technique of performing a sports task. This unique rowing technique can be achieved in several ways depending on the discipline, weather conditions, water characteristics, waves, etc. Thus, we can assume that the biomechanics of rowing can be observed through sports specialization (age categories, gender, scull and sweep, larger - smaller boat, a certain rowing school, etc.) and that the improvement of technique leads to the formation of a flexible motor program of the same basic rowing technique. (Mitrović, 2003a). While the age group of 11-14 is considered the best to start rowing training, the

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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period from 14 to 16 is considered the best for the specialization process so that top results can be expected between the ages of 22 and 25. (Bompa, 2001). Rowing is one of the sports of late specialization. Athletes are recommended to participate in various activities and sports before specializing in rowing.

The athlete's specialization in rowing before reaching the age of 10 can lead to uneven and inadequate physical development, as well as incomplete development of sports skills, injuries due to overload and early quitting (Taylor, 2010). An additional unknown is introduced by the sensitive periods of motor skills development, which individually and depending on the intensity of stimulans, affect the development of young athletes. The development of several very important motor skills (for men) such as explosive power (13-17 years), maximum power (14-18 years), endurance in power (11-17 years) and aerobic endurance extends through three competition categories. (15-18 years), (Meinel, Schnabel, 1976; Martin, 1980; Volkov, 1986; according to

Issurin, 2009). Information on which biomechanical parameters play a leading role in competitive rowing is important for researchers and coaches. They are sometimes decisive in the early selection of rowers, which often interrupts the careers of promising rowers or rowers whose coaches have embarked on a long-term development path rather than on the path of quick and easily achievable results. Different time norms at 2000m, force, power and other variables are used at the club, age and representative level. Often the correct and patient work of the coach leads his team to regression from competitive to recreational crew, while fast results without a good basis extend which later leads to a stalemate in progress. This article is an attempt to discover the regularities of the relationship between force and power, but also by comparing the similarities, and differences between the two rowing schools to emphasize possible generalization errors, under the influence of numerous parasitic factors.

### METHODS

A Fitrower instrument from Weba Sport, which is connected to a computer with a probe, is placed on the rowing ergometer. The measuring instrument measures the time, force and length of movement of the handle. As a result, the computer calculates the power from the obtained data. Force and power are recorded in this way at each moment of the stroke, so the average force and power are obtained as the arithmetic mean of the measured forces and power during one stroke, or during the entire rowing interval. Experiment participants received verbal advice from the coach on how fast to row in order to achieve their best result on the 2000 m test. The sample consisted of 19 rowers age under 14, 7 from RC "Danubius" and 12 from RC "Partizan". These clubs were chosen because they represent the bearers of the

quality of rowing in Serbia, RC "Danubius" in Vojvodina, and RC "Partizan" in Belgrade. In almost all rowing clubs in Serbia, training is done in a similar way. The variables used to assess the quality of rowing are average force and average power. Based on the collected data, descriptive statistics, central tendency measures and variances for the measured variables were calculated. Statistical significance was checked by T-test for independent small samples, while due to a clearer understanding of the relationship between the stroke variables, the bivariate correlation method was used, where Pearson's correlation coefficients with numerical expression of significance were calculated. All statistical data were processed by the statistical software package SPSS Statistics 20.

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

### RESULTS WITH DISCUSSION

The category of age under 14 is initially characterized by a large number of participants in the rowing school, where numerous differences are manifested, which are gradually less manifested by the influence of training. Some of the rowing technique pattern are learned very quickly, which is concluded at the level of absolute values, as well as the significance of differences, variability and correlation (Rajković, 2015).

**Table 1.** Descriptive statistics for rowers from RC "Danubius"

RC „Danubius“ age under 14							
	Hight (cm)	Age (month)	Weight (kg)	Sport experience (year)	Time 2000m (s)	Fsr (N)	Pstr (W)
average	181.86	172.71	70.43	1.14	453.74	384.93	286.18
st dev	2.79	4.15	10.29	0.38	9.92	31.70	28.14
var coef	0.015	0.024	0.146	0.331	0.022	0.082	0.098
min	178.00	166.00	60.00	1.00	439.60	345.84	232.71
max	186.00	177.00	88.00	2.00	465.70	426.15	314.67
range	8.00	11.00	28.00	1.00	26.10	80.31	81.97

**Table 2.** Descriptive statistics for rowers from RC "Partizan"

RC „Partizan“ age under 14							
	Hight (cm)	Age (month)	Weight (kg)	Sport experience (year)	Time 2000m (s)	Fsr (N)	Pstr (W)
average	176.00	163.58	66.00	1.42	481.26	352.34	232.34
st dev	6.32	9.39	10.07	0.79	38.84	54.04	50.54
var coef	0.036	0.057	0.153	0.560	0.081	0.153	0.218
min	166.00	152.00	56.00	1.00	432.80	268.40	167.30
max	185.00	177.00	92.00	3.00	531.90	422.40	325.93
range	19.00	25.00	36.00	2.00	99.10	154.00	158.63

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

**Table 3.** T-test for time at 2000 m, average force and average power of rowers RC "Danubius" and RC "Partizan"

T-test for Equality of Means										
Variables	Equal variances	Levene's Test for Equality of Variances		t	df	sig	Mean diff.	Std. Err. Diff.	95% confidence interval of difference	
		F	Sig						Lower	Upper
T 2000m (s)	assumed	23.43	0.000	1.82	17	0.086	27.515	15.121	-4.388	59.419
	not assumed			<b>2.327</b>	13.295	<b>0.036</b>	27.515	11.823	2.03	53.001
Fav (N)	assumed	2.778	0.114	<b>-1.445</b>	17	<b>0.167</b>	-32.558	22.53	-80.092	14.976
	not assumed			-1.655	16.975	0.116	-32.558	19.672	-74.068	8.951
Pav (W)	assumed	4.417	0.051	<b>-2.575</b>	17	<b>0.02</b>	-53.837	20.906	-97.945	-9.73
	not assumed			-2.982	16.997	0.008	-53.837	18.055	-91.93	-15.744

Comparing the two rowing schools, or in some other case two rowers at an early age is hampered by the fact of sudden and turbulent changes during the age under 14, which can significantly limit the interpretation of the obtained results, which is the main message of this study. Comparing the time at 2000m, force and power between the two clubs, it can be concluded that RC "Danubius" achieves better values in all three variables, while a statistically significant difference was recorded at time on 2000m and power, while there are no statistically significant differences in average force, which is expected considering the results of previous research. In the review of previous research, a great difference of results is noticed in different researchers, when it comes to maximum force, average force, work performed and average power of rowers (Zatsiorsky, Yakunin 1991). It is also stated that the force in the boat has been measured in different ways in the past, on the oarlock, the footstretcher, oar

grip and the blade. The results were often surprising because some rowers who achieved less force had higher average boat speeds (Filter, 1997). It is also stated that the average force on the oar handle of top skiers is around 500N. According to Archimedes, when this force is calculated with respect to the ratio of the size of the inner and outer arm of the oar, a force of about 200N is obtained on the paddle blade. Very interesting is the large range in the obtained maximum and average tensile forces manifested on the handrail of rowers in recognized researchers, (Zatsiorsky, Yakunin 1991). The character of the force curve changes over time depending on the section being paddled, the pace, the speed of the boat, the heart rate and the energy sources. Thus, the trapezoidal shape of the force-time curve corresponds to aerobic energy sources, low pulse, sections of about 15 km, continuous training method, low power values, large force values and small boats (skiff).



## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

With the increase of rowing speed, with shortening of sections, but also with rowing in group boats, the pulse increases as the force increases, the force decreases, and the force curve takes more and more shape with a characteristic peak with a steeper force establishment curve, which is manifested through a shorter force gradient (Bachev, Neykov, 2005). Comparing the results at 2000 m (Table No. 3), it can be concluded that the rowing school of RC "Danubius" (Table No. 1) achieved slightly better results than the school of RC "Partizan" (Table No. 2). However, the difference in the results can come from several factors: the age of the rowers, the weight of the rowers, body height, sports experience, degree of constructed rowing technique, tactical skills and performance, competition experience, current fitness abilities, possible differences between the chronological and biological age of the rowers, previous selections, etc. The results

may also differ due to the different approach in rowing school among beginner rowers. This is supported by the differences in the values of average force and average power, where Danubius rowers also achieve better results.

A special question can be asked about the funds used by the coaches of the two compared schools during the training. For example, the use of a galley (which is usually used in training by both clubs) - a school boat with 12 seats where rowers sit in two rows of 6 rowers, can significantly increase the amount of force and power of rowers, consequently both force and power later in the competition boat, but in case of overuse can disrupt the fine mechanisms of temporal and spatial variables of rowing (Rajkovic et al., 2011).

**Table 4.** Correlation between time at 2000 m, average force and average power of rowers RC "Danubius"

RC "Danubius"	Fav (N)		Pav (W)	
t 2000m (s)	Pearson C.	<b>-0.931</b>	Pearson C.	<b>-0.896</b>
	Sig	<b>0.002</b>	Sig	<b>0.006</b>
	N	7	N	7

**Table 5.** Correlation between time at 2000 m, average force and average power of rowers RC "Partizan"

RC "Partizan"	Fav (N)		Pav (W)	
t 2000m (s)	Pearson C.	<b>-0.955</b>	Pearson C.	<b>-0.928</b>
	Sig	<b>0.000</b>	Sig	<b>0.000</b>
	N	12	N	12

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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These results do not mean that the rowing school RC "Danubius" has better quality. Achieved extremely high negative and significant correlation between time at 2000 m and average force, but also time at 2000 m and average strength in both rowers RC "Danubius" (Table No. 4) and rowers RC "Partizan" (Table No. 5) is expected because the time at 2000 m represents the reciprocal value of the speed which is directly related to the average force and power. Although the RC "Partizan" rowers recorded slightly worse results in speed (expressed here in the usual rowing manner through a rowing time of 2000m), force and power, they recorded a slightly higher degree of correlation between force and speed, and power and speed, than the RC "Danubius" rowers. A

possible explanation for this phenomenon is that RC "Danubius" rowers achieve higher speed values with a smaller share of force and power, and a larger share of some other paddle variables such as: time variables (frequency, duration of active and passive paddle phase, rhythm) and paddle length. The question is what did the coaches of the mentioned clubs actually work on, or before, which way is right? Whether working first on the length of the stroke or higher force, or working at a higher pace, or a different rhythm with slightly lower values of force. This raises the question of short-term measurable results, but also proper long-term development. When, and should anyone be rejected at all in the selection process in the two mentioned clubs?

**Table 6.** *Correlation between the average force and the average power of the under 14 rowers of RC "Partizan" and RC "Danubius"*

RC "Danubius"	Pav (W)	
Fav (N)	Pearson C.	<b>0.755</b>
	Sig	<b>0.05</b>
	N	7
RC "Partizan"	Pav (W)	
Fav (N)	Pearson C.	<b>0.95</b>
	Sig	<b>0.000</b>
	N	12

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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Comparing the correlation between force and power, especially the rowers of RC "Partizan" and the rowers of RC "Danubius" (Table 6), it was concluded that the rowers of RC "Partizan" achieved values of rowing speed with a slightly higher share of force in the manifestation of power compared to Danubius rowers. In the Danubius rowers, it is possible that some other variables contributed to the speed values (length of stroke, duration of active and passive phase, pace and rhythm). The recorded results are associated with two leading world rowing schools, the Australian and the American, related to the calculation of rowing time norms, sections and pace, where one of the schools favors a slightly longer one, while the other favors a slightly stronger stroke (Ilić, Rajković, 2009). Both ways of standardizing rowing norms, which occurs in the later stages of training of mature rowers, are wrong if they are literally transcribed, and if the specific characteristics of each individual rower are not taken into account (Rajković, 2015). Comparing the rowers under 14 of the two clubs is often important during selecting process within clubs, but also when selecting for different national teams. The comparison given in this article can have great consequences for the further careers of young rowers, while the possible conclusions can be wrong due to the different way of reaching the compared values of force and power. A large number of eventual possible parasitic factors, such as the most common situation in practice, do not allow quick and one-sided conclusions. Any possible differences that can be noticed between two rowers or two groups of rowers, do not necessarily have to be significant and crucial for the harsh process of reaching different norms and selection in rowing clubs. Therefore, in the continuation of the

article, emphasis is placed on several factors that may or may not affect the neglect of the observed differences in kinetic variables. Body height and weight have a great influence on the success of rowing results (Žeželj, 1978; Marinović, 1989). The greatest acceleration of the increase in body height occurs on average around the age of 12 for men. At puberty, changes in height are accelerated again and are accompanied by an exponential decrease to fully reached height in men around the age of 18. Body weight in men follows the trend of development of body height, but it is still defined a little later, around 14.5 years of age. Muscle mass naturally increases continuously with the increase of body mass up to the highest values at the time of the strongest secretion of the male hormone testosterone, during puberty. (Fratric, 2006). During late childhood and early adolescence, athletes of the same chronological age can differ up to 5 years in their maturity. It is necessary for coaches to understand these differences in speed of development and to take them into account when designing training and selecting athletes (Taylor, 2010). What makes it difficult to make the right coaching decisions is the existence of large differences in morphological, biological and calendar age among young athletes (Ugarković, 1996).

These differences depend on various factors, of which the climatic, geographical, food, endocrine and environmental influences stand out (Medved, 1966). At a younger age, the best athletes are more mature than their peers, while at an older age, the best are those who have matured on time or those who are late in maturing (Troup, 1991, according to Issurin, 2009). During sensitive periods of development of physical abilities, it often happens that children born in the first half of the year achieve

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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the best results, so significant differences in the assessment of children's abilities can be obtained within the same year with relatively close morphological and biological ages. Even the defined norms and standards for the assessment of body height, weight and physical abilities in young people become obsolete in 5 to 10 years due to the phenomenon of acceleration. The influence of biological development on sports results is evident, so it is necessary to adjust the norms and standards in a particular sport (Paranosić, Savić 1977), in this case rowing.

### CONCLUSION

By comparing the force and power of the rowers under 14 of RC "Danubius" and RC "Partizan" in the 2000m rowing test with maximum intensity, we obtained results that give a slight advantage to VK "Danubius", with statistical significance of differences in time on 2000m and power, while there is no significant difference in average force. Further analysis of the relationship between speed (time at 2000m) and force and power, obtained small differences in correlation, which may lead to conclusions of different approaches to work in clubs, but do not give enough arguments to reject one of the teams in the selection process. The correlation of force and power within both teams separately provides additional data on the construction of each stroke in terms of the contribution of individual kinetic variables, but even that does not provide significant information that can reject one of the teams and direct them from competitive to recreational treatment. All of the above should be kept in mind when selecting or postponing the selection of rowers, so coaches should be patient and wait for the maturation of

Indicators of age, height and weight for rowers are very important, but they are not able to replace the level of preparation in terms of power, endurance, motivation and will, which along with effective technique allows to achieve top results (Bača, 1976). Comparing the results of previous studies with the results obtained in this study, it can be concluded that the numerical indicators of force and power during training and testing are not sufficient indicators for strict selection that is constantly carried out in rowing.

their athletes. In doing so, transient goals do not always correspond to the ultimate goal or the model to be pursued. First of all, coaches need to know what the goal of certain periods in training is in terms of development, or it can be said in terms to learn optimal values of force and power involved in boat speed as a final results. In addition to the initially measured and final focused values of the measured biomechanical variables of rowing during a single rowing or average values during rowing of differently selected sections, transient values and periodic changes that must be monitored by the coach are very important.

At the same time they should not attach much importance by imposed norms or in comparison with previous generations. Each individual rower should be given the chance to build their rowing skill in their own specific different way, given the mentioned large differences in a number of parasitic factors related to the comparison in this study.

## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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At the same time, the coaches and club management should show a certain amount of patience, and wait for the natural maturation of the rower and his multi-layered mastery of rowing technique, tactics and fitness. The rapid progress in the category of age under 14 and age between 14 and 16 is a particularly important phenomenon. It happens very often and is characterized by alternating breakthroughs in the notions of rowing, technique, fitness, values of force, power, pace...

Every sudden progress in one area disrupts the fine relationships between systems, so it takes some time to manifest the new quality at the speed achieved on the ergometer or the speed of the boat (Rajković, 2015).

In doing so, commitment for two extremes, such as the American or Australian system, or any attachment to numerous values

power and speed, should by no means be a reference point solely on the basis of sympathy, available literature or coach experience and corresponding prejudices.

A simple but rarely applied approach is to adapt tasks and passing goals to each individual athlete while keeping records of, among other things, the achieved kinetic variables of the stroke and patient continuous work, and waiting for the natural maturation of the athlete, without strict selection and rejection of young rowing athletes when they have not even matured as persons and athletes.

The direction of future research could be in the longitudinal monitoring of kinetic variables of rowers, where different patterns of reaching the transient and final normalized values of kinetic variables of rowing are expected.

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## KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

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### SAŽETAK

Savremena dijagnostika u veslanju omogućava sve više mogućnosti za beleženje i poređenje brojnih varijabli zaveslaja. Pri tom mnogi treneri padaju u zamke strogog poštovanja propisanih normi, odnosa i prolaznih rezultata, koje sportista mora ostvariti ukoliko želi da ostane u svetu takmičarskog veslanja. Na primeru poređenja veslačkih škola VK "Danubiusa" i VK "Partizan", deskriptivni pokazatelji su na strani VK "Danubius" kod vremena na 2000m, prosečne sile i prosečne snage. Prosečna sila, ne beleži značajnost razlika između veslača VK "Danubius" i VK "Partizan" ( $\text{sig}=0,167$ ), dok su zabeležene statistički značajne razlike kod vremena na 2000m ( $\text{sig}=0,036$ ) i snage ( $\text{sig}=0,02$ ) u korist veslača VK Danubiusa". S druge strane veću korelaciju prosečne sile (-0,955) i snage (-0,928) sa vremenom na 2000m ostvarili su veslači VK "Partizan" od veslača VK "Danubius" (-0,931) i (-0,896). Korelacija između prosečne sile i prosečne snage unutar jedne ekipe pokazuje veću korelaciju kod veslača VK "Partizan" (0,95) u odnosu na veslače VK "Danubius" (0,755). Dobijeni rezultati nisu dovoljni da se jedna od ekipa ili pojedini veslač u nekom sličnom poređenju izbaci iz takmičarskog pogona u procesu previše čestih i strogih selekcija veslača, obzirom na različite moguće puteve izgradnje veslačke tehnike i brojnih parazitarnih faktora, koji na navedene varijable mogu uticati, posebno u uzrastu pionira i veslača početnika uopšte.

**Ključne reči:** veslanje, veslački ergometar, brzina, sila, snaga.

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# INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

UTICAJ PROGRAMSKIH SADRŽAJA VJEŽBANJA  
NA OSOBE TREĆE ŽIVOTNE DOBI  
OBOLELE OD DIABETES MELITUSA TIP 2

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## SUMMARY

*The research included seven original scientific papers. All of them addressed the main problem and could give an adequate answer. The aim of this study was to determine the impact of exercise content on people with type 2 diabetes mellitus (DM) and the importance of this activity on the health of people with this problem. The selection of works from 2002 to 2019 was taken as a method. We conclude that the physical activity of people with DM is partially limited due to the specificity of the disease. Special attention should be paid to side effects, especially hypoglycemia. Exercise frequency should be at least three days a week for aerobic activities and two days a week for resistance activities. The risk of hypoglycemia is increased, glycemic control in this population is more difficult to achieve. The goals of DM management in the elderly should be set differently for each patient.*

**Key words:** *diabetes mellitus, physical activity, elderly, type 2 mellitus, exercise program, glycemic control.*

## INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

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### INTRODUCTION

Diabetes mellitus is a syndrome characterized by chronically elevated blood glucose level (above 6.1 mmol / l) and disorders of carbohydrate, fat and protein metabolism associated with absolute or relative deficiency of insulin secretion and / or insulin action. (Stefanović, et al., 1980; Đukanović, et al., 2010). Diabetes mellitus type 2 (DM) is a major cause of serious health problems in the elderly. In addition to well-known microvascular (retinopathy, nephropathy, neuropathy) and macrovascular (coronary heart disease, cerebrovascular disease, peripheral vascular disease) complications, older people with diabetes may also suffer from devastating conditions such as depression, cognitive impairment, muscle weakness, fractures, and physical weakness (American Diabetes Association, 2012; Sinclair et al., 2012). Chronic hypoglycemia in DM is associated with damage, dysfunction of various organs, especially eyes, kidneys, nerves, heart and blood vessels (Sučić & Škrabalo, 1990). Older people with DM have altered body composition, decreased skeletal muscle strength, and poor muscle quality in general (Park et al., 2006). Good control of DM depends on constant monitoring of blood glucose, proper medication, diet and especially physical activity (Schuster & Duvuuri, 2002). Proper physical participation and exercise can

prevent or delay the onset of DM in a high-risk population (Schneider & Elouzi, 2000). The potential risk of developing insulin-independent diabetes, with moderate or intense exercise, which is performed regularly, reduces the possibility by 30-50% compared to inactive individuals (Manson & Spelsberg, 1994). Physical activity is a powerful therapeutic tool in various patients with diabetes or risk for its development. However, before recommending physical activity, the team of doctors who treat DM must carefully weigh the benefits and possible risks of exercise that may occur in given patients (Baretić., 2017). Despite a number of beneficial effects, in a number of people with DM, exercise can be a burden because their glucoregulatory mechanisms are not at an adequate level (Lindstrom et al., 2006). In older people with DM, the risk of disability related to mobility and daily tasks is increased by twice as much as those who do not suffer from this disease (Gregg, Engelau & Narayan, 2002). Exercise has positive effects on many processes in people with diabetes, the most important of which are: increase in insulin sensitivity, increase in VO<sub>2</sub> max, reduction of body weight, which improves blood glucose control, prevention of cardiovascular diseases etc.

# INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

## METHODS

Research data for the purposes of this paper were collected through electronic databases PubMed, Scholar Google, DOAJ. The search of works was done in the period from 2002 to 2019. The following keywords were used in the database research: diabetes mellitus, physical activity, elderly, mellitus type 2, exercise program, glycemic control. The found research titles, abstracts and full texts were then read and analyzed. In order for the research to be accepted for the final analysis, it had to meet

two criteria: the first criterion refers to the issue of DM in the elderly (40 - 67 years of age), the second criterion is the analysis of works in the selected period. The research that met the set criteria was then analyzed and presented on the basis of the following parameters: reference (first letter of the name of the author, year and year of research publication, sample of respondents (age, total number and subgroups of respondents), applied exercise program, program duration and research results.

## RESEARCH RESULTS

Based on the key words, 263 works were identified. The number of studies that were immediately excluded on the basis of titles, duplicate papers, as well as papers that were excluded on the basis of the period when they were published (older than 2002) is 228, while 35 papers were included in further analysis.

Further analysis of 35 papers excluded 28 papers based on several criteria: abstract, because it was a systematic review research, as well as the absence of a control group in the research. The remaining seven papers met the set criteria, namely: being published in the period from 2002 to 2019, and participants who all had DM.

**Table 1.** Procedure for collection, analysis and elimination of found works

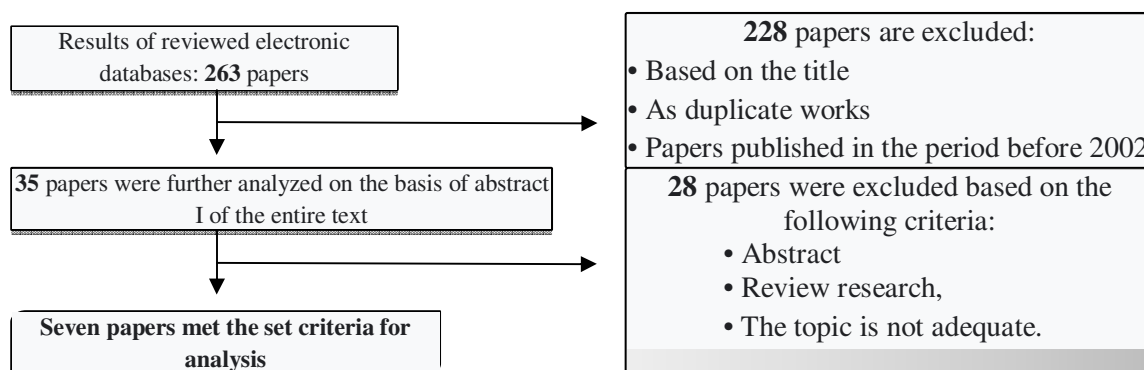


Table 1 shows the entire protocol on the basis of which the works that met the set criteria were selected.

## INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

*Table 2.* Overview of works

Reference	Populacija	Grupacija	Tretman	Protokol	Rezultati
<b>Castaneda et al. (2002)</b>	Population M. and F. 66 +/- 8 suffering from DM	n=40 (Ž) n=22 (M) random division on EG and KG	EG- training PO high intensity; CG- UA control GK, MS, ST.	TT - 16 weeks, 3x weekly	Improvements in all tested variables. High-intensity PO training improves the control of MS-associated GC in DM individuals.
<b>Loimaala et al. (2003)</b>	Population M. 53.3 +/- 5.1 suffering from DM	n=50 (M) random division on EG and KG	Effect asse TT na BRS, HRV, VO <sub>2max</sub> .	TT - 12 month, 2x weekly	Improvements in BRS and sensitivity to DM, increase in blood pressure, muscle strength and glucose control. Improving the prognosis from a person with DM
<b>Brooks et al. (2006)</b>	Population M. 55 +/- 6 suffering from DM	n=62 (M) random division on EG and KG	EG - (health care +TT); CG - (UA) TS n, HM, IK, protein, FFA.	TT - 16 weeks, 3x weekly	TS improves the quality of muscles and the whole body and KI. The use of this program in the ongoing monitoring of persons with DM remains to be considered.
<b>Bello et al. (2011)</b>	Population M. 46,22 ± 9,79 suffering from DM	n=18 (M) random division on EG and KG based on TG.	EG –individually prescribed AV CG – (UA) GK, GH, LVG, LNG, WHOQ	TT – 8 weeks, 3x weekly, 30 min.	TT AV showed significant improvement. Not in all variables, but in most. Quality of life improved.
<b>Moura et al. (2014)</b>	Population M. 51,1 ± 8,2 suffering from DM	n=8 (M), only EG.	EG – consumption VO <sub>2max</sub> na 50 – 60%. Body composition, GK, FZ, KGK.	TT – 8 weeks, 3x weekly, 30 – 60 min.	After TT increase VO <sub>2max</sub> . Progress in GC control. This TT is effective and can replace additional medications.
<b>Yavari et al. (2015)</b>	Population M. 40-65 suffering from DM	random division on EG and KG EG=35; KG=30 respondents	EG – aerobic training; CG – standard activities GH, GK	EG - 16 weeks, 3x weekly, 90 min.	In EG GH significantly reduced. Changes in body weight, significant reduction in pressure. GC control can be achieved with such TT.
<b>Mikolčević, J. (2019)</b>	Population M-F. suffering from DM	n= 100	The survey method was used. Data about age, education, marital status, place of residence and the type of therapy used by the respondents were collected.	The questionnaire examines the physical, mental or social consequences of limited health.	By analyzing the results obtained by the research, we come to the conclusion that type 2 diabetes has a greater impact on the physical than on the emotional health of patients. Patients feel less restricted in performing physical activities.

M.-male; F- female; DM-diabetes mellitus type 2; EG-experimental group; CG-control group; PR-progressive resistance; UA-usual activities; GK-glycemia; MS-metabolic syndrome; BC-body composition; TT treatment; BRS- baroreflex sensitivity; HRV-heart rate variability; VO<sub>2max</sub>-maximum oxygen consumption; Skilled exercise capacity; TS strength training; HM-muscle hypertrophy; IK insulin control; FFA-free fatty acids; SB-secret ballot; AE-aerobic exercise; GH - glycosylated hemoglobin; High-density LVG-lipoprotein; Low density LNG lipoprotein; WHOQ-questionnaire by the health organization on quality of life; FZ-fructosamine; CBG-capillary blood glucose.

## INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

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### DISCUSSION

Table 2 contains an overview of papers dealing with the exercise program in elderly people with DM. The table shows the results of applying a particular exercise program, as well as the methods used in working with these individuals. The analysis of the table shows that various exercise programs generally give positive results in the rehabilitation of people with DM.

The first paper of the table contains research data conducted on a sample of 66 respondents, 40 female respondents and 22 male respondents. The subjects were 66 +/- 8 years old. The sample was randomly divided into experimental and control groups. The experimental group was subjected to a high-intensity progressive resistance program, while the control group had normal activities. The experimental program lasted sixteen weeks with a frequency of three training sessions per week. The results on the control measurement in the experimental group showed statistically significant improvements in all tested variables. This type of treatment improves the glycemic control associated with the metabolic syndrome in people with diabetes mellitus (DM).

The second part of the table contains data from a research conducted on a sample of 50 male respondents. The subjects were 53.3 +/- 5.1 years old. The sample was randomly divided into experimental and control groups. The

experimental group was subjected to a program that monitored baroreflex sensitivity (a measure of the body's ability to change heart rhythm depending on changes in blood pressure, diabetes), frequency variability and maximum oxygen intake. The experimental program lasted 12 months with a frequency of two trainings per week. The results indicate an improvement in baroreflex sensitivity, an increase in exercise capacity, muscle strength and glucose control. This type of treatment improves the prognosis in people with DM.

The third part of the table contains data from a research conducted on a sample of 62 male respondents. The sample was randomly divided into experimental and control groups. The subjects were 55 +/- 6 years old. The experimental group underwent a strength training program and nutrition care. The control group had normal activities. The experimental program lasted sixteen weeks with a frequency of three trainings per week. Strength training improves the quality of muscles and the whole body and acts on insulin control. The use of this program in the ongoing monitoring of persons with DM remains to be considered.

The fourth paper of the table contains data from a research conducted on a sample of 18 male respondents. Ages 46.22 ± 9.79 years. The sample was randomly divided into experimental

## INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

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and control groups. The experimental group underwent an aerobic exercise program, while the control group had normal activities. The parameters of lipoproteins, glycemia as well as the questionnaire by the Health Organization for quality of life were measured. Aerobic training has contributed to the quality of life and improvement of most variables, not all.

The fifth paper of the table contains data from a research conducted on a sample of 8 male respondents. Ages  $51.1 \pm 8.2$  years. The study had only an experimental group and an aerobic program with monitoring of maximal oxygen consumption, body composition, and capillary glucose. The results show a significant impact of the eight-week program with a frequency of 3 workouts per week on all parameters with the conclusion that drug intake under this treatment can be significantly reduced.

The sixth paper of the table contains data from a survey conducted on a sample of 65 respondents. The respondents were aged 40-65 years. The sample was divided into an experimental group with 35 subjects and a control group with 30 subjects. The experimental treatment had the application of aerobic training with monitoring of glycosylated hemoglobin (GH) and glycemia. The program lasted 16 weeks with a training frequency of 3 times a week for 90 min. After the experimental

program, GH was significantly reduced, there were changes in body weight and arterial blood pressure. With this type of treatment, it is possible to control glycemia within 16 weeks.

The seventh paper of the table contains data that was conducted at the Department of Internal Medicine OB "Dr. Josip Benčević" in Slavonski Brod. The study included 100 patients with type 2 diabetes. Data were collected through a questionnaire survey. The method of personal interrogation was used. Data were collected on age, level of education, marital status, place of residence and the type of therapy that respondents receive. The questionnaire examines the physical, mental or social consequences of limited health. Results: Analyzing the results of the research, we conclude that type 2 diabetes has a greater impact on the physical than on the emotional health of patients. Patients feel less restricted in performing physical activities. Respondents who assess their health more positively, have a better level of physical functioning, less physical or emotional problems interfere with social activities and perform the desired number of activities. The quality of life of people with type 2 diabetes is of great importance.

The quality of life of the patient will also depend on the way in which the patient will maintain a good general condition.



## INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

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### CONCLUSION

Elderly people must be encouraged to exercise. The aging process leads to degeneration of muscles, ligaments, bones and joints, and inactivity and DM can exacerbate this problem. For this reason, we must take care of the selection of patients with this disease and the control of diabetes and taking care of it. Regular exercise and physical activity also have special benefits for people with DM, such as the body's sensitivity to insulin, helping to regulate blood glucose levels, weight and blood pressure. Physical activity is one of the best complementary factors in the regulation of type

2 diabetes, for both men and women. Preparing people with DM for safe and useful exercise is just as important as the exercise itself. Exercise frequency should be at least three days a week for aerobic activities and two days a week for resistance activities. The risk of hypoglycemia is increased, glycemic control in this population is more difficult to achieve. The goals of DM management in the elderly should be set differently for each patient. Type 2 diabetes affects the quality of life, but a positive and responsible attitude towards the disease can provide patients with a better quality of life.

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## INFLUENCE OF EXERCISE PROGRAM CONTENT ON ELDERLY PERSONS WITH DIABETES MELITUS TIP 2

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### SAŽETAK

*Istraživanje je obuhvatilo sedam originalnih naučnih radova. Svi radovi su zadovoljili problematiku i mogli su da daju odgovor na postavljeni problem. Cilj rada je bio da se utvrdi uticaj programskih sadržaja vežbanja na osobe koje boluju od diabetes melitusa tipa 2 (DM) i značaj navedene aktivnosti na zdravlje osoba sa ovim problemom. Kao metod uzeta je selekcija radova od 2002. do 2019. godine. Zaključujemo da je fizička aktivnost osoba sa DM delimično ograničena zbog specifičnosti bolesti. Posebna pažnja treba da bude usmerena na neželjene efekte, posebno hipoglikemiju. Učestalost vežbanja treba biti najmanje tri dana u nedelji za aerobne aktivnosti i dva dana nedeljno za aktivnosti sa otporom. Rizik od hipoglikemije je povećan, kontrola glikemije kod ove populacije je teže ostvariva. Ciljeve upravljanja DM kod starijih osoba treba postaviti drugačije prema svakom pacijentu.*

**Ključne reči:** *diabetes melitus, fizička aktivnost, starije osobe, melitus tip 2, program vežbi, glikemijska kontrola.*

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**RELATIONS OF MOTOR ABILITY  
OF BALANCE AND SUCCESS OF PERFORMANCE  
OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE**

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*RELACIJE MOTORIČKE SPOSOBNOSTI RAVNOTEŽE I  
USPJEHA IZVOĐENJA GIMNASTIČKIH ELEMENATA NA PARTERU*

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**SUMMARY**

*The purpose of this study is to investigate the relationship between motor ability for balance and the performance of selected gymnastic elements on the floor in students aged 7-8 years, to provide an overview of the current motor status of the respondents at this age, and to develop suggestions for possible changes in the curriculum at this age, and to develop suggestions for supplementing training methodology. Training of selected gymnastics elements was conducted on a sample of 42 subjects who had no previous experience in performing gymnastics elements during regular physical education classes, and the predictor variable was tested using four tests assessing motor balance ability. The tests assessing motor balance ability showed a statistically significant predictive value for the performance of all three gymnastics exercises. It is noticeable that the value of the prediction model increased the more complex an item was derived, indicating the complexity of the motor balance space and the high and stable level of the same in the subjects at the time of testing. Regarding the tests used, it can be noted that the test FLAM was significantly involved in the prediction of performance success in all three gymnastic elements, while the other two tests showed their predictive value in the execution of the hand stand. On the other hand, the study shows that the gymnastic elements used should be used in physical education classes to contribute to the promotion and development of all motor skills of students and as part of the preparation for the execution of more complex elements on the floor and apparatus in higher grades.*

**Key words:** *gymnastic beginner, physical education, training*

# RELATIONS OF MOTOR ABILITY OF BALANCE AND SUCCESS OF PERFORMANCE OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE

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## INTRODUCTION

Gymnastics is one of the esthetic sports in which it is extremely important to maintain various forms of balance during the execution of individual elements or exercises as a whole, which builds a complex relationship between levels and forms of balance in the execution of movement structures in gymnastics (Cohen, 2002). Živčić Marković and Krističević (2016) classify all sports in which acrobatic skills are performed on gymnastics equipment or with props, with several related branches: rhythmic gymnastics, acrobatics, trampoline, aerobics, including and gymnastics (Mezga, I., 2020). According to Vidović (2008), balance can be defined as the ability to maintain a stable body position in certain postures or positions (balance, hand stand, one-legged stance, etc.), during movement (running, walking, skating, skiing) and at the end of movement (landing after jumping, jumping on/off the apparatus, etc.). The literature identifies three types of balance: stable (body center of gravity is below the supporting surface), unstable (body center of gravity is above the supporting surface), indifferent (body center of gravity is at the supporting point), and static (ability to maintain a balanced position for as long as possible posture), dynamic (ability to maintain a balanced - stable position in movement - movement for as long as possible) and balancing objects; where all types of balance can be performed with open and closed eyes (Kurelić et al. 1975). Many children acquire the first knowledge of mastering the basic dynamic and static positions of the body during physical education in the first triad through basic gymnastic training (Novak, D., Kovač, M., Čuk, I. 2008, Živčić Marković 2007, 2010). The part of the gymnastics program that is applied from 1st to 4th grade is called

beginner gymnastics and emphasizes that children's development occurs through the development of coordination, balance, flexibility and strength (Hmjelovjec, I., Redžić, H., Hmjelovjec, D., 2004). The program of beginner gymnastics includes simpler gymnastic movements, individual elements and exercises that take place on various gymnastics equipment, with the aim of applying this content to improve the health of children and the development of basic motor skills that will be evident in everyday life (Živčić Marković, Krističević, 2016; Bijelić, S., Živčić Marković, K., Krističević, T., 2018). At this age, we are talking about the end of the sensitive period for the development of motor balance ability (Koprivica, V., 2002; Željaskov, C., 2004), and assuming that there is a level of developmental stabilization, it would be interesting to investigate the relationship between the motor status of girls aged 7-8 and the performance of certain gymnastic elements. Miletić Đ., Srhoj Lj. and Bonacin D. (1998) in their research determined the relationship between the predictor set of motor variables and success in performing elements and compositions in RG on a sample of subjects practicing rhythmic gymnastics, but no individual predictor value of balance as an independent factor was determined. Within the framework of a larger study, Delaš Kalinski (2009) found, among other results, the existence of a statistically significant influence of the predictor motor variables on the performance of gymnastic motor knowledge (shoulder stand, forward roll, etc.). In their research, Madić and associates (2011), on a sample of 120 girls (aged 11-12 years), through the results of a battery of 13 tests of basic motor abilities, evaluated the success of performing six

# RELATIONS OF MOTOR ABILITY OF BALANCE AND SUCCESS OF PERFORMANCE OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE

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gymnastic exercises. The obtained results indicated the predictor ability of motor abilities of strength, coordination, speed and agility to perform selected gymnastic elements on different apparatus. Petković, E. (2004) on a sample of 58 gymnasts aged 7-9 years applied a set of 10 predictor variables and 5 criterion variables to assess athletic success. Using two separate factors, the first responsible for a rapid solution of complex motor tasks and the second representing coordination in rhythm and the correct execution of hand movements in the lateral and frontal planes, it was possible to determine the overall success factor in the execution of short combinations individually on

the horizontal bar, on the beam, floor exercise, and on all apparatus combined. Similar results were obtained in the studies of Prassas, S., Kwon, Y.X., Sands, W.A. (2006), Di Cagno, et al, (2008), Miletić Đ., Srhoj Lj. and Bonacin D., 1998, Živčić Marković (2010), Sleeper, Kenyon, Elliott, & Cheng, (2016). The aim of this study is to investigate the relationship between the motor ability to balance and the performance of selected gymnastic elements on the floor exercise in students aged 7-8 years, in order to get an overview of the current motor state of the subjects.

## METHODS

The sample consisted of 42 respondents aged 7-8 years, with no previous experience in performing gymnastics elements, during the period when the training of selected gymnastics elements took place in regular physical education classes, all respondents were healthy and able to participate in class. The predictor variable was tested using four tests of motor balance ability that have the necessary measures (Metikoš, Prot, Hoffman, Pintar, and Oreb, 1989): standing on one leg crosswise on a balance beam with eyes open; standing on two legs lengthwise on a balance beam with eyes closed; standing on two legs lengthwise on a balance beam with eyes open and a flamingo test.

**Table 1.** *Scale for assessing the quality of performing movement of acrobatics elements*

score	description
<b>0</b>	Unsatisfying technique and amplitude
<b>1</b>	Satisfying technique, small amplitude
<b>2</b>	Satisfying technique, large amplitude
<b>3</b>	Good technique, small amplitude
<b>4</b>	Good technique, large amplitude
<b>5</b>	Very good technique, small amplitude
<b>6</b>	Very good technique, large amplitude
<b>7</b>	Great technique, small amplitude
<b>8</b>	Great technique, large amplitude
<b>9</b>	Excellent technique, small amplitude
<b>10</b>	Excellent technique, large amplitude

## RELATIONS OF MOTOR ABILITY OF BALANCE AND SUCCESS OF PERFORMANCE OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE

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The criterion variable was formed by the assessed success in the performance of selected gymnastic elements: shoulder stand, head stand and hand stand, whose performance was evaluated by three licensed judges of the Gymnastics Federation of Republic of Srpska, with scores from 0 to 10 (Table 1). The scoring was done according to a predetermined set of values, given in tens of points for each exercise, according to the penalties established, leading to a final score of 10.00. The scoring was carried out in accordance with the FIG set of rules for scoring and activities of the judging panel "B" regarding the deduction of performance points, as well as scoring for compulsory exercises - GAY-GASMN set of rules (Petkovic E, 2004). In addition to basic descriptive statistical parameters for all variables, multiple regression analysis was performed to determine the presence of relationships. The results were processed using the SPSS 20 software package.

### RESULTS AND DISCUSSION

**Table 2.** *Intraclass correlation coefficients*

shoulder stand	0.991
head stand	0.986
hand stand	0.985

The values of the intraclass correlation coefficients used to determine the agreement of the different judges in the evaluation of the performance of the acrobatic elements are shown in Table 2. All the coefficients obtained were above 0.90, which confirms the very high objectivity of the measurement.

**Table 3.** *Central parameters of balance tests and gymnastic elements*

	Min.	Max.	AM	SD
hand stand	.00	10.00	3.293	2.681
shoulder stand	.33	10.00	5.761	3.505
head stand	.00	10.00	3.928	3.235
MBAP	.12	2.71	1.126	.587
FLAM	.63	3.84	1.875	.653
MBAU	.00	4.87	1.526	.979
MBAUZ	.00	1.86	.975	.434

Legend: Min.-minimum, Max.-maximum, AM- arithmetic mean, SD - standard deviation

Table 3 shows the values of the arithmetic mean for the balance tests and the evaluation of the performance of each gymnastics element, with the obtained results indicating the highest values for the execution of shoulder stand and for the test FLAM.



**RELATIONS OF MOTOR ABILITY  
OF BALANCE AND SUCCESS OF PERFORMANCE  
OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE**

**Table 4.** *Results of the Kolmogorov-Smirnov test*

	Stat. val.	Sig.
MBAP	0.112	.200
FLAM	0.089	.200
MBAU	0.122	.200
MBAUZ	0.098	.200

Legend: Stat. val. - statistical value, Sig. - statistical significance

The data on the normal distribution of the obtained results, verified by statistical processing with the KS test, are presented in Table 4. The values obtained for the variables used are at the lower limit of the normal distribution, so it is possible to proceed with the statistical analysis.

**Table 5.** *Results of regression analysis for all criterion variables*

	R	R <sup>2</sup>	F	Sig.
shoulder stand	.628	.394	6.022	<b>.001</b>
head stand	.699	.489	8.860	<b>.000</b>
hand stand	.688	.474	8.319	<b>.000</b>

Legend: R- the share of variance in the dependent variable, R<sup>2</sup>- coefficient of determination, Sig. - statistical significance

Table 5 shows the results of the regression analysis for the performance of all three gymnastic elements. The obtained value of the coefficient of determination for the value of the results of the execution of the shoulder stand is .394, which means that a total of 39.4% of the variance is explained by the predictive model used. This is followed by the values of the coefficient of determination for the value of the results of head stand (.489) and the value of the results for the variable of hand stand (.474), indicating that a total of 48.9% and 47.4% of the variance of these gymnastic elements. The results obtained in the prediction of the model used showed statistical significance in the performance of all three gymnastic elements at the level of  $p = .001$ .

**Table 6.** *Selected significant predictor coefficients for all criterion variables*

criterion variables	predictor variable	Stand. B. Coef.	Sig.
shoulder stand	FLAM	<b>.458</b>	<b>.003</b>
headstand	FLAM	<b>.514</b>	<b>.000</b>
hand stand	MBAP	<b>.255</b>	<b>.046</b>
hand stand	MBAUZ	<b>.435</b>	<b>.003</b>
hand stand	FLAM	<b>.314</b>	<b>.025</b>

Legend: Stand.B coef. - standardized Beta coefficient, Sig. - statistical significance

The presented values of beta coefficients (Table 6) show that the highest BETA coefficient in predicting headstand outcomes based on FLAM test scores (.514), with a statistically significant contribution (.000). Similarly, in the performance of posture with support on the leaves, where a statistically significant

## RELATIONS OF MOTOR ABILITY OF BALANCE AND SUCCESS OF PERFORMANCE OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE

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prediction result (.003) was obtained with the value of beta coefficient .458. The values of BETA coefficient for the performance of hand stand showed the highest value in the MBAUZ test (.435), followed by the values for the FLAM (.314) and MBAP (.255) tests, with all three variables making a statistically significant contribution in the regression model (.003, .025, .046).

### DISCUSSION

Bala and Katic (1989) concluded that the anthropological characteristics that form the basis for the practice of various sports are improved in respondents who participate in athletic gymnastics, the activities of the educational process (Milanović, 1997). The subject of this research was an anthropological feature from the group of motor ability - balance, which depends on the maturation of the functions of the vestibular, kinesthetic, tactile and visual analyzer (Massion, 1998). The elements of sport gymnastics most commonly performed on the floor and used as a means of training beginners, which were analyzed in this research (shoulder stand, headstand and hand stand), are performed in a static position. Considering the above facts, the research was conducted under the assumption that there is a relationship between the quality of their performance and static balance. The results obtained showed that the respondents scored the highest marks when performing the gymnastic element shoulder stand (5.761). Before discussing the results obtained, it is necessary to refer to the scale used to evaluate the performance of gymnastic elements, from which it could be concluded that it was not entirely appropriate for the age of novice gymnasts who are not competitors and the scale is intended for the evaluation of competitors. In this context, the retraining of professional judges should also be considered. In addition, according to the research findings, it can be assumed that a greater number of training hours are required,

which suggests that the introduction of a greater number of physical education classes should be considered, in which gymnastic content is taught to a greater extent, as this can improve the growth and development of children. Since balance is a motor ability with a high coefficient of innateness and it is necessary for its development to repeat actions frequently (Breslauer, Hublin, Zegnal Koretić, 2014), it can be assumed that one of the reasons for the obtained scores is an insufficient number of attempts, i.e. insufficient training time. Since good balance requires a well-integrated nervous system with adequate afferent input, mobile joints and healthy muscles, and the quality of movement depends on the quality of postural tone, which ensures the balance of the body and its segments during movement, this suggests that disruption of any of these factors reduces the ability to maintain balance (Kosinac, 2009, 2011). From this point of view, the quality of postural tone of the subjects could be one of the reasons for poorer performance in gymnastic elements, but also in balance tests, as well as the level of other motor skills essential for the execution of gymnastic elements, which were not the subject of this research (Radanovic, D., Stajer, V., Popovic, B., & Madic, D., 2013; Madić, D., Popović, B., Tumin, D., Obradović, J. & Radanović, D., 2011; Petković E., 2004, Sleeper, MD, Kenyon, LK Elliott, JM & Cheng, MS, 2016). The second part of the explanation could be found in the biological maturity of the subjects, which had a positive effect on their

# RELATIONS OF MOTOR ABILITY OF BALANCE AND SUCCESS OF PERFORMANCE OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE

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motor-morphological status at the time of training and testing (Đorđić et al., 2006).

Considering one of the more common classifications of motor knowledge, made according to the following criteria: according to the precision and type of musculature; according to the type of organization; according to the possibility of prediction in the environment; according to the proportion of cognitive elements (Schmidt and Wrisberg, 2000; Coker, 2009), an overview of the achieved scores of gymnastic element performance can be given.

According to the first criterion, it can be said that the subjects achieved a relatively satisfactory movement precision using a positive ratio of smaller and larger muscle groups, indicating a higher motor maturity of the subjects.

Various authors have addressed the issue of chronological and biological age at the younger school age and found that girls at this age have already entered the phase of stabilization of the relationship between morphological changes and changes in accompanying motor skills, which allow for better movement control and execution of elements (Madić, D., Popović, B., Tumin, D., Obradović, J. & Radanović, D., 2011; Radanovic, D., Stajer, V., Popovic, B., & Madic,

D., 2013). When considering the criterion of organization of motor knowledge, the respondents showed a higher level of discrete knowledge characterized by the precision of execution from the beginning to the end of the action, but also a more responsible approach to the execution of the test elements in terms of serial organization of knowledge. Since the serial organization of knowledge characterizes sports and activities with a more pronounced esthetic component, such as dance, rhythmic and athletic gymnastics, it is understandable that the respondents have a greater propensity for it, and it was found that performing these activities leads to positive morphological and motor changes influence the derivation of given elements (Steinberg et al, 2008; Uzunović, Kostić and Živković, 2010; Cvetkovic, M., Popovic, B., Stupar, D., Spasic, A., Orlic, D., & Andrasic, S., 2014). The predictable environment in which complete planning of movements was possible was characterized by the execution of the elements used, and it can be said that closed motor knowledge prevailed in this criterion. The criterion that probably had its importance besides the motor segment is the one that spoke about the proportion of cognitive elements, where the respondents used a balanced proportion of cognitive and motor knowledge in the execution of gymnastic elements on the floor (Delaš Kalinski, 2009).

## CONCLUSION

The tests assessing the motor ability of balance showed a statistically significant predictive value for the performance of all three gymnastic elements. It is noticeable that the value of the prediction model increased the more complex an element was derived, indicating the complexity of the motor balance space and the high and

stable level of the same in the subjects at the time of the test. Regarding the tests used, it can be noted that the test FLAM was significantly involved in predicting performance success in all three gymnastic elements, while the other two tests showed their predictive value in the execution of the hand stand. In this sense, it

# RELATIONS OF MOTOR ABILITY OF BALANCE AND SUCCESS OF PERFORMANCE OF GYMNASTICS ELEMENTS ON THE FLOOR EXERCISE

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raises the question of the use of balance tests whose performance is based on vertical performance, while the gymnastic elements were performed in steep positions with different support surfaces. In this sense, we can speak of the need to apply more specific tests of motor ability to balance in the study of gymnastic knowledge. On the other hand, the level of scores obtained in the performance of gymnastic elements indicates the need to increase the amount of gymnastic training through the number of hours or a longer duration of training for a certain age.

One of the assumptions is that better methodical treatment is necessary to ensure optimal progress in the development of balance in all its manifestations. The gymnastic elements used are an example of basic balance positions in a beginner gymnast, which the respondents successfully mastered to a greater

extent, showing that they are ready to adopt more complex motor skills from gymnastics. The limitations of strictly applying the current curriculum can be mitigated by individualizing the work of individuals or individual sections, which in turn requires good periodization and quality diagnostics, which should be addressed when working with this age. In this way, better conditions could be created (larger sample, more predictive tests, longer training time, more criterion elements in gymnastics, etc.) to determine the predictor value of motor balance ability and draw a generalized conclusion. On the other hand, the study shows that the gymnastic elements used should be used in physical education classes to contribute to the promotion and development of all motor skills of students and as part of the preparation for the execution of more complex elements at the ground floor and higher grades.

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## SAŽETAK

Cilj ovog istraživanja je ispitivanje relacija motoričke sposobnosti ravnoteže sa izvođenjem izabranih gimnastičkih elemenata na parteru, kod učenika uzrasta 7-8 godina, kako bi se dao osvrt na trenutno motoričko stanje ispitanika tog uzrasta, konstruisanje prijedloga eventualne izmjene u nastavnom planu rada u tom uzrastu kao i konstruisanje prijedloga dopunjavanja metodike obuke. Na uzorku od 42 ispitanice, bez prethodnog iskustva u izvođenju gimnastičkih elemenata, sprovedena je obuka izabranih gimnastičkih elemenata na redovnoj nastavi fizičkog vaspitanja, pri čemu je prediktorska varijabla testirana pomoću četiri testa za procjenu motoričke sposobnosti ravnoteža. Korišteni set testova za procjenu motoričke sposobnosti ravnoteža pokazao je statistički značajnu prediktivnu vrijednost za izvođenje sva tri gimnastička elementa. Uočljivo je da je vrijednost prediktivnog modela rasla što je izvođen složeniji element ukazujući na složenost motoričkog prostora ravnoteže te na visok i stabilan nivo iste kod ispitanica u vreme testiranja. Govoreći o korištenim testovima može se konstatovati da je test FLAM učestvovao značajno u predikciji uspješnosti izvođenja kod sva tri gimnastička elementa dok su preostala dva testa pokazala svoju prediktivnu vrijednost kod izvođenja stava o šakama. Sa druge strane iz istraživanja je evidentno da korišteni gimnastički elementi trebaju biti upotrebljavani na časovima fizičkog vaspitanja kako bi se doprinijelo podsticanju i daljnjem razvoju svih motoričkih sposobnosti učenika te kao dio pripreme za izvođenje složenijih elemenata na parteru i na spravama u višim razredima.

**Ključne riječi :** gimnastička početnica, fizičko vaspitanje, obuka

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# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

PROCJENA UČINKA RAZLIČITIH PROGRAMA TRENINGA  
FIZIČKE PRIPREME I POBOLJŠANJA SPORTSKIH PERFORMANSI  
POWERLIFTERA SA VISOKO KVALIFIKACIJSKIM OŠTEĆENJEM VIDA

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## ABSTRACT

*Systematic overload, which is a training characteristic of powerlifters with visual impairments of high qualification has a negative impact on the functioning of body systems and the course of the underlying and comorbidities. This determines the relevance of the scientific substantiation of training programs for athletes with visual impairments as the most important component of ensuring the achievement of sports results in powerlifting. This study aimed to experimentally substantiate the effectiveness of the impact of various training programs on physical fitness and athletic performance of powerlifters with visual impairments of high qualification. To solve the goal we used methods of analysis of scientific and methodological literature, pedagogical observation, pedagogical experiment and methods of mathematical statistics. The study involved 16 visually impaired athletes who were members of the national powerlifting team. The pedagogical experiment was based on testing the effectiveness of two training programs, which differed in the parameters of the load components in the annual training and macrocycle periods. After the pedagogical experiment, the experimental group showed reliable indicators of growth on all tests and improvement of sports results, and athletes of the control group increased physical fitness in three tests out of five and sports results are available only in squat and bench press. In both groups, the highest growth rates in the level of development of physical qualities were found in tests aimed at determining the level of development of strength and flexibility. Comparing the results of the introduction of various training programs in the training process of powerlifters with visual impairments, we can conclude that the performance of the experimental group is much higher than among the powerlifters of the control group.*

**Key words:** macrocycle, disability, adaptive sports, volume, intensity.

# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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## INTRODUCTION

A significant increase in public interest in the sports results of athletes with disabilities leads to the acquisition of adaptive sports Olympic characteristics (Dehghansai, Lemez, Wattie & Baker, 2017; McNamee, 2017; Wareham, Burkett, Innes & Lovell, 2017; Rudenko, Hlozhyk, Guzii & Prystupa, 2017). The principle of maximum approximation to Olympic sports extends to the ideological principles of adaptive sports and scientific and methodological support for the training of athletes, which leaves its mark on the practical side of the training of athletes in various sports (Kozina, Lytovchenko, Safronov, Boichuk, Chaika, Shepelenko, Polianskyi, Protsevskiy, Peretyaha, & Konnova, 2019).

The same competitive exercises and identical rules of competitions in power sports among athletes with disabilities and among healthy people allowed coaches to use the experience of Olympic sports in adaptive sports (Vanlandewijck & Thompson, 2016; Ferland & Comtois, 2019). Therefore, the scientific justification for the training of athletes with disabilities in power sports for a long time was based on the scientific work of scientists in the study of the system of training healthy athletes (Castro, Cardoso, Filho, Gaya & Araújo, 2016; Bengtsson, Berglund & Aasa, 2018). The active development of power sports in the structure of adaptive sports in recent decades and significant progress in athletic performance of athletes in powerlifting among athletes of different nosological groups has led to a number of studies to train athletes with disabilities.

Most of the works on scientific and methodological support for the training of athletes with disabilities in power sports relate to the nosological group of musculoskeletal injuries (Roztorhui, Perederiy, Briskin & Tovstonoh, 2018). In the context of the fact that only athletes with musculoskeletal injuries participate in the Paralympic Games in power sports, conducting a significant amount of research is justified by the great social significance of sports results. Power sports in the structure of adaptive sports also include powerlifting, armwrestling and bodybuilding among athletes of other nosological groups. Despite the fact that the representation of power sports among visually impaired athletes is not in the program of the Paralympic Games, powerlifting among athletes of this nosological group is actively developing both in Ukraine and in the world.

Scientific knowledge on the training of athletes with visual impairments in powerlifting is formed on the basis of studying the impact of power sports on the body for athletes with visual impairments (Barone, Ascione & Tafuri, 2018), psychological aspects of training athletes with visual impairments (Winnick, 2016), technical and physical fitness for athletes in this nosological group (Winnick, 2016; Roztorhui, Perederiy, Briskin, Tovstonoh, Khimenes & Melnyk, 2018) and effectiveness of competitive activities for athletes (Swinton, Lloyd, Keogh, Agouris & Stewart, 2012; Santos, Vigario, Mainenti, Ferreira & Lemos, 2017). Scientists do not pay attention to the problem of rational construction of training of visually impaired



# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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athletes in power lifting, which is the basis for the realization of sports potential and the formation of adaptation to intensive training in competitive activities. Today in the practice of adaptive sports to build training programs for powerlifters with visual impairments of high qualification uses an approach characterized by the maximum possible parameters of the volume and intensity of the load and causes forcing sports results and depletes the body's reserve capacity (Colquhoun, Gai, Walters, Brannon, Kilpatrick, D'Agostino & Campbell, 2017; Androulakis-Korakakis, Langdown, Lewis, Fisher, Gentil, Paoli & Steele, 2018; Pichardo, Oliver, Harrison, Maulder, Lloyd & Kandoi, 2019). In addition, shortcomings in the construction of training programs and the lack of consideration of nosological features in the training process do not allow to fully realize the sporting potential, and excessive stress can cause irreversible negative changes in the body of highly qualified athletes (Sherrill, 2003; Weiler, Van Mechelen, Fuller & Verhagen, 2016; Willick, Cushman, Blauwet, Emery, Webborn, Derman, Van de Vliet, 2016; Roztorhui, Perederiy, Briskin & Tovstonoh, 2018).

The aim of the research was to experimentally substantiate the effectiveness of the impact of various training programs on physical fitness and sports performance of powerlifters with visual impairments of high qualification.

## METHODS

*Participants.* The study involved members of the national team in powerlifting among visually impaired athletes, including 4 athletes of sports class B1, 6 athletes of sports class B2 and 6 athletes of sports class B3 (Mann & Ravensbergen, 2018). Information on the medical diagnosis was taken from the medical and classification cards of the athletes. The average age of athletes was  $34.50 \pm 4.31$  years. Athletes were divided into control and experimental groups of 8 people each. All athletes were informed about the conditions of the experiment and agreed to the processing of personal data. The research has followed the tenets of the Declaration of Helsinki and has been approved by the authors' institutional review board.

*Procedures.* Participants of the study were engaged in groups of higher sportsmanship on the basis of regional centers of physical culture and sports "Invasport" with the norm of a weekly regime of educational and training work of 36 hours. The total duration of the experiment was 12 months. Training programs for visually impaired athletes of the control and experimental groups provided for a total of 1877 hours of training work. The number of training activities per year for highly qualified athletes was 469, in a weekly microcycle – 9, and the duration of training activities was 4 hours.

The structure, means and methods of training programs for athletes of the control and experimental groups were the same. Table 1 shows the percentage distribution between the different sections of the training programs for athletes of the control and experimental groups.

## ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

**Table 1.** *The structure of training programs for powerlifters with visual impairments of high qualification*

Program material section	Number of hours	% of the total
Callisthenics(Physical preparation\training)	670	35,69
Technical training	383	20,41
Theoretical training	192	10,23
Mental training	304	16,20
Tactical training	29	1,55
Restorative measures	245	13,05
Control	30	1,59
Competitive activity	24	1,28

The content of training programs for athletes of the control and experimental groups differed in the parameters of the load components in the annual training and macrocycle periods: the total number of barbell lifts in the annual training of powerlifters with visual impairments, the number of barbell lifts in the intensity zone 90-100% of the maximum at different periods of the macrocycle and the ratio of general physical training, auxiliary physical training and special physical training described in Table 2.

**Table 2.** *Load indicators in the annual training of powerlifters with visual impairments of highly qualified experimental and control groups*

Load components	Indicators in CG	Indicators in EG
Total volume in annual training*, thousands of times	15.8	12.8
The repetitions in the intensity zone 90-100% of the maximum result,%	5.4	4.5
Training intensity of squat in the competitive / preparatory / transitional period of the macrocycle,%	74.3/70.0/60,9	77.0/65.6/54.2
Training intensity of bench press in the competitive / preparatory / transitional period of the macrocycle,%	76.2/69,0/61.0	79.0/65.2/53.1
Training intensity of deadlift in the competitive / preparatory / transitional period of the macrocycle,%	73.4/68.5/60.3	75.2/64.0/50.2
Correlation GPT, APT and SPT, %	10:10:80	10:10:80

**Legend:** CG – control group; EG – experimental group; GPT – general physical training; APT – auxiliary physical training; SPT – special physical training; total volume in annual training = sets × repetitions.

## ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

The control group trained of a standard program that provided high indicators of the volume and intensity of the load both in the annual training and in some structural elements of the macrocycle. A training program for experimental group contained much lower indicators of the total volume, the repetitions in the intensity zone 90-100% of the maximum result and the training intensity in competitive exercises in the preparatory and transitional periods of the macrocycle.

*Testings.* In order to determine the level of physical fitness for athletes with visual impairments before and after the experiment, indicators of physical development were determined using pedagogical tests described in Table 3. For this purpose, nosological features for athletes and the specifics of their motor activity in the training process were taken into account. Determination of the level of physical fitness before and after the experiment was performed in the same time period with the obligatory warm-up before testing.

**Table 3.** *Pedagogical tests to determine the physical fitness of powerlifters with visual impairments of high qualification*

Test	Physical quality
Push-ups, the number of repetitions	Muscular endurance
Seated medicine ball throw, m	Power
Sit and reach flexibility test, cm	Flexibility
One-leg balancing test (right leg), s	Coordination qualities
One-leg balancing test (left leg), s	Coordination qualities

The level of muscular endurance development in visually impaired athletes was determined by the results of push-ups. To perform the exercise, the athletes took the starting position: lying down, arms shoulder-width apart, legs raised, torso parallel to the floor, on the coach's command, the athlete bent his arms at the elbows to an angle of 90°, while maintaining the torso parallel to the floor. After fixing the stationary position at the lowest point, the athlete returned to the starting position.

The seated medicine ball throw from behind the head was performed from a seating position, holding the ball with both hands in

front of it. Medicine ball weighing 1 kg was used for throwing. A centimetre mark was applied to the floor. On the coach's command, the athlete swung backwards for his head and threw forward.

To determine the level of flexibility in visually impaired athletes used sit and reach flexibility test, conducted from the initial sitting position, the athlete's feet were in a vertical position to the floor, five – at the level of zero marking, the distance between the feet – 20-30 cm, hands placed in front of him palms down. At the coach's command, the athlete leaned forward, reaching for the

# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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markings with his fingers, and fixed this position for 2 seconds.

Keeping the balance on one leg meant that on the coach's command, the athlete with his eyes closed raised one bent leg at the knee to a 90° angle and raised his arms to a sideways position. After the athlete fixed the stationary position, the coach used a stopwatch to record the time in seconds during which the athlete held this position.

*Statistical analysis.* The obtained results were analysed using Statistica (Statsoft version 6.00). Because the number of athletes

did not allow for an analysis of the normality of the distribution, Wilcoxon signed-rank test was used to determine the significance of differences in performance on the level of physical fitness of athletes before and after the experiment. The Mann-Whitney U test was applied to determine the significance of differences in performance by the level of physical fitness for athletes before and after the experiment between the control and experimental groups. Significance of differences was defined as an indicator at a significance level of  $p < 0.05$ .

## RESULTS

Analysis of the results of pedagogical testing before the experiment revealed the absence of significant differences ( $p > 0.05$ ) between the indicators of physical fitness for athletes in the control and experimental groups, which indicates their homogeneity. It was found that after the experiment between the indicators of physical fitness for athletes in the control and experimental groups there were significant differences ( $p < 0.05$ ), which indicates a different direction and effectiveness of the proposed training programs. The analysis of the dynamics of indicators for athletes with visual impairments of high qualification of the control group revealed reliable indicators of growth of physical fitness ( $p < 0.05$ ) in three of the five tests described in Table 4.

The highest indicators of improvement of physical fitness among athletes with visual impairments high qualification of the control group was found in the tests that determine the manifestation of power and flexibility. Thus, in the test "Push-ups" the increase was 8.33%, "Seated medicine ball throw" – 15.13% and "Sit and reach flexibility test" – 15.77%. The lowest rates of increase in physical fitness among the control group were found in the test "One-leg balancing test", which characterizes the level of development of coordination qualities. According to the results of tests "One-leg balancing test" before and after the experiment among athletes of the control group no significant differences were found ( $p > 0.05$ ).

## ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

**Table 4.** Indicators of physical fitness of powerlifters with visual impairments of high qualification before and after pedagogical experiment

Tests	Results in CG ( <i>n</i> = 8)			Results in EG ( <i>n</i> = 8)		
	Before	After	<i>p</i>	Before	After	<i>p</i>
	experiment	experiment		experiment	experiment	
	$\bar{x} \pm SD$	$\bar{x} \pm SD$		$\bar{x} \pm SD$	$\bar{x} \pm SD$	
Push-ups, the number of repetitions	20.40±3.28	22.10±4.11	<0.05	21.10±4.04	25±2.26	<0.05
Seated medicine ball throw, m	4.23±0.63	4.47±0.36	<0.05	4.27±0.74	5.43±1.13	<0.05
Sit and reach flexibility test, cm	2.03±2.11	2.21±3.07	<0.05	2.07±4,04	2.73±0.53	<0.05
One-leg balancing test (right leg), s	13.31±1.11	13.45±1.01	>0.05	13.26±1.07	14.33±1.10	<0.05
One-leg balancing test (left leg), s	12.43±0,78	12.55±0.53	>0.05	12.48±0.96	13.74±0,91	<0.05

**Legend:** CG – control group; EG – experimental group; *p* – the difference in the group before and after experiment.

Analysis of the results of the implementation of training programs in the training process shows the presence of reliable indicators ( $p < 0.05$ ) of the increase in physical fitness among athletes with visual impairments of the experimental group for all tests. As a result of the experiment, the best growth rates were found in tests aimed at determining the level of development of power and flexibility. A comparative analysis of the increase in the parameters of physical fitness for athletes of the control and experimental groups shows that the indicators of the experimental group are much higher than among the powerlifters of the

control group. Growth rates among athletes of the experimental group in the test "Push-ups" the increase was 27.17%, "Seated medicine ball throw" – 18.48% and "Sit and reach flexibility test" – 31.88%, "One-leg balancing test" – 8.01% for the right leg and 10.05% for the left leg.

Based on the analysis of the effectiveness of competitive activities of powerlifters with visual impairments, which was conducted based on the performances for athletes at the championships of Ukraine and the world championships 2018–2019, the effectiveness of the developed programs described in Table 5. In the analysis of the effectiveness of competitive activities, we

## ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

used the Wilks coefficient, which in accordance with the rules of competition is used to compare the sports results of powerlifters of different weight categories. Thus, the sports result in points was defined as the product of the Wilks

coefficient and the result in competitive exercises and the amount of total, which was demonstrated by athletes in competitive activities before and after the pedagogical experiment.

**Table 5.** Indicators of sports results of powerlifters with visual impairments of high qualification before and after the pedagogical experiment

Competitive exercises	Results in CG ( <i>n</i> = 8)			Results in EG ( <i>n</i> = 8)		
	Before experiment	After experiment	<i>p</i>	Before experiment	After experiment	<i>p</i>
	$\bar{x} \pm SD$	$\bar{x} \pm SD$		$\bar{x} \pm SD$	$\bar{x} \pm SD$	
Squat, points	115.38±24.30	121.81±25.07	<0.05	116.21±22.08	129.76±24.11	<0.01
Bench press, points	78.35±19.42	81.58±14.18	<0.05	77.24±11.18	85.15±15.01	<0.05
Deadlift, points	146.65±25.20	148.34±22.12	>0.05	145.23±23.70	158.54±22.39	<0.05
Total, points	340.38±63.25	351.73±62.23	>0.05	339.68±64.87	371.45±60.47	<0.05

**Legend:** CG – control group; EG – experimental group; *p* – the difference in the group before and after experiment.

It was found that the performance for athletes with visual impairments of high qualification of the control group before and after the experiment differ statistically at a confidence level of *p* <0.05 in squats and bench press. In deadlift and total no significant differences in the performance for athletes in the control group were found (*p*>0.05). Among the representatives of the experimental group there are significant differences before and after the experiment in all competitive exercises and total (*p* <0.05). The analysis of indicators of dynamics of efficiency of competitive activity of sportsmen of control and experimental groups allows making a conclusion about higher parameters of simple sports result both in

competitive exercises and total at representatives of experimental group. This is especially noticeable when analyzing the growth rates in deadlift and total. As a result of the pedagogical experiment among the athletes of the control group, the increase in sports results in deadlift was 1.15% and in total – 3.33%, and among the experimental group, these figures were 9.16% and 9.32%. The increase in sports results in squat and bench press among the athletes of the control group was 5.57% and 4.12%, and among the representatives of the experimental group, the increase in these competitive exercises was 11.66% and 10.24%.

# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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## DISCUSSION

As a result of the pedagogical experiment, we obtained data confirming the provisions of the general theory of training athletes in terms of determining the intensity and volume of load in the process of building the training of highly qualified athletes (Colquhoun, Gai, Walters, Brannon, Kilpatrick, D'Agostino & Campbell, 2017; Androulakis-Korakakis, Langdown, Lewis, Fisher, Gentil, Paoli & Steele, 2018; Solberg, Hopkins, Paulsen & Haugen, 2019). The results obtained in our study indicate a significant impact of the parameters of the load components in some structural elements of the annual training of powerlifters with visual impairments of high qualification on the level of their physical fitness and competitiveness. Given such a significant impact of load components on the training of highly qualified powerlifters, irrational construction of training using excessive parameters of the volume and intensity of the load can have an adverse effect on the body for athletes with disabilities (Sherrill, 2003; Weiler, Van Mechelen, Fuller & Verhagen, 2016; Willick, Cushman, Blauwet, Emery, Webborn, Derman & P Van de Vliet, 2016; Barone, Ascione & Tafuri, 2018).

According to most authors, with the increase of preparedness, all indicators of the load components increase, and in the training of highly qualified athletes, the parameters of volume and intensity reach a maximum (Colquhoun, Gai, Walters, Brannon, Kilpatrick, D'Agostino & Campbell, 2017; Bengtsson, Berglund & Aasa, 2018). In accordance with these recommendations, we introduced into the training process a training program for athletes of the control group, which provided high indicators of the volume and intensity of the

load both in the annual training and in some structural elements of the macrocycle. Thus, the total volume in the training program for athletes of the control group amounted to 15.8 thousand times, which is the limit of the amount of annual training for athletes in powerlifting.

Instead, the training program of the experimental group contained much lower indicators of the total volume, the repetitions in the intensity zone 90-100% of the maximum result and the training intensity in competitive exercises in the preparatory and transitional periods of the macrocycle. But the indicators of training intensity in some exercises in the competitive period in the training program of powerlifters with visual impairments of the experimental group were higher than in the training program of the control. This approach to building a training program for highly qualified athletes has been substantiated by a number of experts in the field of weightlifting, but experimental confirmation of the effectiveness of this approach in powerlifting has not been conducted (Solberg, Hopkins, Paulsen & Haugen, 2019).

According to the results of the pedagogical experiment it was found that both training programs are effective for improving the preparedness and effectiveness of competitive activities of powerlifters with visual impairments, due to the growth of leading physical qualities for powerlifting and sports results in some exercises. That is why we can talk about the effectiveness of both training programs. However, the impact on the level of development of physical qualities for athletes with visual impairments is not the same, as evidenced by the presence of significant differences ( $p < 0.05$ ) between the indicators of

## ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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physical fitness for athletes in the control and experimental groups after the experiment. The positive effect of the implementation of the author's training program on the indicators of physical fitness and sports performance of powerlifters with visual impairments of high qualification is much higher. As a result of the pedagogical experiment, the representatives of the experimental group of growth on all tests and in all competitive exercises and total are higher and they differ before and after the experiment at a confidence level of  $p < 0.05$ . After the experiment in athletes of the control group, significant growth rates ( $p > 0.05$ ) were not detected in tests to determine the level of development of coordination qualities, deadlift and total.

An important result of the study is to confirm the possibility of improving the construction of powerlifters with high visual impairments not by increasing the parameters of the total volume and total intensity in annual training, but by increasing the training intensity only in the competitive period against the background of reducing all other load

parameters. On the one hand, the use of such an approach to the training of highly qualified athletes allows to ensure a sufficient level of adaptive shifts in the body of powerlifters to demonstrate high sports results, and on the other – to reduce the negative consequences of intensifying the load on reserve capacity and health. This is especially important in the training for athletes with disabilities, which is due to the social unjustifiability of the adverse effects of high-achievement sports on their bodies and the need to maintain athletic longevity.

The results obtained in our study partially contradict the current provisions of training athletes in powerlifting, as declared in the studies of Colquhoun, R. J., Gai, C. M., Walters, J., Brannon, A. R., Kilpatrick, M. W., D'Agostino, D. P., & Campbell, B. I. (2017). However, these provisions were formulated on the basis of experimental data among healthy powerlifters, which suggests the need to substantiate approaches to the construction of training powerlifters with high qualifications with disabilities other than those used in sports high performance among healthy athletes.

### CONCLUSIONS

The analysis of the obtained results revealed that after the experiment the indicators of physical fitness of the control group significantly differed ( $p < 0.05$ ) from the indicators of the athletes of the experimental group. The highest rates of increase in physical fitness and increase in sports results were found in athletes of the experimental group. This indicates a more specialized impact on the effective components of the training of powerlifters with visual impairments of the highly qualified program, which trained athletes of the experimental group. As a result of the introduction of various training programs in the training process of athletes with visual impairments of highly qualified confirmed much greater effectiveness of the training program, which is based on lower indicators of total volume and intensity in annual training and relative intensity in competitive period of the macrocycle.



# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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## ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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## ОЦЕНКА ВЛИЯНИЯ РАЗЛИЧНЫХ ПРОГРАММ ТРЕНИРОВОК НА ФИЗИЧЕСКУЮ ПОДГОТОВЛЕННОСТЬ И СПОРТИВНЫЕ РЕЗУЛЬТАТЫ ПАУЭРЛИФТЕРОВ ВЫСОКОЙ КВАЛИФИКАЦИИ С НАРУШЕНИЕМ ЗРЕНИЯ

### РЕЗЮМЕ

Систематические перегрузки, характерные для тренировок пауэрлифтеров высокой квалификации с нарушением зрения, негативно сказываются на функционировании систем организма, течении основных и сопутствующих заболеваний спортсменов. Это определяет актуальность научного обоснования программ тренировок спортсменов с нарушением зрения как важнейшего компонента обеспечения достижения спортивных результатов в пауэрлифтинге. Целью данного исследования было экспериментальное обоснование эффективности влияния различных программ тренировок на физическую подготовленность и результативность соревновательной деятельности пауэрлифтеров высокой квалификации с нарушением зрения. Для решения поставленной задачи использовались методы анализа научно-методической литературы, педагогического наблюдения, педагогического эксперимента и методы математической статистики. После педагогического эксперимента экспериментальная группа показала достоверные показатели роста по всем тестам и улучшение спортивных результатов во всех упражнениях, а у спортсменов контрольной группы повысилась физическая подготовленность в трех тестах из пяти, а спортивные результаты повысились только в приседаниях и жиме лежа. В обеих группах наиболее высокими темпами роста уровня развития физических качеств были выявлены тесты, направленные на определение уровня развития силы и гибкости. Сравнивая результаты внедрения различных программ тренировок в тренировочный процесс пауэрлифтеров с нарушением зрения, можно сделать вывод, что показатели экспериментальной группы намного выше, чем у пауэрлифтеров контрольной группы.

**Ключевые слова:** макроцикл, инвалидность, адаптивные виды спорта, объем, интенсивность.

# ASSESSING THE EFFECTS OF DIFFERENT TRAINING PROGRAMS FOR PHYSICAL PREPARATION AND SPORTS PERFORMANCE IN POWER LIFTERS WITH VISUAL IMPAIRMENTS OF HIGH QUALIFICATION

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## SAŽETAK

Sistematsko preopterećenje, koje je karakteristika treninga powerliftera sa oštećenjima vida visoke kvalifikacije, negativno utiče na funkcionisanje tijela i tok osnovnog stanja vida i na pojavu komorbiditeta. Time se utvrđuje relevantnost naučnog utemeljenja programa treninga za sportiste sa oštećenjem vida kao najvažnije komponente osiguravanja postizanja sportskih rezultata u powerliftingu.

Ovo istraživanje imalo je za cilj eksperimentalno potkrijepiti učinkovitost uticaja različitih programa treninga na tjelesnu spremnost i atletske performanse powerliftera sa oštećenjem vida visoke kvalifikacije. Da bi se cilj ostvario, korištene su metode analize naučne i metodičke literature, pedagoško posmatranje, pedagoški eksperiment i metode matematičke statistike. U istraživanju je učestvovalo 16 slabovidnih sportista koji su bili članovi nacionalnog powerlifting tima. Eksperiment se temeljio na testiranju učinkovitosti dva programa treninga koji su se razlikovali u parametrima komponenti opterećenja u godišnjem trenažnom i makrociklusnom razdoblju. Eksperimentalna grupa je nakon eksperimenta pokazala pouzdane pokazatelje povećanja na svim testovima i poboljšanja sportskih rezultata, a sportisti kontrolne grupe povećali su fizičku spremnost u tri od pet testova (sportski rezultati dostupni su samo u čučnju i bench pressu). U obje grupe najveće stope rasta nivoa razvijenosti tjelesnih osobina utvrđene su u testovima za utvrđivanje stepena razvoja snage i fleksibilnosti. Upoređujući rezultate uvođenja različitih programa treninga u trenažni proces powerliftera sa oštećenjem vida, može se zaključiti da je učinak eksperimentalne grupe znatno veći nego kod powerliftera kontrolne grupe.

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**Ključne riječi:** *makrociklus, invalidnost, adaptivni sportovi, volumen, intenzitet*

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# INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

UTJECAJ VANJSKIH ČIMBENIKA RIZIKA NA OZLJEDE  
U ALPSKOM SKIJANJU KOD REKREATIVNIH SKIJAŠA

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## SUMMARY

*The main goal of this study was to identify potential external risk factors for injury in recreational skiers through a survey questionnaire. Subjects were divided into injured skiers and a control group who never had an injury. Injured skiers (N=212) answered questions that helped define potential risk factors. The control group (N=206) completed the same questionnaire but without questions about injury. Common questions were used to determine the possibility of injury using Chi-Square test, and additional questions were used to determine the influence on injury severity using Fisher's test. An analysis of external factors showed that formal ski school was not statistically related to the possibility and severity of injury, but significantly increased knowledge of skiing. Skiing with another person did not decrease the possibility of injury but did increase the severity of injury. Visibility, field of vision, condition of the slope, temperature, and weather conditions are not statistically related to injury severity, but when combined, they could be an important factor in the possibility of injury.*

**Keywords:** *skiing, alpine skiing, ski injuries, causes of skiing injuries*

# INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

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## INTRODUCTION

Skiing is a widespread recreational activity regularly practiced by approximately 200 million skiers per year (Ropret, 2014). With 2 skiers injured per 1000 ski days (Johnson, Ettlinger, & Shealy, 2008), skiing injuries are considered a public health problem, affecting the majority of the working-age population. For the purposes of this study, we defined a ski injury as one after which someone could not ski for at least one day. In recent years, the number of injured skiers has decreased significantly, mainly due to the better quality of equipment (St-Onge, Chevalier, Hagemeister, Van de Putte, & De Guise, 2004), but many external risk factors are still poorly explained, such as visibility, temperature, or company while skiing. In the literature, risk factors are defined (Ruedl, Ploner, Linortner, Schranz, Fink, Patterson, & Burtscher, 2011; Bahr & Krosshaug, 2005) and divided into internal and external. Some papers claim that attending a formal ski school has nothing to do with a lower likelihood of being injured while skiing (Bouter & Knipschild, 1991; Garrick & Requa, 1977). The opposite is argued by researchers from Canada (Macnab, Cadman, & Greenlaw, 1998), and France (Goulet, Régnier, Grimard, Valois, & Villeneuve, 1999).

A comprehensive analysis of previous research cites formal ski training as one of the biggest myths in reducing the likelihood of injury (Johnson, Ettlinger & Shealy, 2009). Recent research indicates little effect on injury prevention for individuals who learned from a professional (Ekeland, Rødven, & Heir, 2019). To date, no studies have described skiing in a group or with someone as an external factor in injury, while one study shows that children are

less likely to be injured in ski school compared to skiing in a group, which is not the case for adults (Cadman & Macnab, 1996). The ski surface is a relatively frequently described risk factor in skiing (Moore & Knerl, 2013; Demirag, Oncan & Durak, 2004), but it is the greatest risk for young skiers (Dohin & Kohler, 2008). It is noted that there are so-called "AOC - areas of concern" areas on the trail where up to 40% of all trail injuries occur (Shealy, Scher, Johnson, & Rice, 2015), and that the number of injuries decreases proportionally to the number of hours of trail fixation (Bergstrøm & Ekeland, 2004). Air temperature is a rarely researched and dubious risk factor for injury. Aschauer concluded that low air temperature favours injury, but attributes this to poor weather and visibility (Aschauer, Ritter, Resch, Thoeni, & Spatzenegger, 2007).

Comparing intra-articular to skin temperature at the knee after 60 minutes of skiing, the mean intra-articular temperature was 19.6% higher than the skin temperature at the knee. The reason for this is a decrease in skin temperature, as well as thigh muscle temperature after one hour of skiing (Becher, Springer, Feil, Cerulli, & Paessler, 2008). Meteorological conditions as a risk factor have not been significantly described. It is stated that women are twice as likely to suffer a knee injury in snowfall compared to other injuries (Ruedl, Fink, Schranz, Sommersacher, Nachbauer, & Burtscher, 2012). In a sample of 3512 casualties, the risk of injury was twice as high on sunny days than on precipitation days, but the authors linked this to poorer visibility (Aschauer, Ritter, Resch, Thoeni, & Spatzenegger, 2007). In addition, one study failed to demonstrate an

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

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association between weather conditions and the occurrence of LCA injuries in women (Ruedl, Linortner, Schranz, Fink, Schindelwig, Nachbauer, & Burtscher, 2009). The influence of weather conditions on injuries has also been analysed by Japanese researchers, but no association was found, so weather conditions remain a doubtful risk factor for injuries. Visibility has been described in the literature mostly as an influence of weather conditions on injury and rarely as an individual factor. Aschauer stated that poor visibility is the main cause of injury in bad weather (Aschauer, Ritter, Resch, Thoeni, & Spatzenegger, 2007), while Ekeland claimed that poor visibility is one of the main causes of injury in new equipment (Ekeland & Nordsletten, 1994), whose quality is evolving at a rapid pace (Davey, Endres, Johnson, & Shealy, 2019). Ruedl found that poor visibility increased the likelihood of LCA injury in skiers tenfold (Ruedl, Fink, Schranz, Sommersacher, Nachbauer, & Burtscher, 2012). Finally, one study found that the incidence of injury was lower with good visibility (Bouter, Knipschild, & Volovics, 1989). It can be

concluded that visibility, like many others, is a questionable risk factor for injury. Obscuration of the field of view by some of the equipment has not been studied in previous work but has been consistently observed as visibility for the duration of certain weather conditions. An interesting 2011 study described those polarized glasses recommended for motorcycling or bicycling are not suitable for skiing because they prevent the occurrence of glare that could be a sign of a potential threat (person or object) (Lingelbach & Jendrusch, 2010), as well as that there are no significant differences between filters for glasses of different colors (Jendrusch, Senner, Schaff, & Heck, 1999). The helmet is cited as an insignificant factor in reducing the field of view (Hagel, 2005). To our knowledge, there is no study with so many external risk factors related to environmental conditions and also compared with a control group. Therefore, the purpose of this study was to analyse the data of some external risk factors in injured recreational skiers during the winter season 2013-2018 and their influence on the possibility and severity of injury.

## MATERIALS AND METHODS

### Procedure

This study was conducted as a retrospective, questionnaire-based study during five winter seasons (2013-2018). Data were collected from injured recreational skiers of all ages and both sexes in special rehabilitation hospitals and included in the study. The survey was conducted in accordance with

the ethical guidelines for surveys approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb, at its meeting on 23 April 2013. All participants were informed about the purpose of the study before completing the questionnaire. Data from the control group of uninjured

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

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skiers were collected by random recruitment at ski resorts after a full day of skiing after leaving the ski slopes, also over a five-year period. The planned sample size was 200 injured skiers and the same number of uninjured skiers. Considering the statistical significance level (0.05), the targeted statistical power (0.95), and the moderate impact factor (effect size  $d = 0.5$ ), the minimum sample size for the Mann Whitney U test was 186 subjects divided into two groups, whereas the student's t test required 176 subjects and the multiple regression analysis, e.g., with three predictors, required 119 subjects. Therefore, the planned sample size was sufficient for reliable analysis, even though some skiers did not answer all questions. The required sample size was calculated using the freely available software G \* Power Software (Heinrich-Heine-University Duesseldorf, Duesseldorf, Germany).

### Questionnaire

Both groups (injured and uninjured) completed a validated questionnaire, as a test-retest review of the questionnaire was performed on 20 subjects who completed the questionnaire again, and it showed a satisfactory reliability of  $r=0.857$  with  $p < 0.001$ . More than 90% of the invited patients and 50% of the uninjured skiers agreed to participate in this study. Skiers were also asked about their self-reported skiing level (expert, advanced, intermediate, beginner) according to Sulheim et al. (Sulheim, Ekland, & Bahr, 2007). While the injured

group completed the entire questionnaire, the uninjured group completed an identical questionnaire without questions about the conditions of the injury (vision, visual field, track condition, temperature, and weather conditions). All study participants were informed about the aims of the study and gave their written consent to participate.

### Statistical analysis

To compare the distribution of individual characteristics between injured and uninjured groups of skiers, the chi-square test was used, i.e., Fisher's exact test in the case of a small number of occurrences of individual values of a given category variable. In addition to the test of statistical significance and in order to examine the strength of the correlation between the variables, the results also include the size of the effect or the measure of correlation in the form of Cramer's coefficient V. In the case of injured skiers, the influence of certain factors on the severity of the injury was analysed, measured by three ISS categories (mild, moderate and severe injury) estimated by the authors (Stevenson, Segui-Gomez, Lescohier, Di Scala, & McDonald-Smith, 2001). Ordinal logistic regression, corresponding to a larger number of categories of the dependent variable compared to standard logistic regression, examined the influence of a single factor on injury severity. Statistical analysis was performed using the SAS System software package (SAS Institute Inc., North Carolina, USA).

## RESULTS

A total of 418 surveys were collected, an equal number of injured (212 surveys; 51%) and uninjured (206 surveys; 49%) skiers. According to the results, of the total number of respondents, 11% were beginners, 36% were average skiers, 28% were advanced skiers, and 25% were excellent skiers. Based on the observed values and previous research, the ISS numerical variable, i.e., the injury severity indicator, was transformed into a categorical variable with three categories (Table 1).



## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

**Table 1.** *Distribution of categorized ISS indicators*

ISS <sub>kat</sub>	N	%
Minor injury	70	33.0
Moderate injury	47	22.2
Severe injury	95	44.8
Total	212	100.0

1. Minor injury (0 > ISS > 8)
2. Moderate injury (8 > ISS > 15)
3. Serious injury (ISS > 15)

Attending a ski school or learning to ski from a licensed instructor was not statistically significantly associated with injury (Chi-Square test;  $p = 0.721$ ) (Table 2). Most skiers surveyed learned to ski from a licensed ski instructor (71.5%).

**Table 2.** *The association between injuries and learning to ski from a licensed ski instructor.*

Variable	Total	Injured	Uninjured	p-value <sup>a</sup>	Cramer V
<i>Ski school</i>				0.721	0.018
Learning from a licensed ski instructor	71.5 %	70.8 %	72.3 %		
Didn't learn from a licensed ski instructor	28.5 %	29.3 %	27.7 %		

<sup>a</sup> *P-value of the Chi-Square test to compare the distribution of characteristics between injured and uninjured groups of skiers.*

Ski school or learning from a licensed ski instructor was not statistically significantly associated with injury severity (Chi-Square test;  $p = 0.505$ ) (Table 3).

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

**Table 3.** *The association between severity of injury and learning from licensed ski instructor*

Varijable	Minor injury (ISS ≤ 8)	Moderate injury (8 < ISS ≤ 15)	Severe injury (ISS > 15)	p-value <sup>a</sup>	Cramer V
Ski school				0.505	0.081
Learning from a licensed ski instructor	75.7 %	66.0 %	70.2 %		
Didn't learn from a licensed ski instructor	24.3 %	34.0 %	29.8 %		

<sup>a</sup> *P-value of the Chi-Square test to compare the distribution of characteristics between three groups of skiers.*

It is also interesting to note that skiers who attended an official ski school had significantly better self-assessed skiing skills (32% excellent, 33% advanced, 31% intermediate, and only 4% beginner) compared to those who did not attend a ski school (8% excellent, 32% advanced, 35% intermediate, and even 25% beginner). Skiing with someone or in a group (Chi-Square test;  $p = 0.834$ ) showed no statistically significant association with skier injuries (Table 4).

**Table 4.** *The association between injury and skiing with other person*

Varijable	Total	Injured	Uninjured	p-value <sup>a</sup>	Cramer V
<i>Company during skiing</i>				0.834	0.030
Alone	10.8 %	10.4 %	11.2 %		
In a group	79.6 %	79.2 %	80.0 %		
In ski school	9.6%	10.4%	8.8%		

<sup>a</sup> *P-value of the Chi-Square test to compare the distribution of characteristics between injured and uninjured groups of skiers.*

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

Company during skiing was statistically significantly associated with injury severity (Fisher's test;  $p = 0.005$ ). A higher proportion of skiers with company was found among severely injured skiers (88%) than among moderately injured skiers (78%) and slightly injured skiers (67%) (Table 5).

**Table 5.** *The association between injury severity and skiing with other person*

Varijable	Total	Minor injury (ISS ≤ 8)	Moderate injury (8 < ISS ≤ 15)	Severe injury (ISS > 15)	p-value <sup>a</sup>	Cramer V
<i>Company during skiing</i>					0.005	0.182
Alone	10.8 %	17.1 %	15.2 %	3.2 %		
In a group	79.6%	67.1%	78.3 %	88.3 %		
In ski school	9.6%	15.8%	6.5%	8.5%		

<sup>a</sup> *P-value of the Fischer's test test to compare the distribution of characteristics between three groups of skiers.*

Most of the injured skiers had no visual field defects (92%). The trail was usually in good condition (according to 39% of the injured skiers), while 24% of the injured skiers skied on a trail with ice surfaces, 15% on a trail with bumps, 11% on a wet trail, 9% on deep snow, and 2% on an uneven (broken, narrow) trail (Table 6).

Visibility was mostly good (68%), 18% of skiers rated it as average and 14% as poor. Almost one in two injured skiers (47%) rated the temperature as comfortable, while 44% said it was cold, 8% said it was warm, and 1% said it was hot. Most of the injured skiers skied in sunny weather (58%), one in five skied in snow, 14% skied in fog, and 4% skied in cloudy weather or reduced sunlight (Table 6).

**INFLUENCE OF EXTERNAL RISK FACTORS  
ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS**

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**Table 6.** *Slope and weather condition*

Visual disturbance	No 92%	Yes 8%
Track conditions	Good 39%	Other (ice surfaces, bumps, wet trail, deep snow, broken trail) 51%
Visability	Good 68%	Other (average and poor) 32%
Temperature	Comfortable 47%	Other (cold, warm, hot) 53%
Weather conditions	Sunny 58%	Other (snow, fog, cloudy, dusk) 42%

Weather and other disturbances, such as limited field of vision (Chi-Square test;  $p = 0.744$ ), track conditions (Chi-Square test;  $p = 0.105$ ), visibility (Chi-Square test;  $p = 0.453$ ), temperature (Fisher's test;  $p = 0.340$ ), and other meteorological conditions (Fisher's test;  $p = 0.649$ ), were examined only in the injured group and showed no statistically significant correlation with injury severity (Table 7).

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

**Table 7.** Correlation between weather and slope condition with the severity of a skiing injury.

Variable	Minor injury (ISS ≤ 8)	Moderate injury (8 < ISS ≤ 15)	Severe injury (ISS > 15)	p-value <sup>a</sup>	Cramer V
<i>Visual disturbances (fog, tears, darkness, cap, glasses, flash or poles)</i>				0.744	0.053
No	89.9 %	93.5 %	92.6 %		
Yes	10.1 %	6.5 %	7.5 %		
<i>Track condition</i>				0.105	0.178
Good	47.8 %	28.3 %	37.2 %		
Wet	4.4 %	17.4 %	11.7 %		
Ice	23.2 %	21.7 %	26.6 %		
Deep snow	8.7 %	17.4 %	5.3 %		
Uneven surface	15.9 %	15.2 %	19.2 %		
<i>Visibility</i>				0.453	0.093
Good	61.4 %	69.6 %	72.3 %		
Mediocre	22.9 %	19.6 %	12.8 %		
Bad (fog, dark)	15.7 %	10.9 %	14.9 %		
<i>Temperature</i>				0.340	0.130
Cold	51.4 %	37.0 %	42.6 %		
Comfortable	44.3 %	47.8 %	47.9 %		
Warm	4.3 %	10.9 %	8.5 %		
Hot	0.0 %	4.4 %	1.1 %		
<i>Weather conditions</i>				0.649	0.121
Snow or rain	23.5 %	26.1 %	15.1 %		
Sun (sunny, windy)	54.4 %	56.5 %	61.3 %		
Fog	16.2 %	8.7 %	15.1 %		
Cloudy	2.9 %	6.5 %	3.2 %		
Reduces sunlight	2.9 %	2.2 %	5.4 %		

<sup>a</sup> P-value of the Chi-Square test / Fisher's test to compare the distribution of characteristics between the three ISS categories

### DISCUSSION

The main finding of the present study was that external risk factors, such as official ski school and company during skiing, do not influence the possibility of injury, nor do environmental conditions influence the severity of injury in recreational skiers. As it has been found, professionally trained ski instructors have

a doubtful influence on the likelihood of injury (Bouter & Knipschild, 1991; Macnab, Cadman, & Greenlaw, 1998; Johnson, Ettlinger & Shealy, 2009; Davey, Endres, Johnson, & Shealy, 2019). This study confirms the thesis of most studies that a trained ski instructor has no effect on injury likelihood or severity. However, when we

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

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examine the self-assessment of skiing skills compared to attending a formal school, we find that those who have attended a ski school are excellent skiers 32% of the time and beginners 4% of the time, while those who have not attended a ski school are beginners 25% of the time and excellent skiers only 8% of the time.

And this gives us the information that the official ski school fulfils its main purpose, which is to increase the knowledge of skiing and therefore probably to have more fun. Accompaniment while skiing is a factor that had no effect on the possibility of injury in the present study (the injured were accompanied by another person 79% of the time, the uninjured 80% of the time), whereas skiing in a group increased the severity of injury, which might be explained by increased relaxation.

Visual disturbance has not been previously studied, unless limited by bad weather, and thus was not a significant risk factor except at high speeds (Carus & Castillo, 2021). This study failed to demonstrate the influence of visual field impairment on injury severity, suggesting that other factors still have a much greater influence on injury severity. The influence of slope condition on injury has been extensively addressed in previous work and according to Dohin (Dohin & Kohler, 2008) is a risk particularly for younger and less experienced skiers. In this analysis, it had no statistically significant effect on injury severity. Considering that only 39% of injured skiers responded that the slope was good, it can be concluded that a

poor slope, although not influencing the severity of injury, can likely increase the possibility of injury. Visibility has been presented as a dubious factor in previous work, although it has been shown to increase the possibility of injury in poor weather (Aschauer, Ritter, Resch, Thoeni, & Spatzenegger, 2007).

This work showed that visibility had no effect on the severity of injury. Temperature is the next factor that has been studied only in the injured population and had no statistically significant effect on the severity of injury. It has been little studied in previous research and is mainly associated with weather conditions and poor visibility (Aschauer, Ritter, Resch, Thoeni, & Spatzenegger, 2007). According to previous research, cold weather leads to greater heat loss in women, so this could be a predisposing factor for injury, which has been shown specifically for the knee but was not investigated in this study. Meteorological conditions (sun, precipitation, etc.) were also only examined in the injured group and had no effect on injury severity.

Although the condition of the slope and the weather conditions were only studied in the injured skier group, so the possibility of injury itself was not studied for these factors, it can be concluded that they still have an influence on injury, as visibility was only good in 68% of skiers, only 47% of skiers rated the temperature as comfortable, and only 39% of injured skiers answered that the slope was good, so together they could be an important factor in the possibility of injury.

### Limitations

The disadvantage of this study is primarily the rather small sample compared to some other

analyses, but the advantage is that a control group was also selected. Most of the existing

## INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

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studies have not included a control group. Also, this study has an important condition for participation, which is the inability to ski for at least one day after the injury. Although this seems to be irrelevant data, other studies show that many injuries are contusions, abrasions, sprains, after which one could ski that day and the next and still be defined as a ski injury.

Finally, another real shortcoming of the study is the objectivity of the responses for some factors. The most obvious example is the subjective assessment of air temperature and slope conditions, so the above example may lead to an exaggeration or downplaying of the importance of external factors in describing conditions or assessing the cause of injury.

### CONCLUSION

By examining the external risk factors, they were found to have an impact on injuries in recreational skiers. However, the impact is exclusive in relation to improving skiing skills when attending formal ski school and increasing injury severity when skiing in a group. Environmental conditions do not increase injury severity, but could be an important factor in the possibility of injury. The results should be presented to recreational skiers, as well as professional coaches during their training sessions. Subsequent research should include additional self-assessments of injury causes as new variables and compare with the results obtained.

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# INFLUENCE OF EXTERNAL RISK FACTORS ON ALPINE SKIING INJURIES IN RECREATIONAL SKIERS

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## SAŽETAK

Glavni cilj ovog istraživanja bio je identificirati potencijalne vanjske čimbenike rizika za ozljede rekreativnih skijaša putem anketnog upitnika. Ispitanici su podijeljeni na ozlijeđene skijaše i kontrolnu skupinu koja nikada nije imala ozljedu. Ozlijeđeni skijaši (N=212) odgovarali su na pitanja koja su pomogla definirati potencijalne čimbenike rizika. Kontrolna skupina (N=206) ispunila je isti upitnik, ali bez pitanja o ozljedi. Zajednička pitanja korištena su za utvrđivanje mogućnosti ozljede pomoću Chi-Square testa, a dodatna pitanja za utvrđivanje utjecaja na težinu ozljede Fisherovim testom. Analizom vanjskih čimbenika pokazalo se da pohađanje službene škola skijanja nije bilo statistički povezano s mogućnošću i težinom ozljede, ali je značajno povećalo znanje skijanja. Skijanje u društvu nije smanjilo mogućnost ozljeda, ali je povećalo težinu ozljede. Vidljivost, vidno polje, stanje staze, temperatura i vremenski uvjeti nisu statistički povezani s težinom ozljede, ali kombinirano mogu biti važan čimbenik u mogućnosti ozljeda.

**Ključne riječi:** *skijanje, alpsko skijanje, skijaške ozljede, uzroci skijaških ozljeda*

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## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

HRONOLOŠKA STAROST ALPSKIH SKIJAŠA I SKIJAŠICA  
OSVAJAČA MEDALJA U OLIMPIJSKOM CIKLUSU 2015-2018.

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### ABSTRACT

*Personal motivation, as well as engagement in alpine skiing, brought the authors to inspect the differences in average chronological age of alpine skiers, and to present the results to the professional public, in order to improve planning and programming of the training process. The paper analyzed the average chronological age of medal winning professional alpine skiers in the World Cups in the 2015-2018 Olympic cycle. The following alpine disciplines were analyzed: Slalom (SL), Giant Slalom (GS), Super-G (SG), Downhill (DH) and Alpine Combination (AC). The obtained results indicate that there was a significant difference in the average chronological age between male and female competitors. The results of the present study show that there were differences in GS, SG, DH, and AC, where male skiers are on average older than female skiers. Conversely, there was no significant difference between male and female skiers in SL. The results of this study could aid coaches and experts in future years of individual management of sports careers of male and female skiers.*

**Key words:** alpine skiers, age, competitions, alpine disciplines.

# CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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## INTRODUCTION

Moving on snow has always been a challenge, more or less pleasant, which a person, depending on the time in which he lived, solved in different ways. Basically, skiing is lowering and crossing the falling line with skis, left and right turns at higher speed (Savić, & Stijepović, 2019). Alpine skiing is a complex sport of high intensity, from the category of acyclic polystructural sports (Koprivica, 2002). Skiing is a sport that is constantly evolving and improving, and in which we are involved from a different needs and motives perspective (entertainment, leisure, competitions, work). In contemporary conditions, the influence of science and technology in the sport of skiing is constantly growing, especially in terms of design and equipment, mechanics and aerodynamics, diagnostics and training planning. This points us to the fact that skiing definitely has a perspective, as well as to the fact that skiing has turned into a global sport and recreational activity, because it has experienced a great expansion in recent years. Today, alpine skiing competitions are a great attraction, especially competitions in the World Cup. The races take place from autumn to late spring in 8 disciplines: Slalom (SL), Giant Slalom (GS), Super-G (SG), Downhill (DH) and Alpine Combination (DH or GS and SL), Team Parallel (TP), Parallel Giant

Slalom (PGS), Parallel Slalom (PSL). Each of these disciplines has certain characteristics according to the international rules of the World Ski Federation (FIS). Moreover, skiing is a high intensity sport, where races last on average from 30 to 160 seconds and where isometric and eccentric muscle contractions are dominant. Contemporary competitive skiing, like most other sports, requires a high degree of specialization for certain competitive disciplines (Matković, Ferenčak, & Žvan, 2004). Therefore, the elite competition results depend on good diagnostics, training plan, mental readiness of competitors, appropriate training content selection, application of appropriate load, which are in compliance with periodization and competition calendar (Savić, Stojanović, Stojiljković & Jorgić, 2013).

The aim of this study fully defines the content and indicates the framework of the given tasks and goals, therefore appropriate statistical procedures could clarify the main goal of the present study. The chronical age of the athletes and the elite sports results have only been partially researched in similar studies and other sports. In the field of skiing, there are relatively few papers with a similar research problem, which is the reason why the authors decided to conduct this study. Furthermore, it complements

## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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the existing research problem with the new material, new comments and conclusions, and emphasizes the importance in the context of practical application in the training process. In the following text, we listed some of the studies regarding this topic.

Authors, Hancock, Adler & Côté (2013) in their study consider the effect of relative age (RAE) of athletes through different social contexts and emphasize the importance of the theoretical model (RAE). Authors Baker, Janning, Wong, Cobley, & Schorer (2014) also point out the term of relative age effect (RAE), which we will not apply in its original form in this study, since we did not take into account the exact date of birth of competitors in the competition season, but only the year of birth. In this regard, we used the term relative age of competitors (RAC). In a similar study, the authors of Müller, L., Müller, E., & Rashner, (2016) pointed out the fact that relatively older skiers are more successful in alpine races. Contrary to these findings, Bjerke, Pedersen, Aune, & Lorås, (2017) indicate the existence of a reverse relative age effecting skiers (RAE). Therefore, younger skiers achieved better results in competitions than older skiers.

Findings of similar research by Müller, L., Müller, E., Hildebrandt, & Raschner, (2016) clearly show the significant impact of biological

maturity status on the selection process of youth alpine skiers depending on the level of competition. It seems that relatively younger athletes have a chance to compete only if they have matured early. Neumayr, Hoertnagl, Pfister, Koller, Eibl, & Raas, (2003), dealt with the anthropometric characteristics of skiers with reference to their age, where they connect them with the researched characteristics. The process of growth and development, as well as the process of aging, are manifested by numerous changes in the structure and function of the individual, so the best period for achieving elite sport results is up to 30 years.

Scientific thought in modern society in the field of skiing is mostly based on achieving elite sport results. This study was methodologically set up so that it does not deal with causal relationships, but only analyzes, discusses and concludes on the differences between the arithmetic means of the relative age of alpine skiers and medal winners at the world's largest competitions. We have observed the practical values of such research interdisciplinary, because we are of the opinion that it is necessary. Such analysis can provide us some new information on the value of elite sport and its further development. The problem is implied in the increase and decrease of average chronological age in certain alpine disciplines

## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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and throughout competition seasons, and the differences across gender. The hypothesis of the present study indicates the fact that there are significant differences between male and female skiers who won medals in major competitions.

Based on the target sample of medal-winning alpine skiers and in certain alpine disciplines, a specific research goal has been set. The aim of the present study was to compare the differences in the relative age of the respondents by disciplines and therefore contribute to everyday practice, and provide recommendations to trainers to create their long-term goals and training plans. Therefore, the contribution could be towards practical application, and the ability to generate new theories and hypotheses.

### METHODS

In the present study, the targeted sample was employed (Stojiljković, Bratić & Sporiš, 2020), and selected on the basis of a specific characteristic of interest for this research - medal winners at the world's the most important competitions, therefore the interpretation

### RESULTS

To test the hypothesis that there was a statistically significant difference in the chronological age of the competitors, the T test for independent samples was applied. In Table 1, we can observe that the results of the Kolmogorov-Smirnov test (.09 - .22) are within the critical values, therefore, the assumption of normal distribution was met. The range of chronical age is scattered, therefore from the aspect of chronological age, this sample was not homogeneous. Moreover, based on the coefficient of variation, we can observe that there was a significant variation in the age of the competitors.

of gathered data could be significant for practical use. The targeted sample in this study was derived from a representative sample of alpine skiers and can serve to generalize the results of the alpine skier population. The results from the tables and graphs are descriptively treated and interpreted. A descriptive method was used, as well as the method of analysis and critique. The conclusions were established on the same basis.

The parameters of descriptive statistics, minimum and maximum, range, standard deviation, coefficient of variation, and Kolmogorov-Smirnov test were used to describe the continuous variable. To test the hypothesis that there is a statistically significant difference in the chronological age of the competitors, the independent samples t-test was applied. In the discussion and analysis of the obtained results, the comparison with the median was abandoned due to the great coincidence of the obtained results, especially when it comes to the tendencies of the average age by seasons and disciplines. All statistical analysis were carried out using Statistica 8 (StatSoft Inc., Tulsa, OK).

**CHRONOLOGICAL AGE OF ALPINE SKI  
MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE**

**Table 1.** Descriptive statistics of male and female Ski World Cup medal winners (age).

Event	Gender	N	M	Min.	Max.	Range	Std.Dev.	Coef.Var.	KS
Slalom	Male	117	27.59	20	35	15	3.94	14.29	.11
	Female	111	26.61	20	34	14	4.55	17.10	.17
G Slalom	Male	96	27.17	21	37	16	3.70	13.62	.14
	Female	98	26.16	19	34	15	3.12	11.92	.14
Super G	Male	81	29.72	23	37	14	3.883	13.07	.09
	Female	90	27.53	23	34	11	2.92	10.60	.16
Downhill	Male	108	30.72	24	38	14	3.61	11.75	.11
	Female	89	28.08	22	35	13	3.49	12.43	.14
AC	Male	27	28.74	22	36	14	4.12	14.33	.22
	Female	24	26.08	22	32	10	2.96	11.36	.14

**Legenda:** N – number of cases; M – mean; Std. Dev. – standard deviation; Min. – minimum; Max. – maximum; Range – range of results; Coef. Var. – coefficient of variation; KS – Kolomogorov-Smirnov test.

In Table 2, we have applied the independent T test to find that there were statistically significant differences in the chronological age of male and female competitors in Giant Slalom (M = 27.17, SD = 3.70; M = 26,16, SD = 3.12; t (192) = 2.04, p = 0.042), Super G (M = 29.72, SD = 3.88; M = 27.53, SD = 2.92; ; t (169) = 4.18, p < 0.001), Downhill (M = 30.72, SD = 3.61; M = 28.08, SD = 3.49; ; t(195) = 5.19, p < 0.001), and Alpine Combination (M = 28.74, SD = 4.12; M = 26.08, SD = 2.96; t(49) = 2.61, p = 0.012). There was no statistically significant difference between the examined subsamples in Slalom

(M = 27.59, SD = 3.94; M = 26,61, SD = 4.55; t(226) = 1.74, p = 0.084).

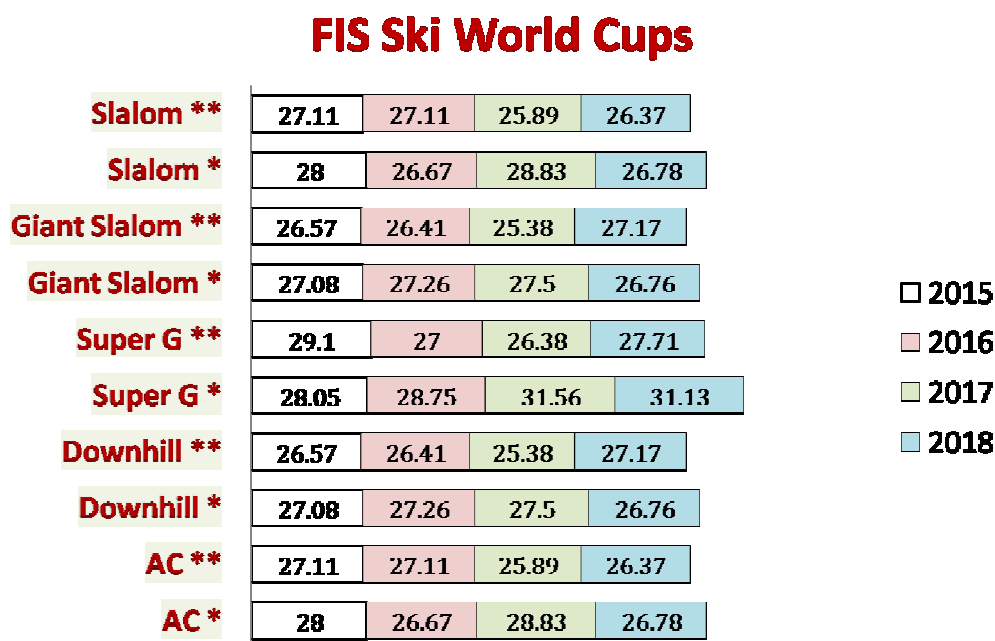
We can be 95% sure that there is a real difference between the mean values of the examined groups in Giant Slalom CI = [0.03, 1.97], Super G CI = [1.15, 3.21], Downhill CI = [1.64, 3.65], and Alpine Combined CI = [0.62, 4.70]. Moreover, the effects size was interpreted according to Hopkins (Hopkins, 2010), where the values of the effect size are low for Slalom and Giant Slalom. (Es = .11; Es = .15), and moderate for Super G, Downhill, and Alpine Combined (Es = .30; Es = .30; Es = .35).

## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

**Table 2.** The mean age difference between Ski World Cup medal winners (male vs female), Independent Samples Test.

Event	t - value	Mean diff.	95% CI	Effect size (r <sup>2</sup> )	p - value
Slalom	1.74 (226)	0.98	[-0.13, 2.09]	0.11	0.084
G Slalom	2.04 (192)	1.00	[0.03, 1.97]	0.15	<b>0.042</b>
Super G	4.18 (169)	2.18	[1.15,3.21]	0.30	<b>0.000</b>
Downhill	5.19 (195)	2.64	[1.64, 3.65]	0.35	<b>0.000</b>
AC	2.61 (49)	2.66	[0.62, 4.70]	0.35	<b>0.012</b>

**Legend:** t - value – value of t test; 95% CI – Confidence intervals (lower and upper bounds); Mean diff. – Mean difference between groups; Effect size (r<sup>2</sup>) – Effect size expressed as correlation coefficient; p - value – statistical significance.



**Legend:** \* - male competitors; \*\* - female competitors.

**Figure 1.** Mean age of medal winners at FIS Ski World Cups

The graphical representation in Figure 1 shows the average values of the chronological age of skiers by disciplines and competition seasons in the World Cup, which were the most frequent competition in the 2015-2018 Olympic cycle. It is important to note, that there was a decreasing trend in both categories in Alpine combination (AC) and Slalom (SL), that is younger medal winners in recent years, due to the fact that the entry categories in the FIS are primarily competing in the technical disciplines (SL and GS). Only in GS we can observe a slight increase in age (from 28.05 to 31.13).



## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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### DISCUSSION

The obtained results in the present study clearly give the basic descriptive indicators of the average age of the medal winners in the alpine ski disciplines (SL, GS, SG, DH, and AC), i.e., provide a basis for comparisons, discussion, and concluding remarks. With a general retrospective, we can observe that the obtained values oscillate according to competitive disciplines, which indicates the justification of this study. The lowest average age was observed among female competitors (26.08) in AC, and the highest (30.72) among skiers in DH. Due to frequent victories (80% of races) and / or winning medals of individual competitors (Marcel Hirscher, Henrik Kristoffersen, Alexis Pinturault, as well as skiers Lindsey Vonn, Mikaela Shiffrin, Petra Vlhova, Federica Brignone, etc.), the average years in one season did not change significantly, but the numbers grew through the seasons due to the aging of aforementioned competitors. Moreover, the results of the present study indicate that there are significant differences in the average age of competitors in all alpine disciplines, except in Slalom, where male competitors are on average chronologically older than female competitors. The results of this study should, however, be considered with some caution, given the fact that several factors in addition to age determine the medal winner, or affect the overall result. In

most cases, the result depends on subjective factors, individual technical and tactical abilities, mental strength, psychophysical readiness of athletes. However, the result in skiing often depends on other unpredictable factors: quality of equipment, technical malfunction of equipment, poor track inspection, ski dropouts, fall of rivals, "riding" gates, start errors, drop-loss of pole, sudden adverse weather conditions, high starting number, etc. However, the career of ski competitors has significantly extended over time. For example, from 1967 to 1971 the average age of medal winners was 20.7 for females, and 24.3 for males. The results of the study conducted by Neumayr, Hoertnagl, Pfister, Koller, Eibl, & Raas, (2003), showed an increasing trend in the average age of female and male skiers. In 1993, female and male Swiss skiers were on average 25 and 26 years old, respectively. Moreover, in the 1999/2000 season, female and male skiers were on average 25.2 and 27.6 years old, respectively. Finally, from 2009 to 2013 female and male skiers were on average 25.8 and 28.7 years old, respectively. Evidently, there was an extension in alpine ski career, for both female and male skiers.

Furthermore, it should be noted, that there were statistically significant differences in average age between male and female skiers in all speed disciplines (GS - 27,17 and 26,16; SG

## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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– 29,72 and 27, 53; DH - 30,72 and 28, 08, respectively), except in Slalom as a technical discipline (27.59 and 26.61). Moreover, Müller, L., Müller, E., & Rashner, (2016) emphasize that mostly older skiers are generally more successful in alpine racing. Contrary to these findings, Bjerke, Pedersen, Aune, & Lorås, (2017) pointed out the fact that younger skiers generally achieved better results in competitions than older skiers. Therefore, it should be noted, in addition to chronological age, that other previously described factors can significantly affect the top sports result (individual technical and tactical abilities, mental strength, psychophysical readiness of athletes, equipment quality, technical equipment malfunction, poor track inspection, ski dropouts, fall of rivals, "riding" gates, start errors, drop-loss of the pole, sudden adverse weather conditions, high starting number, etc.). Similar results and a tendency to extend the sports career for a few more years were found for fast disciplines, and maintenance or a slight decline for technical. This could be an important guideline for ski coaches in planning the long-term training process (long-term development planning for youth or several Olympic cycles for older competitors). It could be important to take these results into account when planning an elite sports form.

The results obtained in this study could potentially aid coaches and sports experts in the long-term individual management of the sports career of skiers. Ski experts work with different age categories, both male and female skiers, and therefore such process is hard, complex and responsible, however it provides great satisfaction Živanović, Savić, Milojević, & Milutinović, (2003). Sports in the twenty-first century was characterized as a period of new sporting frontiers and results. Modern sports principles exist on the basis of professionalism and earning profit. Throughout history, sport was developed and attracted attention with the constant tendency to increase sports results and win as many medals as possible. The background of today's elite sport is a well-organized sports industry in which a lot of profit is invested and from which a lot is earned (Savić, Randjelović, Stojanović, Stanković, & Šiljak, 2017).

The new technological challenges of the ski industry are related to lighter and faster torsion-resistant skis - "calm" in turns of different radii, but also to a combination of shorter and longer skis in the training for beginners (Stojanović, Savić, Stjepović, & Lilić, 2017).

## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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### CONCLUSION

The results of the present study indicate a trend of extending skiing careers for male and female competitors in the context of elite sports results, i.e., medal-winning performance at the World Cups, compared to the last two decades. Moreover, a significant difference was found in the average age of male and female competitors, where male skiers are on average significantly older in all disciplines, except in the Slalom. Based on these results, we could conclude that the sports career, in terms of elite results, is significantly longer for male skiers. Conversely, there was a declining trend in the average age of skiers in the SL and GS in the period from 2015 to 2017. However, the modern framework of alpine skiing could be reflected through several important spheres: social, elite sport result,

media, marketing, health, philosophical and personal, each of which, in its own manner promotes and improves skiing and the accompanying sports industry (material sphere). Therefore, it was difficult to determine which of them is the most important and it is necessary to observe them interdisciplinary, because only from this standpoint they can provide valuable scientific contribution. The present study considered the elite sport result only from average age perspective, however, it should be noted that other valuable unobserved factors, could be quite beneficial for medal-winning performance. Therefore, future studies should explore this matter in depth, in order to draw more adequate conclusions.

## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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## CHRONOLOGICAL AGE OF ALPINE SKI MEDAL WINNERS IN THE 2015-2018 OLYMPIC CYCLE

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### SAŽETAK

*Lična motivacija, kao i angažovanje i rad u skijanju naveli su autore da istraže razlike u prosečnoj hronološkoj starosti skijaša i skijašica kao i da stručnoj javnosti prezentuju rezultate u cilju uspešnijeg planiranja i programiranja trenaznog procesa. U radu je analizirana prosečna hronološka starost profesionalnih alpskih skijaša i skijašica, osvajača medalja na Svetskim kupovima, u olimpijskom ciklusu 2015–2018. Analizirane su sledeće alpske discipline: Slalom SL, Vleleslalom GS, Super G SG, Spust DH i Alpska kombinacija AC. Dobijeni rezultati ukazuju da postoji statsitički značajna razlika u prosečnoj hronološkoj starosti između skijaša i skijašica. Pri tome, može se uočiti da postoje značajne razlike u disciplinama GS, SG, DH i AC, gde su skijaši stariji u proseku od skijašica. Nasuprot tome, u disciplini SL nije bilo značajnih razlika u hronološkoj starosti skijaša i skijašica. Rezultati ovog istraživanja mogu pomoći trenerima i stručnjacima u višegodišnjem individualnom upravljanju sportske karijere skijaša i skijašica.*

**Ključne reči:** *skijaši, skijašice, godine starosti, takmičenja, analiza, alpske discipline.*

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# INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

UTICAJ COVID 19 NA MORFOLOŠKI I KARDIOVASKULARNI STATUS PROFESIONALNIH RUKOMETAŠA

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## ABSTRACT

*Handball is one of the very popular sports games in the world. The current COVID 19 pandemic directly affects handball players in the training and competition processes from all age categories but professional players seem to be at a higher risk of contracting the disease. This study aimed to assess morphological and cardiovascular status of 20 participants, professional handball players who compete at elite competition rank, and therewith to adjust their training process and to test the differences between COVID 19 positive and COVID 19 negative participants. Testing included measurements of basic morphological parameters while the function of the cardiovascular system (CVS) was assessed at rest and effort - exercise stress test with Vita Maxima protocol. The results of t-test did not show a statistically significant difference in morphological and cardiovascular characteristics of participants who had COVID 19 infection (with a positive PCR test), who had symptoms of infection but no PCR test for the virus, and those who did not contract COVID 19.*

**Keywords:** COVID 19, handball players, exercise stress test, cardiopulmonary performance

# INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

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## INTRODUCTION

Handball is an international sport and as such it is one of the very popular sports games in the world. Global events with COVID 19 pandemic directly affect the handball players in the quality of the training and competition process from all age categories. Some authors have created exercise programs at home for elite handball players for keeping their aerobic capacity and jumping performance during lockdown period due to the COVID 19 pandemic (Font, Iruiria, Gutierrez, Salas, Vila, & Carmona, 2021). Those authors have confirmed that that program can contribute to the preserving of the jumping performance but it proved to be inefficient in terms of aerobic capacity in elite handball players. Handball is a sport with frequent contact between the players which directly exposes them to the higher potential risk of the infection. On the other hand, considering the health issues in post COVID 19 period, there is growing evidence in the literature that changes in the heart in symptomatic and asymptomatic individuals after COVID 19 infection may be a critical factor (Tahir, Bin Arif, Ahmed, Malik, & Khalid, 2019). Elite athletes may be at increased risk of sudden cardiac death due to myocarditis during COVID 19 infection as a result of their higher level of physical activity (Verwoert, de Vries,

Bijsterveld Willems, Vd Borgh, Jongman, Kemps, Snoek, Rienks, & Jorstad, 2020). The screening strategy for the myocardial effects of COVID 19 on elite athletes has not yet been confirmed.

The results obtained by spiroergometry testing did not prove useful and sufficient for the evaluation after COVID 19 (Stöbe, Richter, Seige, Stehr, Laufs, & Hagendorff, 2020). Also in an MRI (magnetic resonance imaging) study that included 26 athletes with and without symptoms, signs of myocarditis were confirmed in 4 cases. Eight athletes showed late MRI improvement (McKinney Connelly, Dorian, Fournier, Goodman, Grubic, Isserow, Moulson, Philippon, Pipe, Poirier, Taylor, Thornton, Wilkinson, & Johri, 2021). Another study identified significant number of athletes with persistent symptoms characteristic of this virus for weeks and months after COVID 19 infection (Phelan, Kim, Elliott, Wasfy, Cremer, Johri, Emery, Sengupta, Sharma, Martinez, & La Gerche, 2020). A cohort study of 1,597 athletes at the American Football Conference identified 37 athletes (2.3%) with signs of clinical or subclinical myocarditis (Stöbe, Richter, Seige, Stehr, Laufs, & Hagendorff, 2020).

Therefore, MRI of the heart is a sufficiently sensitive method, but the problem arises in the

## INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

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unavailability of this testing procedure for athletes around the world due to the economic reasons, i.e. diagnostic costs. In the study where both methods, MRI and spiroergometry, were used, a new conclusion was reached (Fikenzer, Kogel, Pietsch, Lavall, Stöbe, Rudolph, Laufs, Hepp, & Hagendorff, 2021). Namely, those authors have confirmed significant decrease in VO<sub>2</sub>max and respiratory minute volume in athletes with a history of COVID 19 infection ( $p < 0.05$ ), while all these parameters remained

### METHODS

The sample of participants consisted of 20 senior handball players who competed in the Serbian Handball Super League in season 2020-2021. During the regular medical checkup, after the first part of the season, two groups of players were identified. The first group of 12 players was labeled as COVID 19 positive (four players recovered from COVID 19 and eight players had COVID 19 symptoms but negative PCR test), and the second group of eight players was asymptomatic and negative COVID 19 group. The symptoms present in the first group of eight players were typical for COVID 19 with different degrees of alterations from one participant to another: elevated temperature, weakness, loss of smell, coughing. The recovery from COVID 19 was confirmed by

unchanged in handball players who were not infected. Having in mind the magnitude of the current COVID 19 pandemic, and its endangerment of the professional athletes, the main aim of the present study was to assess the morphological and cardiovascular status of 20 participants who professionally play handball at the elite level in order to adjust their training process, and to examine the differences between the participants who were COVID 19 positive and negative.

medical checkup and it followed general recommendations from the WHO of 14 days from the first symptoms and positive PCR test. The study was conducted six months after the disease diagnosis since that was considered a sufficient period for the recovery, low risk, and uneventful exercise stress testing. Furthermore, this period was decided since the participants did not undergo MRI scan during the COVID 19 diagnostic procedures.

Body height, body weight and body fat percentage were the basic morphological variables and it included measurement of these parameters in clinical environment with following procedure: body height was determined by Seca stadiometer (unit of measure is 1 cm). The Tanita® BC-418MA



## INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

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bioimpedance method was used to determine body weight (kg) and body fat percentage - FAT%.

The function of the cardiovascular system (CVS) was assessed at rest and effort – measuring the blood pressure, heart rate, ECG monitoring and exercise stress test of the first clinic of the sports medicine in Serbia, Vita Maxima (modified STEEP protocol, Northridge, Grant, Ford, Christie, McLenachan, Connelly, McMurray, Ray, Henderson, & Dargie,1990). Before the exercise stress test, the participants underwent basic medical checkup (blood pressure, heart rate, auscultation, and clinical examination) to determine their health status to perform the exercise stress test. A 12-channel ECG (Fukuda) was performed at rest, heart rate was recorded and arterial blood pressure was measured on both arms. Ergometric testing monitored the function of CVS in exertion: ECG recording during exertion, the maximum heart rate, as well as the maximum value of arterial blood pressure. A treadmill (HP-COSMOS®) was used in executing the exercise stress test. Exercise stress test protocol of the first clinic of the sports medicine in Serbia, Vita Maxima, included stepwise increase in workload with an

initial speed of 5 km/h and an elevation of 3° was used for the test. The treadmill speed increased by 1 km/h every 60 seconds, while the elevation was constant during the test. Participants wore a mobile ECG device (Quarck® T 12x, Wireless 12-lead ECG) on their back to directly monitor heart rate during exercise. For the participants safety, i.e. overload avoidance and potential cardiologic complications, the test was terminated in the following two cases: 1. 90% or more of the predicted theoretical heart rate maximum for sex and age calculated by the formula: 220 - number of years, 2. a subjective feeling of exhaustion.

In the data analysis, basic descriptive parameters were calculated for all variables including arithmetic mean, standard deviation, minimum, maximum, and range. The differences in morphological characteristics and parameters of the CVS at rest and effort between handball players who had COVID 19 infection (with confirmed positive PCR test and no test performed, but with symptoms characteristic of COVID 19) and those who did not, were tested by t-test for independent groups. Statistical data processing was performed in the statistical package SPSS 20.0 for Windows.

## INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

### RESULTS

Results of the descriptive statistics are presented in Table 1.

**Table 1.** Descriptive characteristics of the selected variables for both groups of the sample

Variables	Group	Mean	SD	Range	Min	Max
Age	positive	21.8	3.7	13.0	17.0	30.0
	negative	26.6	7.5	19.0	20.0	39.0
BM (kg)	positive	90.0	9.4	27.2	77.7	104.9
	negative	96.9	14.9	43.0	78.2	121.2
BH (cm)	positive	187.3	5.4	19.0	178.0	197.0
	negative	186.3	5.4	16.0	179.0	195.0
Body fat (%)	positive	13.4	4.3	15.0	6.0	21.0
	negative	16.2	4.5	10.6	11.2	21.8
SBP at rest (mmHg)	positive	120.8	7.9	20.0	110.0	130.0
	negative	121.4	18.6	50.0	110.0	160.0
DBP at rest (mmHg)	positive	72.5	4.5	10.0	70.0	80.0
	negative	75.7	5.3	10.0	70.0	80.0
HR at rest (bpm)	positive	67.9	13.7	50.0	52.0	102.0
	negative	59.6	11.8	34.0	46.0	80.0
HR max (bpm)	positive	183.5	7.6	25.0	171.0	196.0
	negative	177.6	9.3	26.0	160.0	186.0
Percent of max HR	positive	92.6	3.7	12.5	85.5	98.0
	negative	91.8	4.1	11.4	85.5	96.9
HR recovery 1 min (bpm)	positive	153.6	12.8	46.0	127.0	173.0
	negative	155.1	8.9	21.0	145.0	166.0
HR recovery 2 min (bpm)	positive	128.3	20.1	80.0	78.0	158.0
	negative	125.0	11.1	34.0	107.0	141.0
HR recovery 3 min (bpm)	positive	115.3	17.6	73.0	73.0	146.0
	negative	113.4	9.3	26.0	100.0	126.0

**Legend:** BM – Body mass; BH – body height; SBP – systolic blood pressure; DBP – diastolic blood pressure; HR at rest – Heart rate at rest; HR max – Maximal heart rate; Mean – Arithmetic mean; SD – Standard deviation; Range – Difference between maximal and minimal result; Min – minimal result; Max – Maximal result

## INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

The differences in morphological characteristics and parameters of the CVS at rest and effort between the two groups of participants were tested by t-test for independent samples (Table 2.)

**Table 2.** *The results of the t-test between COVID 19 positive and negative groups*

Variables	t	p
Age	-1.460	0.09
BM (kg)	-0.880	0.93
BH (cm)	0.080	0.93
Body fat (%)	-0.720	0.48
SBP at rest (mmHg)	0.175	0.87
DBP at rest (mmHg)	-0.426	0.68
HR at rest (bpm)	0.950	0.36
HR max (bpm)	1.080	0.30
Percent of max HR	0.180	0.86
HR recovery 1 min (bpm)	-0.690	0.50
HR recovery 2 min (bpm)	0.100	0.92
HR recovery 3 min (bpm)	0.060	0.95

**Legend:** BM – body mass; BH – body height; BMI – body mass index; SBP – systolic blood pressure; DBP – diastolic blood pressure; HR – heart rate

The t-test did not show a statistically significant difference in morphological and cardiovascular characteristics of handball players who had COVID 19 infection (with a positive PCR test), who had symptoms of infection but no PCR test for the virus, and those who did not ( $p > 0.05$ ).

## DISCUSSION

By examination of handball players, we assessed the function of the cardiovascular system (CVS) at rest and effort, heart rate and arterial blood pressure in both arms, maximum heart rate, and maximum value of arterial blood pressure. There were no statistically significant differences observed between the participants with COVID 19 infection, and/or with

characteristic symptoms, but without a PCR test, and the participants who did not have COVID 19. The insight into the ergometry results suggested that handball players did not have cardiac rhythm disorders, nor signs of ischemic heart disease in both groups of participants. COVID 19 infection did not lead to heart muscle damage or affect the morphological

## INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

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characteristics of infected athletes. The limitations of the current study are primarily a small sample of infected athletes as well as the total sample. At the same time, we did not have the results from COVID 19 pre-pandemic period of these athletes with the same parameters with which obtained results could be compared. Namely, the ergospirometric testing that was not done with these participants, would have given a more concrete insight into the functional status of participants, in terms of possible pulmonary obstructions, indirect assessment of the left ventricular function, but also fitness in terms of maximum oxygen consumption and anaerobic endurance. There is a research, where besides MRI scanning, ergospirometric was performed and new conclusions were drawn (Fikenzer, S., Fikenzer, K., Laufs, Falz, Pietrek, & Hepp, 2021). Namely, eight top level handball players (27±3.5 years) who had COVID 19 infection were tested and compared with four uninfected teammates (22 ± 2.6 years). The infected athletes were examined 19±7 days after the first positive PCR test. MRI showed fewer signs of acute inflammation/edema in all the infected, while ergospirometric analysis showed a significant decrease in VO<sub>2</sub>max (-292 ml/min, -7.0%), pulse (-2.4 ml/beat, -10.4%), and respiratory minute volume VE (-18.9 l/min, -13.8%) in athletes with a history of COVID 19 infection (p<0.05). All above mentioned

parameters have remained unchanged in the uninfected handball players. Due to the very limited number of studies on the handball players, the findings of the current study, where no differences were found between the post COVID 19 and non COVID 19 players, can be compared with the study of Fikenzer, S., Fikenzer, K., Laufs, Falz, Pietrek, & Hepp, (2021). The existing differences in results are probably due to the time of testing of the convalescents which significantly differs in these two studies (19±7 days after the confirmed diagnosis in Fickenzer et al., and 6 months in the current study). Considering that the Fikenzer, S., Fikenzer, K., Laufs, Falz, Pietrek, & Hepp, (2021) undoubtedly concluded that the COVID 19 infection causes impairment of cardiopulmonary performance during the physical exertion in elite handball players, it supports the recommendation of conducting ergospirometric testing of professional athletes after a COVID 19 infection. The importance of the echocardiographic heart examination, in order to exclude suspicion of the occurrence of myocarditis, which may also be a consequence of coronary infection, were confirmed in an earlier study (Stöbe, Richter, Seige, Stehr, Laufs, & Hagendorff, 2020). Any suspicion of the development of myocarditis, according to the latest literature data related to a COVID 19 infection, should be further examined and

## **INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS**

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verified by an examination that includes magnetic resonance imaging of the heart, especially when echocardiographic examination does not show clear signs of myocardial inflammation (Fikenzer, Kogel, Pietsch, Lavall, Stöbe, Rudolph, Laufs, Hepp, & Hagendorff, 2021). Unfortunately, sports clubs often do not have the financial means to do all the necessary tests, which was the case with presented testing as well.

It would be ideal to do an exercise test (ergometry), an ultrasound examination of the

heart and ergospirometry, to determine whether there are malignant heart rhythm disorders.

Certainly, it would be wrong to ignore any hints of changes in the state of performance of athletes at submaximal and maximum loads, even in asymptomatic forms of a COVID 19 infection. A new study has proven that only cardiac magnetic resonance imaging (CMR) has revealed focal myocarditis (Nedeljković, Giga, Ostojić, Đorđević-Dikić, Stojmenović, Nikolić, Dikić, Nedeljković-Arsenović, Maksimović, Dobrić, Mujović, & Beleslin, 2021).

### **CONCLUSION**

Based on the ECG findings, parameters of the arterial blood pressure, and heart rate which were monitored continuously by a sports medicine specialist during the exercise stress testing, it has been observed that within both groups of participants there were no cardiac rhythm disorders, nor signs of an ischemic heart disease. These parameters, as well as the results at the exercise stress test in participants who recovered from a COVID 19 infection, indicate that the disease did not lead to a heart muscle damage or affected the morphological characteristics of infected athletes.

In line with the earlier findings, it could be recommended to perform ergospirometry as a useful means in identifying limitations in performances of athletes after the COVID 19 infection, and based on this information it could be easier to control and manage their return to the training process.

## INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

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# INFLUENCE OF COVID 19 ON MORPHOLOGICAL AND CARDIOVASCULAR STATUS OF PROFESSIONAL HANDBALL PLAYERS

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## SAŽETAK

Rukomet je jedna od vrlo popularnih sportskih igara na svijetu. Trenutna pandemija virusom COVID 19, pored ostalih sportista, direktno otežava igračima rukometa trenažni proces, kao i održavanje takmičenja u svim uzrasnim kategorijama, s tim da su profesionalni igrači vjerovatno pod većim rizikom od zaražavanja. Ovo istraživanje je imalo za cilj da se procijeni morfološki i kardiovaskularni status 20 ispitanika koji se profesionalno bave rukometom u vrhunskom rangu takmičenja kako bi se adekvatno mogao prilagoditi trenažni proces i da se ispituju razlike između ispitanika koji su bili pozitivni na testu za COVID 19 i ispitanika koji su bili negativni na testu za COVID 19. Testiranja su obuhvatala mjerenja osnovnih morfoloških parametara, a funkcionalnost kardiovaskularnog sistema (CVS) je testirana u mirovanju i naporu – testom progresivnog opterećenja po protokolu Vita Maxima. Rezultati t-testa su pokazali da ne postoje statistički značajne razlike u morfološkim i kardiovaskularnim karakteristikama ispitanika koji su imali COVID 19 infekciju (sa pozitivnim PCR testom), igrača koji su imali simptome ali bez PCR testa i igrača koji nisu imali COVID 19.

**Ključne riječi:** *COVID 19, rukometaši, maksimalni test opterećenja, kardiopulmonarne performanse*

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Svi članci obavezno podliježu recenziji. Za svaki članak predviđena su dva recenzenta iz relevantne naučne oblasti i oba su anonimna (Imena autora takođe su i za recenzente anonimna (double blind recension)). Ukoliko članak, prema mišljenju recenzentata, ne zadovoljava kriterije časopisa, uredništvo članak ne prihvata. Postupak recenzije traje 8 do 12 sedmica. Ukoliko pak recenzenti pozitivno ocjene članak, svrstavaju ga u jednu od kategorija:

- Izvorni naučni članak predstavlja prvu objavu originalnih istraživačkih rezultata u takvom obliku da istraživanje može da se ponovi, a utvrđene činjenice da se provjere. Organizovan je po šemi IMRAD za eksperimentalna istraživanja ili na deskriptivan način za deskriptivna naučna područja.



## Guideliness for Authors

- Scientific work review is a review of papers on a specific topic, works of an individual researcher or a group of researchers whose aim is to summarize, analyze, evaluate or synthesize already published information. It brings new syntheses which also include results of author's own research.
- Short scientific article is an original scientific article which may skip some elements of IMRAD. It concisely presents results of a completed own research or of an ongoing research.
- Scientific gathering presentation is a comprehensive article that has previously been briefed to a scientific gathering, but it has not been published in its comprehensive form in the Paper Collection Book of the gathering.
- Professional article is a review of something that is already known, with an emphasis on the usability of the results of the original research and the spread of knowledge. The complexity of the text is adjusted to the needs of the professional and scientific aspects of the journal. After reviews have been done, the editorial board will analyze them. If needed, the paper is sent back to the author who must comply with the suggestions and objections made by the reviewers. Once they have redone the paper, the authors need to specifically describe, on a separate sheet of paper, how they have resolved the reviewer's suggestions. Only those papers that have been placed in one of the categories and which have two positive reviews will be published.

### Text style and organization

Scientific articles must adhere to the IMRAD scheme (Introduction, Methods, Results and Discussion).

### Title

The title page of the manuscript should contain the following information: (1) a concise, but informative title. Use of abbreviations is not encouraged; (2) the author's names (do not include degrees); the last one is introduced by "&"; (3) the affiliation of the authors, town and state; (4) the name and address of the corresponding author (must include title, degree and position of the corresponding author, phone and fax numbers - zip code for the country and city, and email address).

### Summary, large summary and key words

The summary should be brief and Self-explanatory. It should cover a general presentation of the topic

## Uputstvo za autore

- Pregledni naučni članak predstavlja pregled naj-novijih radova o određenom predmetnom području, radova pojedinog istraživača ili grupe istraživača sa ciljem da se već publikovane informacije sažmu, analiziraju, evaluiraju ili sintetizuju. Donose nove sinteze koje, takođe, uključuju i rezultate sopstvenog istraživanja autora.
- Kratki naučni članak predstavlja izvorni naučni članak kod kojih neki elementi šeme IMRAD mogu da budu ispušteni. Ukratko sažima rezultate završenog izvornog istraživačkog rada ili rada koje je još u toku.
- Izlaganje sa naučnog skupa predstavlja cjelovit članak koji je prethodno referisan na načnom skupu, ali u obliku cjelovitog članka nije objavljen u zborniku naučnog skupa.
- Stručni članak predstavlja prikaz već poznatog, s naglaskom na upotrebljivost rezultata izvornih istraživanja i širenja znanja, a zahtijevnost teksta prilagođena je potrebama stručnosti i naučnosti časopisa. Nakon primljenih recenzija uredništvo ih analizira. Ukoliko je to potrebno, rad se vraća autoru koji je dužan uvažiti sugestije i primjedbe recenzenata. Kada preradi svoj rad autor-i treba da, na posebnom listu papira, konkretno navedete kako su razriješili sugestije vezane za recenziju. Objavljuju se samo radovi koji su svrstani u jednu od kategorija i koji imaju dvije pozitivne recenzije.

### Stil i organizacija teksta

Naučni članci se organizuju po šemi IMRAD (Introduction, Methods, Results, i Discussion).

### Naslov rada

Naslov rada treba da sadrži sledeće informacije: (1) kratak ali informativan naslov u kome se ne preporučuje korištenje skraćenica; (2) ime autora bez titule gdje se ispred poslednjeg autora stavlja "i"; (3) institucija u kojoj autor-i radi, grad i država; (4) ime i adresa autora predviđenog za korespondenciju (naučno zvanje, položaj, broj telefona i faksa, poštanski broj grada, državu i e-mail adresu).

### Sažetak, veliki sažetak i ključne riječi

Sažetak treba da bude kratak i razumljiv sam po sebi. U sažetku se ne treba pozivati na tekst članka. Treba da obuhvati opšti prikaz teme (predmet i cilj rada), rezultate i zaključak. Autori ne bi trebali da tom prilikom koriste skraćenice. Sažetak treba da sadrži 150-250 riječi. Velik sažetak ne smije da pređe 1800 karaktera (do tri stranice u duplom proredu), i treba da sadrži naslov rada, ključne riječi i tekst sažetka.

## Guideliness for Authors

(the purpose and the objective of the paper), results and conclusions. Authors should not use abbreviations. The abstract should include 150-250 words. Authors from abroad write the large summary in their native language (the summary has to be reviewed), and the authors whose native language is BCS write the mentioned summary in one of the official languages of the IOC Assembly (article 27 of Olympic Charter), except English. The translation should be made by relevant person. Large summary should not exceed 1800 characters (up to three pages of double spaced text), and should include title, keywords and summary text. Three to six words, which are not part of the title, need to be singled out. The Key words need to reflect the contents of the paper.

### Introduction

This part of the paper ought to inform the reader of the issues dealt with in the research and the results of previous analyses. The purpose of the research should also be clearly stated in this part.

### Methods

This part should consist of the following subtitles: entity sample, variables, procedures, tastings, statistical analysis. Units of measurement, symbols and abbreviations must conform to international standards. Measurements of length, height, weight and volume should be given in metric units (meter, kilogram, liter).

### Results

The results should be presented as tables, graphs and pictures, possibly processed statistically and be concisely presented in the text.

Tables, graphs and pictures showing the results of individual analyses need to be indicated in the text for easier reader navigation.

### Discussion

The authors are expected here to comment on the results and compare them with literature data. The discussion must be professional and correspond to experimental data. Practical implications are welcome.

### Conclusion

Contains clearly stated scientific assertions, open issues and recommendations for further research.

### Tables, graphs and pictures

Each table and any illustration (black and white only) must be submitted on a separate sheet of paper. Tables should be numbered in the order in which they occur in the text and referred to as, for example, "Table 1". Each table should be accompanied by a short title. Tables should be accompanied with interpretations (legends). It will also be deemed informative if the tables include indications of important

## Uputstvo za autore

Autori iz inostranstva veliki sažetak pišu na maternjem jeziku (sažetak mora da bude lektorisan), a autori kojima je maternji jezik BHS ovaj sažetak pišu na jednom od jezika Međunarodnog olimpijskog komiteta, naravno osim engleskog, na koje se simultano prevodi na svim Skupštinama MOK-a (član 27 Olimpijske povelje). Prevođenje mora da uradi stručna osoba. Potrebno je izdvojiti i dati tri do šest ključnih riječi koje se ne nalaze u naslovu. Ključne riječi moraju da odražavaju suštinu sadržaja rada.

### Uvod

Ovaj dio rada treba da informiše čitaoca o problemima datog istraživanja i rezultatima prethodnih analiza. Cilj istraživanja takođe treba jasno navesti u ovom dijelu.

### Metode

Ovaj dio treba da se sastoji od sledećih podnaslova: uzorak entiteta, varijable, procedure testiranja, statistička analiza. Mjerne jedinice, simboli i skraćenice moraju da poštuju međunarodne standarde. Mjere dužine, visine, težine i zapremine moraju da budu u metričkim jedinicama (metar, kilogram, litar).

### Rezultati

Rezultati bi trebalo da budu predstavljeni kroz, tabele, grafikone i slike, statistički obrađene i koncizno interpretirane.

**Tabele, grafikoni i slike** koje pokazuju rezultate pojedinih analiza trebaju da budu naznačene u tekstu kako bi se pažnja čitaoca skrenula na njih.

### Diskusija

Od autora se očekuje da iznesu dokaze istraživanja i da ih uporede sa dosada objavljenim istraživanjima u toj oblasti. Diskusija mora da bude stručna i u skladu sa podacima eksperimenta. Poželjno je da diskusija obuhvati i praktične implikacije rada.

### Zaključak

Sadrži jasno izrečene naučne tvrdnje, otvorena pitanja i preporuke za daljnja istraživanja.

### Tabele, grafikoni i slike

Svaka tabela, grafikon i slika (samo u crno bijeloj tehnici) treba da bude dostavljena na posebnom listu papira. Tabele treba da budu numerisane po redoslijedu kojim se pojavljuju u tekstu i označena kao npr. "Tabela 1". Svaka tabela treba da ima kratak naslov. Potrebno je dodati legende za tabele. Takođe bilo bi informativno ako bi se u tabelama naznačile značajnije korelacije i značajnije varijable. Tabele treba posebno priložiti.

Ilustracije, grafikoni i slike obilježavaju se sa "Slika 1". Fotografije se šalju u elektronskoj formi u rezuliciji najmanje 300 dpi i formatu .tif (slike) i .eps (grafike). Svaka slika treba da ima kratak naslov.

## Guideliness for Authors

correlations and relevant variables. Tables should be submitted separately.

Illustrations, graphs and pictures shall be marked as "Figure 1". Photographs are sent in electronic form in a resolution not smaller than 300 dpi and in a .tif (figures) and .eps (graphics) format. Each figure needs to have a short title. In case that the figures are taken over from another paper, the title should not include the original name. In such a case, the source where the picture was taken from should be indicated under the picture.

If tables, graphs and pictures contain special symbols, or are prepared in a special program, they must be submitted in a separate file, with clearly indicated order of their inclusion in the text.

### Article technical form

Articles are written and published in Latin alphabet, and, when needed, in other alphabets, in the Serbian language (ijekavica dialect) and the English language. Any deviation from this, needs to be agreed with the editorial board in advance. If author's native language is not Serbian, Croatian or Bosnian their papers will be translated by editorial board. When translating the paper authors are suggested to engage someone whose native language is English.

Texts are to be written in Microsoft Word Windows program, on A4 paper format. Text is to be written in the Times New Roman font, size 12 pt in 1.5 spacing, aligned on both sides, with a 1 tab denting of the first row of a paragraph, with 2.5 cm paper margins. If it is necessary to indicate a word or a sentence in the text, use the italic. Text size should conform to 15 pages. The editorial board may accept a bit longer papers, but it will seldom do so.

Articles and abstracts should be written in the third person, neutrally, adhering to a good style and defined linguistic norms.

### Refereneces

The journal uses the Harvard reference system - APA standards for referencing literature.

The manuscripts are received on e-mail address:  
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## Uputstvo za autore

U slučaju da su slike preuzete iz nekog drugog rada, u naslovu ne bi trebalo da se nalazi originalni naziv.

U takvom slučaju potrebno je da se ispod slike nalazi Izvor odakle je slika preuzeta.

Ukoliko tabele, grafikoni i slike sadrže posebne znakove, te su rađeni u posebnom programu, dostavljaju se na posebnom fajlu, sa tačno navedenim rasporedom po kojem se uključuju u tekst.

### Tehničko oblikovanje članka

Članci se pišu i štampaju latiničnim pismom, po potrebi i drugim pismima, na srpskom (ijekavica) i engleskom jeziku. Svako odstupanje od navedenog, treba posebno unaprijed dogovoriti s Uredništvom. Ako se radi o autorima kojima maternji jezik nije srpski, hrvatski ili bošnjački njihove radove na srpski prevodi uredništvo. Autori su dužni da prilikom prevođenja rada na engleski jezik angažuju stručne osobe, najbolje one kojima je maternji jezik engleski. Tekstovi se pišu u Microsoft Word Windows programu, na papiru A4 formata. Tekst se piše u Times New Roman fontu, veličine 12 pt u proredu 1,5, poravnat sa obje strane, sa uvlačenjem prvog reda pasusa od 1 tab, sa marginama papira 2,5 cm. Ukoliko je u tekstu potrebno posebno označiti neku riječ ili rečenicu, koriste se kosa slova (italik). Obim teksta treba da sadrži do 15 strana. Uredništvo može prihvatiti i malo duže radove ali će to činiti rijetko. Članke i sažetke treba pisati u trećem licu, neutralno, pridržavajući se dobrog stila i utvrđenih jezičkih normi.

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