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ORIGINAL SCIENTIFIC PAPER

Single Bout High Intensity Interval Exercise (HIIE) Prevents Adiponectin Reduction in Sedentary Overweight Women

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Abstract

This study aimed to analyze the effect of a single bout of high-intensity intermittent exercise (HIIE) on serum adiponectin levels in sedentary overweight young adult women. A total of 22 overweight adult obesity women with a BMI of 23-24.9 m2/kg were enrolled in this study. Subjects were divided into 2 groups, control and HIIE. The exercise was static cycling for a total of 25 minutes (3 minutes warming up, 20 minutes HIIE, and 2 minutes cooling down). The HIIE was held 10 sets intermittently with the ratio 1:1, 1 minute cycling in 80-90% HRmax, 1 minute active resting with 40 rpm cycling. The data in this study were taken before and 1 hour after the HIIE. The adiponectin level was measured using a human ELISA kit. The adiponectin level in the control group reduced significantly ($p<0.05$), however, the HIIE group reduced insignificantly. A single bout of HIIE in sedentary overweight young adult women can maintain the adiponectin level. Therefore, it may have a positive contribution to women's health. However, further research needs to be conducted to uncover the underlying mechanism.

Keywords: *HIIE, adiponectin, overweight, sedentary, women, healthy lifestyle*

Introduction

Obesity is a condition of being overweight. Obesity occurs due to an increase in the number of adipocytes and adipose tissue infiltration (Versini, Jeandel, Rosenthal, & Shoenfeld, 2014). Adipose tissue has a function as an energy store, in overcoming excess energy, adipose tissue expands with increasing size and number of adipocytes. A lifestyle characterized by physical activity is one of the causes of being overweight and the main risk of global death (Martins, Lopes, Diniz, & Guedes, 2021). Overweight controls with a higher risk of syndrome diseases such as chronic and progressive disease, increase the risk of morbidity and mortality, risk of developing diabetes, and worsening glycemic index (Kim & Lim, 2017). Apart from being an organ that is active in metabolism, adipose is also capable of secreting several adipokines. Response signals received as a result of endocrine processes, one of the endocrine peptide hormones secreted is adiponectin, which acts in adipose tissue. Increased BMI, overweight, high inflammation, syndrome metabolism, and diabetes correlate with adiponectin (Sirico et al., 2018; Zaidi et al., 2021). This relationship proves that the occurrence of endocrine dysfunction in overweight individuals (Gilbertson et al., 2019). In addition to increasing insulin sensitivity, adiponectin can also mediate anti-inflammatory effects, decreasing adiponectin level results in a balance of homeostasis and disturbances (Zaidi et al., 2021). Thus, it is very important to explore strategies to enhance metabolic processes (Nieste et al., 2021).

The development of overweight is estimated at 23% of peo-

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ple in adults and 81% of adolescents (11-17 years) who do not meet the physical activity recommendations set by WHO. In Indonesia, the increase of overweight in adolescence continues to increase (Rachmi & Baur, 2017). This finding concludes that adults will experience weight gain, which develops more rapidly. The WHO recommendations for physical activity are 150 minutes of moderate-intensity aerobic physical activity or at least 75 minutes of high-intensity aerobic physical activity per week. Therefore, the alternative offered by WHO related to maintaining body homeostasis is through physical exercise, as described above.

Exercise/physically active intervention has been shown to provide physiological changes in adipose tissue, signaling that it can modify adipokine production to prevent long-term chronic disease associated with overweight. Pro-inflammation that occurs in overweight can be minimized through weight loss due to exercise (Rossi et al., 2017). Recently, it has been shown that high-intensity interval training is more beneficial in improving cardiometabolic activity than long-term exercise (Racil et al., 2016). Adiponectin was found to increase through exercise in childhood (García-Hermoso et al., 2016) and adulthood (Simpson & Singh, 2007). However, high-intensity acute aerobic exercise has not found consistent results and very few have studied the adipose tissue, increase factor in response to high-intensity acute exercise.

This study aimed to analyze the effect of acute high-intensity intermittent exercise (HIIE) on serum adiponectin levels in overweight young adult women with a sedentary lifestyle.

Material and Methods

Study Design

This study used a pre and post-control group design. The taking of research subjects was carried out by purposive sampling and then the subjects were divided into 2 groups. Group 1 (CG) was the control group (without any treatment), and Group 2 (EG) conducted the high-intensity intermittent exercise treatment (HIIE).

Subjects

22 overweight adult women participated in the study. The subjects of this study were divided into two groups, namely (CG) with control without treatment, and (EG) with high-intensity intermittent exercise (HIIE) treatment (CG age 22.73±2.05, body weight 60.33±5.28 kg, height 158±6.40 cm, BMI 23.96±0.64; EG age 24.55±1.50, body weight 58.99±4.75 kg, height 156±5.38 cm, BMI 24.16±0.59). Exclusion criteria in this study were under 18 years old, were experiencing pain, infection, or inflammation of canker sores in the week prior to the study did not take drugs in the last 3 days (antibiotics, anti-inflammatory, amphetamines, and vitamins), do strenuous physical exercise 24 hours before the intervention, consuming weight loss supplements since 30 days before the intervention, and consume fruits, oils, tea, and coffee.

Blood Collection and Exercise

Before taking the initial blood sample, the respondent first fasted from the night or 12 hours before the blood sample was taken. Then the blood sample is taken again (1 hour after exercise). The acute HIIE exercise method is performed using an ergocycle. High-intensity physical exercise using active rest intervals. Heating was carried out for 3 minutes at 40 rpm (increased). The HIIE session consists of 10 X 1 minute (80%-90%) HRmax, interspersed with a break of 1 minute at 40 rpm. Cooling for 2 minutes (lower slowly) (Heydari, Freund, & Boutcher, 2012; de Souza et al., 2018).

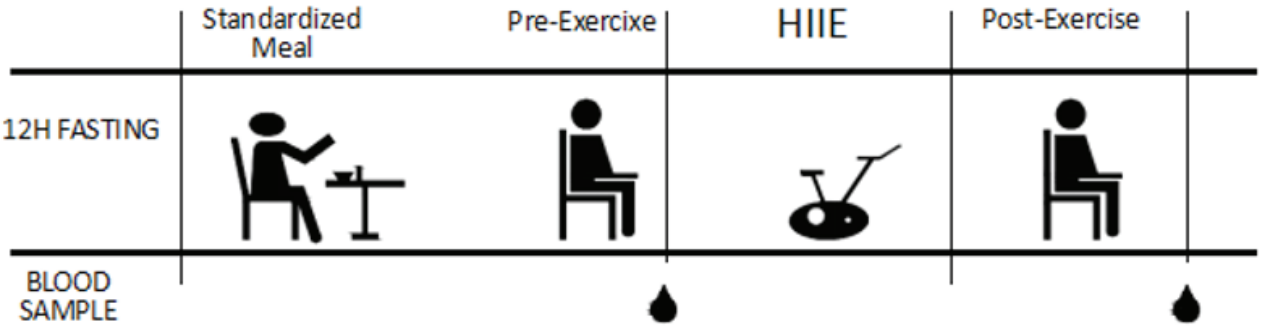

FIGURE 1. Blood Sampling and Intervention Schemes

Statistics

The data obtained were tested using the Shapiro-Wilk method to determine the normality of the data distribution. Data that is normally distributed, that different tests will be carried out with Paired t-test and Independent t-test. For all statistical analyses, significance was accepted at $p<0.05$. Data processing was performed using the statistical program SPSS v23.0 (SPSS Inc., Chicago, IL, USA).

Ethics

This research protocol has been declared to be ethically appropriate in accordance to 7 (seven) WHO 2011 standards, namely 1) Social values, 2) Scientific values, 3) Equitable assessment and benefits, 4) Risks, 5) Persuasion/Exploitation, 6) Confidentiality and privacy 7) Informed Consent, referring to the 2016 CIOMS guidelines. This is shown by the fulfillment of indicators for each standard. The Declaration of ethics was approved by the Health Research Ethics Committee of the Faculty of Medicine, Airlangga University. No ethics that is 248/EC/KEPK/FKUA/2021.

Results

Table 1. Shows the basic characteristics of all participants who are included. Anthropometric indices and metabolic factors did not differ significantly between the two groups, except for a difference in age between the control group and the HIIE group.

Table 1. Characteristics of Research Subjects

Characteristics	Group	n	$\bar{\chi}$±SD	Shapiro-Wilk	p-Value
Weight	Control	11	60.355 ± 5.28	0.718	0.532
	HIIE	11	58.991 ± 4.75	0.545	
Height	Control	11	158 ± 6.40	0.620	0.437
	HIIE	11	156 ± 5.38	0.461	
Age	Control	11	22.73 ± 2.05	0.243	0.028
	HIIE	11	24.55 ± 1.50	0.023	
BMI	Control	11	23.964 ± 0.64	0.334	0.458
	HIIE	11	24.164 ± 0.59	0.266	
Systolic	Control	11	112.18 ± 12.78	0.637	0.530
	HIIE	11	109.18 ± 8.89	0.021	
Diastolic	Control	11	75.36 ± 5.81	0.778	0.868
	HIIE	11	75.91 ± 9.02	0.123	
Body Fat	Control	11	31.827 ± 5.36	0.043	0.286
	HIIE	11	33.745 ± 1.93	0.816	
TBW	Control	11	46.227 ± 2.48	0.959	0.483
	HIIE	11	46.945 ± 2.21	0.971	
Muscle Mass	Control	11	39.191 ± 5.04	0.315	0.097
	HIIE	11	36.109 ± 2.99	0.810	
Bone Mass	Control	11	2.291 ±0.43	0.969	0.491
	HIIE	11	2.182 ± 0.27	0.405	
BMR	Control	11	1255.82 ± 149.79	0.657	0.388
	HIIE	11	1207.18 ± 105.00	0.807	
Viseral Fat	Control	11	4.964 ± 0.80	0.304	0.629
	HIIE	11	4.81 ± 0.56	0.135	
Right ARM	Control	11	1.655 ± 0.27	0.315	0.504
	HIIE	11	1.718 ± 0.14	0.118	
Left ARM	Control	11	1.591 ± 0.28	0.154	0.799
	HIIE	11	1.564 ± 0.20	0.376	
Right LEG	Control	11	6.182 ± 0.71	0.326	0.624
	HIIE	11	6.318 ± 0.55	0.193	
Left LEG	Control	11	6.136 ±0.72	0.275	0.804
	HIIE	11	6.029 ± 0.62	0.435	
Physique Rating	Control	11	3.18 ± 1.47	0.000	0.099
	HIIE	11	4.27 ± 1.48	0.000	

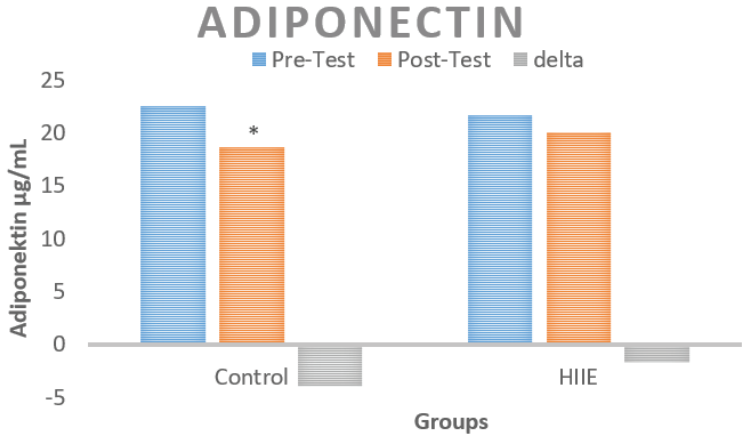

FIGURE 2. The average of adiponectin before and after HIIE in each group.
*Adiponectin decreased significantly ($p<0.05$) in the control group between pre and post HIIE.

Table 2. Mean and Standard Deviation of Adiponectin Serum in Both Groups

Data	Group	n	Adiponectin Levels (ng/mL)		
			(Pre-test)	(Post-test)	(Delta)
			χ±SD	χ±SD	χ±SD
Adiponectin	Control	11	22.571 ± 0.90	18.695 ± 0.70	-3.876 ± 1.20
	HIIE	11	21.659 ± 2.756	20.041 ± 1.05	-1.618 ± 2.53

Table 3. Result of the Normality Test for Adiponectin

Data	Group	n	Shapiro-Wilk
Adiponectin (Pre-test)	Control	11	0.233
	HIIE	11	0.578
Adiponectin (Post-test)	Control	11	0.524
	HIIE	11	0.764
Adiponectin (Delta)	Control	11	0.861
	HIIE	11	0.675

Table 4. Result Test of Adiponectin

Data	Test Method	Group	p
Adiponectin	Paired t-test	Control (pre-test & post-test)	0.000*
		HIIE (pre-test & post-test)	0.061
	Independent t-test	Delta control (CG) & HIIE (EG)	0.068

* there is a difference between the pre-post test (p<0.05)

Discussion

These findings support our initial hypothesis and suggest that acute attacks of high-intensity aerobics (HIIE) successfully maintain serum adiponectin levels in overweight adult women. One session of acute HIIE exercise was sufficient to maintain adiponectin levels compared with no exercise which experienced a greater decrease in serum adiponectin levels. One recent study also found unchanged adiponectin levels in overweight individuals after high-intensity exercise (Kao et al., 2021). However, in our study, it should be noted that adiponectin levels were able to be maintained without any differences in the anthropometric and metabolic characteristics of the respondents. Therefore, these findings add to the list of evidence showing that acute exercise has health benefits in individuals regardless of weight change and a sedentary lifestyle.

Relatively short training sessions have shown some benefit in improving the health status of sedentary adults. The beneficial effect of high-intensity aerobic exercise on adipokine profile has been suggested for overweight/obesity (Vardar et al., 2018). The current findings are supported by previous findings that have reported that acute high-intensity aerobic exercise has little effect on adiponectin levels and is significantly reduced at rest and can regulate short-term adiponectin secretion (Hojbjerre, Rosenzweig, Dela, Bruun, & Stallknecht 2007; Pop et al., 2010). In contrast to the research findings mentioned above, short-term acute aerobic exercise in sedentary men (abdominal fat) using a treadmill increased adiponectin levels after high-intensity intervention and remained elevated after rest (Saunders et al., 2012). A recent meta-analysis of 14 randomized controlled trials conducted among 347 youths revealed that exercise was associated with a significant increase in adiponectin; exercise intensity, changes in body fat, total duration of exercise, and duration of training sessions, were all found to significantly influence the effect of exercise on adiponectin (García-Hermoso et al., 2016). The investigators, therefore, concluded that exercise appears to be able to maintain adiponectin levels in overweight individuals.

Two intermittent exercise studies also found conflicting results: Varady, Bhutani, Church, & Phillips (2010) found an increase in adiponectin levels after one resistance training exercise in trained weightlifters and in individuals who combined weightlifting with running, in this study increased adiponectin levels. In response to acute exercise. In contrast, the findings of Mansouri et al. (2011) did not find changes in adiponectin levels after one exercise. On the other hand, the researchers occupied the differences in the two studies above where the researchers found a decrease in adiponectin levels in each group, but an insignificant decrease was found only in the post-exercise group.

Adiponectin strongly influences insulin resistance and inflammation (Otu & Otu, 2021). Exercise has been shown to increase insulin sensitivity, which is mediated through an increase in the hormone to adiponectin receptors (Cho et al., 2015), and inflammation found in research shows that inflammatory biomarkers are lower in people who engage in frequent and intense physical activity, decreased inflammation coincided with increased levels of inflammation. The anti-inflammatory agent whose secretion can be increased in the presence of adiponectin (de Lemos, Oliveira, Páscoa-Pinheiro, & Reis, 2012). Adiponectin reduces inflammation by inhibiting macrophage differentiation, changing the macrophage phenotype to anti-inflammatory (Fang & Judd, 2018). Similar results to previous studies using the HIIE protocol (de Souza et al., 2018) giving a single high-intensity exercise (HIIE) session increased good anti-inflammatory response through lipolysis and fat-free mass. Lipolysis of adipocytes results in a reduction in post-aerobic exercise, resulting in beneficial changes in adipokine secretion (Kelly et al., 2014).

In addition, the correlation of adiponectin changes was significant with a decrease in body fat mass (r=7.06) to (r=6.31) (Cipryan, Dostal, Plews, Hofmann, & Laursen, 2021). Pressure on the body indicates the body needs energy, fatty acids are released from adipose tissue and mobilized for use, reactions in cells activate lipases that hydrolyze triglycerides in fat droplets and produce free fatty acids that are ready to be released through the blood circulation and sent to organs, muscles. And other body tissues. Increased levels of adiponectin in muscles have a beneficial effect on glucose absorption and fatty acid oxidation (de Farias Lelis, de Freitas, Machado, Crespo, & Santos 2019) resulting in an increase in whole-body energy (Homeostasis). Findings (Heydari, Freund, & Boutcher, 2012) showed that 20-minute aerobic exercise bouts of HIIE were shown to decrease adipose tissue, which was associated with increased glucose and lipid metabolism (Okauchi et al., 2007). The found adipose tissue reduction was associated with decreased atherosclerosis. HIIE has been shown to show a significant increase in fatty acid oxidation throughout the body and skeletal muscle so that the response to catecholamines also increases slightly (Heydari et al., 2012). Catecholamines have been shown to promote lipolysis and are responsible for the release of fat from fat stores. Also, significant -adrenergic receptors were also found, adding to the evidence that HIIE has a greater potential for fat loss and increased fat oxidation. Since the HIIE exercise program requires a minimal time commitment, impacting subject compliance, physical activity requiring minimal effort still results in optimal fat loss.

The main finding in this study was that high-intensity aerobic exercise through acute HIIE using ergocycle had little effect in maintaining adiponectin levels expressed in adipose tissue 1-hour post-intervention. The authors found that the results obtained were influenced by time, where adiponectin had a relatively long half-life in serum (2.5 hours - 6 hours) and serum adiponectin was found to be high during the day (Fang & Judd, 2018).

Conclusions

The effect of acute HIIE using ergocycle has been shown to maintain serum adiponectin in overweight adult women with a sedentary lifestyle. This is due to the pressure received by the body, resulting in an increase in energy requirements, catecholamines, and the process of lipolysis. However, further research is needed regarding exercise, age, and timing of research on the mechanisms of other pro-inflammatory and anti-inflammatory mediators.

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Conflicts of Interest

No potential conflicts of interest relevant to this article could be reported.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Influence of Tactical Equipment on the Ergospirometric Assessment of Military Parachutists

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Abstract

The military parachutists are responsible of special air operations who require certain capabilities in their physical condition, due to their intense professional career. The analysis of oxygen consumption (VO_2) and heart rate (HR) allows the determination of aerobic (VT1) and anaerobic (VT2) thresholds and used to study the adequacy of the organism to exercise and in the analysis of sporting performance. The aim of this study was to determine the effect of tactical equipment on the stress test performance of elite parachutists. 10 parachutists participated in the study, between 22 and 36 years old with an average of 27.75 years (±4.20). Anthropometric values were determined of: weight 75.69 kg (±8.79), height 173.34 cm (±5.72) and body mass index (BMI) 25.23 (±2.98). Each one, performed 2 maximal treadmill exercise testing: one a conventional stress test (A) and another with the tactical equipment (weight 20 kg) (B). We obtained maximum oxygen consumption (Metalyzer 3B) and monitored the electrocardiogram continuously. The test started at a speed of 6km/h and a slope of 1%. The results of the two test were compared. The average value and standard deviation (SD) of different variables with equipment (B) and without it (A) and p-value were obtained: velocity (A: 14.80±3.29; B: 11.50±1.42 Km/h; p=0.073), HR (A: 182.7±58.62; B: 177.75±9.71 b/m; p=0.038), VO_2 (A: 51.75±13.60; B: 54.00±30.82 ml/Kg/min; p=0.891). Also, the values of ventilatory thresholds: VT1 and VT2 of both tests were obtained, with significant differences. Tactical equipment causes a decrease in stress test performance with changes in VT1 and VT2.

Keywords: *military parachutist, oxygen consumption, ventilatory thresholds, stress test*

Introduction

The Parachute Sapper Squadron (EZAPAC) is one of the military units that require certain physical conditions due to their intense professional career. They are in charge of Special Air Operations, which are defined as "military operations conducted by specially designed, organised, trained and equipped forces to achieve high-value objectives in sensitive or hostile areas through the use of unconventional and innovative means and tactics" (Ejército del aire, 2022).

In order to carry out their missions properly, it is necessary for these professionals to have a good basic physical condition, especially in terms of strength and cardiorespiratory endurance. In addition, this translates into the study of the body's aptitude to exercise and the analysis of sporting performance through the ergospirometry (Taylor, Hernández, Schoenherr, & Stump, 2019).

Ergospirometry studies the global and non-invasive response of the organism during physical exercise by observing oxygen consumption, electrocardiographic analysis and recording metabolic parameters (Stavrou, Tourlakopaulos, Daniil, & Gourgoulianis, 2021; Rosenblant, Granata, & Thomas, 2022). This test is used for the diagnosis, monitoring and prevention of ischaemic heart disease (Contreras-Briceño et al., 2021; Mouine et al., 2021) and the performance of athletes (Álvarez, Campos, Portes, Rey, & Martín, 2016; Paredes, Jódar, Ferrer, & Martínez, 2021(a)).

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The analysis of oxygen consumption and heart rate allows the determination of aerobic and anaerobic thresholds. This data is very useful for studying the organism's suitability for exercise (Beaver, Wasserman, & Whipp, 1985) and in the analysis of sports performance in both healthy subjects (Anselmi et al. 2021) and high-level athletes (Ksoll, Mühlberger, & Stöcker, 2021).

The use of ergospirometry is frequently applied in sports, especially in endurance sports such as cycling (Mina-Paz et al., 2021) or athletics (Alves et al., 2021), allowing the values obtained from the test to be used in different training plans and to be adapted to the different physical capacities of each subject (Mainenti, Vigário, Batista, Bastos, & Mello, 2021; Paredes, Jódar, Martínez, & Ferrer, 2021(b)).

It has been used in other groups whose professional activities require a certain level of demand, such as police officers (Silva et al., 2009), firefighters (Avellaneda & Urbina, 2015) and the military, both to assess the physical condition of soldiers and for incorporation into specific units (Foulis et al., 2015; Perlsweig et al., 2015; Taylor et al., 2019).

The sappers must possess optimum physical qualities to face the different missions they face during their professional career. It is an elite team, which carries tactical equipment with: military clothing, boots, protective waistcoat, regulation pistol, magazines, backpack with supplies and specific material. All of this, in order to face complicated situations within a mission. For this reason, their physical form must be maintained throughout the years within this group and their training and repeated practice must be the basis so as not to compromise their health (Ejército del aire, 2022). Since it is unclear how tactical equipment affects the physical performance of parachutists, the aim of this paper was to determine the effect of tactical equipment on the stress test performance of elite parachutists.

Methods

Participants

A total of 10 members of the Air Force Parachute Sapper Squadron (participants in a training course), aged between 22 and 36 years (27.7±4.2) formed the sample for the study. They presented a mean of number of years of service for the entire group of 14.0±5.2 and the mean number of jumps was 1061.2±2204.3. In terms of the anthropometric values, we obtained a mean weight of 75.7±8.6 kg, 173.34±5.7 cm in height and 25.2±2.9 kg/m2 with respect to body mass index (BMI).

The participants who were selected according to the inclusion criteria were the sappers who were at the Air Base taking the training course on the dates of the study. The exclusion criterion was that the participants had injuries or pathologies that interfered with the correct performance of the stress test. All persons involved were informed of the objectives and procedures, their informed consent was obtained, as well as permission from the military authorities and a favorable report from the University's Research Ethics Committee with approval number: 1034-2015 (Approval date: 11/03/2015). The research was carried out at the Biomedical Research Laboratory of the University of Murcia.

Measurments

The general protocol was organized into two tests A and B: in test A, each subject in shorts and sports shoes completed a maximal exercise test on a Run 7411 treadmill (Runner®) with continuous recording of the 12 standard leads of the electrocardiogram using the Cardioline® electrocardiograph, model Click ECG and the Cortex® gas analyser, model Metalyzer 3B for VO_2 measurement. All tests were performed according to the standard protocol (Pollock et al., 1976).

FIGURE 1. Conventional stress test

In test B, each skydiver carried his specific equipment with a total weight of 20 kg: boots, protective waistcoat, regulation pistol, magazines, and backpack with supplies. They performed the same test as described in test A. However, on this occasion the electrocardiographic recording was not collected and was replaced by an F10 polar pulsometer, because it was easier to carry the equipment with the latter device. The order of the visits was randomised.

FIGURE 2. Stress test with specific equipment

Before starting the first test, body weight, blood pressure, cardiac auscultation and resting ECG were obtained for each participant. The test started at a speed of 6 km/h and a gradient of 1% with ramp increases of one kilometer per hour and one grade of gradient every minute. During exercise, heart rate was recorded every minute as well as during recovery. Similarly, blood pressure was taken at the beginning of the recovery period, after three and five minutes (Howley, 1995).

The test ends when the subject is exhausted and gestures with his hand to start the recovery phase at 3 km/h for 3 minutes and at rest for another 2 minutes. The tests were considered to be maximum and valid when they exceeded 85% of the theoretical maximum heart rate (220-age) and the respiratory exchange ratio (RER) was greater than 1.15. (Howley, Bassett, and Welch, 1995).

During exercise testing, subjects breathed through a mask connected to the gas analyser (Metalyzer 3b*, Cortex) to determine: physiological ventilatory (thresholds aerobic (VT1); anaerobic (VT2)), velocity, RER, VO_2, VO_2max, HR and percentage HR max. All gas exchange parameters were measured during breathing and averaged every 30 seconds. The method used to determine VO_2max was to reach the oxygen consumption plateau (Fletcher 2009). All tests were conducted under similar environmental conditions.

Statistics

The data was analysed with Statistical Package for Social Science (SPSS v.24). The description of the results is presented by the value of the mean and standard deviation for quantitative variables. The coefficient of variation (CV = mean/SD*100) of each variable and the percentage decrease between both tests (PD = (B-A)/A*100) have been calculated. Samples were tested for normality using the Shapiro-Weils test. The means of independent variables were compared using the Student's t-test and those related with the paired t-test. A minimum level of significance of $p<0.05$ was established.

Results

Table 1 shows the statistical values for basic anthropometry and body composition.

Table 1. Basic anthropometric and body mass index data

	Min	Max	Mean	SD	VC%
Age (years)	22.0	36.00	27.75	4.20	15.14
Weight (Kg)	63.10	88.80	75.69	8.79	11.61
Height (cm)	163.50	185.50	173.34	5.72	3.30
BMI Kg/m^2	20.20	31.60	25.23	2.98	11.81
Waist (cm)	73.00	88.00	79.82	5.22	6.54
Relative Fat Mass (%)	15.40	24.36	20.40	3.13	15.34

Note_ SD: standard deviation; BMI: body mass index; %: percentage; VC%: variation coefficient.

Table 2 presents the pairwise comparison of the maximum values of both tests, the conventional test (A) and the test with equipment (B) and the percentage of decrement between the two tests ((B-A)/A%). Statistically significant differences were found in all the variables described, with $p<0.05$, with higher values for all variables in the conventional test. No correlation was observed between anthropometric variables and percentage decrement ($p>0.05$).

Table 2. Comparison of peak values in the conventional stress test (A) and with tactical equipment (B).

	Test	Means	SD	VC (%)	T-student	p-value
Velocity (km/h)	A	14.17	0.67	4.73	33.00	0.001*
	B	11.52	0.60	5.21		
	(B-A)/A%	-18.72	1.97	-10.52		
Slop (%)	A	7.80	0.68	8.72	21.17	0.001*
	B	5.13	0.52	10.14		
	(B-A)/A%	-34.09	5.10	-14.96		
Total time (min)	A	9.19	0.61	6.64	31.22	0.001*
	B	6.54	1.74	26.61		
	(B-A)/A%	-28.85	3.18	-11.02		
HR (Beat/min)	A	188.67	9.39	4.98	7.88	0.001*
	B	179.67	11.15	6.21		
	(B-A)/A%	-4.81	2.42	-50.31		
HR% (Beat/min)	A	98.08	4.12	4.20	7.84	0.001*
	B	93.40	5.14	5.50		
	(B-A)/A%	-4.81	2.43	-50.52		
VO_2(ml/kg/min)	A	54.20	5.88	10.85	3.57	0.003*
	B	51.53	6.84	13.27		
	(B-A)/A%	-5.00	5.29	-105.80		
RER	A	1.16	0.03	2.59	2.50	0.025*
	B	1.14	0.04	3.51		
	(B-A)/A%	0.00	0.00			
Ventilation (l/min)	A	139.07	16.85	12.12	3.52	0.004*
	B	125.18	11.30	9.03		
	(B-A)/A%	-9.19	10.26	-111.64		

Note_ HR: heart rate; VO_2: consumption oxygen; A: conventional test B: with the tactical equipment test; (B-A)/A%: percentage decrease between the two tests; *p<0.05.

Table 3. Comparison of aerobic thresholds (VT1) of both tests.

		Means	SD	T-Student	p-value
Velocity(km/h)	A	9.51	0.63	7.39	0.000*
	B	8.27	0.50		
HR(beat/min)	A	144.40	10.76	-1.04	0.318
	B	147.47	14.80		
% HR Max(beat/min)	A	76.53	4.17	-3.72	0.002*
	B	81.95	4.43		
VO_2(ml/kg/min)	A	33.80	3.71	-0.69	0.500
	B	34.40	2.90		
$\%VO_2$ Max (ml/kg/min)	A	62.67	5.38	-2.64	0.019*
	B	67.30	5.99		

Note_ %HR Max: maximum heart rate; $\%VO_2$ Max: maximum oxygen consumption; *p<0.05.

As for the comparison of the aerobic thresholds (VT1) shown in Table 3, we found statistically significant differences in the variables velocity, percentage of maximum heart rate and maximum oxygen consumption. Thus, it has been found that in test B, the aerobic threshold is reached at a lower velocity and lower percentage in the maximum oxygen consumption, on the contrary, it is obtained with a higher percentage of maximum heart rate compared to test A.

Similarly, the variables obtained in the anaerobic threshold (VT2) are shown in Table 4. It can be deduced that statistically significant differences are again obtained in the values of velocity and percentage of oxygen consumption, observing as before, in the velocity this threshold is reached earlier in test B. However, in the percentage of maximum heart rate this threshold was reached later.

Table 4. Comparison of anaerobic thresholds (VT2) of both tests.

		Means	SD	T-Student	p-value
Velocity(km/h)	A	12.05	1.10	7.36	0.000*
	B	10.13	0.89		
HR(beat/min)	A	172.60	7.98	1.85	0.086
	B	168.93	10.91		
% HR Max(beat/min)	A	91.53	2.85	-50.50	0.000*
	B	180.89	6.29		
VO_2(ml/kg/min)	A	46.87	6.35	1.46	0.167
	B	45.07	6.02		
%VO_2 Max (ml/kg/min)	A	86.47	6.17	-0.65	0.524
	B	87.62	6.05		

Note_ %HR Max: maximum heart rate; %VO2 Max: maximum oxygen consumption; *p<0.05.

Discussion

The purpose of this study was to analyse the influence of tactical equipment on the performance of elite parachutists in stress tests. Participants took part in the study, and during the two sessions data were collected for the stress tests with equipment (20 kg) and without equipment. It is important to note that this is a new topic and that the literature consulted is scarce in terms of works referring to stress tests performed on soldiers with equipment.

In our study, the "overweight" BMI value (25.23 kg/m2), which shows the mean of the population, is not due to excess fat but to the muscle mass of the participating subjects. Thus, we found similarities with a study published by Pihlainen, Santtila, Häkkinen, and Kyröläinen (2018), in which we obtained similarities with respect to the anthropometric data of their military population in Finland (their results: mean ± SD of: age, height, weight and BMI of the soldiers was 29.8±8.0 years, 179.8±6.3 cm, 79.2±8.5 kg and 24.5±2.3 kg/m2, respectively) and despite having a larger sample size than ours, there are no works in the literature that encompass our aim of this study.

When comparing the maximum values obtained in both stress tests, we found that there is a statistically significant decrease in all physiological (HR, HR%, VO_2, RER, ventilation) and non-physiological (velocity and slope) variables analysed during test B. As the study by Mainenti et al. (2022) shows, the decrease in speed and VO_2max during the stress test is directly related to sports performance. In other words, the greater the load supported by the subject (test B), the lower the values obtained for cardiopulmonary variables such as VO_2max, HR or ventilation during the test.

The mean VO_2max obtained during the exercise test was 54.00±30.82 ml/kg/min in the exercise test without equipment and 51.75±13.60 ml/kg/min in the test with load. These values are lower if we compare them with the study by Ceballos et al. (2021), in which third-year cadets of the military high school (ESMIL), who after performing high-intensity intervallic training (HIT) modified their VO_2max values from 57.26 ml/kg/min to 62.30 ml/kg/min. On the other hand, if we compare these results with other studies where the population is composed of elite athletes, such as professional footballers, we obtain that our VO_2max results are above theirs with a value of 45.90±2.24 ml/kg/min, as reflected by Metaxas (2021). The fact that the latter may be due to the specific training that our military group carries out in comparison to professional footballers.

Furthermore, these results are in line with those obtained by Looney et al. (2018) where a group of 9 military personnel had this variable determined on two occasions: firstly, on a treadmill with light clothing and trainers; secondly, evaluating a walk in difficult terrain with clothing and backpack on. In our study, we compared two similar situations, except for one difference, and that is that the tests were conducted entirely in a laboratory with a treadmill. Both situations were not conducted in a laboratory with a treadmill, in contrast to our work. In which we compared two similar situations.

Furthermore, in the study by Looney et al. (2018) we see how VO_2max decreases considerably with the tactical equipment on, as in our work. The measurement of this variable is considered one of the best predictors of an athlete's aerobic performance and one of the main indicators of cardiorespiratory health.

In this same study, they concluded that the HR is significantly lower with the load than without it, as in our study. When we increase the load on the subject (Test B), we are increasing their cardiorespiratory demand considerably. This can limit sporting performance over long distances on several occasions. Also, from the VO_2max and HR in our study, you tend to have a higher running velocity in the stress test without equipment (A), (14.80 ±3.29 km/h), than with tactical equipment (B) (11.50±1.42) as in the Looney et al., study (2021). As the load on the individual increases, both the velocity and the slope on the treadmill decrease, leading to an earlier stress situation during test B than A in the military.

The coefficients of variation show that in test A, our population presents homogeneous results in all the ergometric variables and that the dispersion increases slightly in test B. Furthermore, in the percentages of decrease we have observed that in the non-physiological variables (velocity, slope and exercise time) the decrease in values is more homogeneous than in the physiological variables (HR, VO_2max, RER and ventilation) where the inter-individual variability is greater. This may suggest that there are individual factors involved in the response to increased load that we have not been able to relate to anthropometric data.

Comparing test, A and B, the aerobic threshold (VT1) was reached with statistically significant differences in speed data (lower in test B), HR max percentage (higher in test B) and VO_2max percentage (higher in test B). This is possible because carrying the weight during test B at a lower speed took longer

for VT1 to appear than in the conventional test (A). In the rest of the variables such as HR and VO_2 no significant differences were observed between the two tests. This may be due to the fact that, during the exercise, the subject maintained the same pace with and without load. This is probably due to the level of training experience, physical fitness and aerobic fitness of the participants in this study (Looney et al., 2018).

In our results, the anaerobic threshold (VT2) was reached at a lower speed and at a higher percentage of HR max during test B, these values being statistically significant. These data agree with those of Mainenti et al. (2022): 14.8 km/h, 191.0 beats/min, 40.2 ml/kg/min. In this study, the velocity at which the ventilatory threshold is reached was found to be an excellent indicator for the prescription of exercise intensity and its relation to sports performance.

When relating the maximum value of VO_2 in tests A and B with the appearance of the ventilatory thresholds VT1 and VT2, we observed that the first ventilatory threshold took longer to appear in test B than in test A, with values of 34.40 ml/kg/min (67.30%) and 33.80 ml/kg/min (62.67%) respectively. The second ventilatory threshold, however, appears earlier in test B with 45.07 ml/kg/min than in A with 46.87 ml/kg/min. This suggests that, on the one hand, in the conventional test the subjects stay longer at VT1 threshold without reaching the maximum exercise intensity, maintaining an aerobic metabolism. On the other hand, in test B, although the appearance of the VT1 threshold is delayed, as the organism is undergoing an increase in intensity, the subject fatigues earlier and anaerobic glycolysis begins to cover the energy demands and VT2 appears quickly, increasing the production of lactate in the blood (Maté-Muñoz, Domínguez, Lougedo, and Garnacho-Castaño, 2017).

A subject with a higher VT2 value, as is the case during test A, will be able to sustain a longer period of time at a higher rate than during test B, thus achieving a higher performance. Therefore, training work based on ventilatory thresholds could be effective in modifying the intensity of an exercise during training that requires high endurance, as in the case of the soldier carrying the 20kg rucksack, as it takes into account individual metabolic responses (Anselmi et al., 2021).

There is no literature available on the Parachute Sapper to be able to compare our results of both tests directly with other authors. Nor are there any studies on the influence on performance of load carrying during the stress test in athletes at any level.

The main limitations of this study is that it has been carried out in a laboratory test, not in their outdoor activities, and also small sample size.

This study is original and innovative, so it is interesting to expand the field of study, as it would be essential to have references that allow us to ensure adequate physical conditions for this elite team. This study has made a series of important contributions in terms of novel data on variations in ventilatory thresholds by comparing conventional stress tests with equipment in a specific population that is difficult to access. It is therefore necessary to analyse their physical capacity in order to be able to maintain strict control in situations that require it.

The contributions of this work are necessary because we are providing basic reference data so that other populations with similar characteristics can be compared and improve physical capacity and performance.

Conclusion

The tactical equipment of the soldier has a negative influence on the physical performance during the exercise test, decreasing the maximum values of velocity and oxygen consumption. It is also observed that the change from VT1 to VT2 is obtained earlier when carrying the load (B) than without it (A). Therefore, during test B, a stress situation is generated in the organism previous, in which there is insufficient capacity to supply oxygen to the muscles that are active. Also, comparing tests A and B, VT1 is reached at significantly higher values of HR max percentage and VO_2max percentage; in VT2, it is achieved at a higher percentage of HR max.

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Conflict of interest
The authors declare that there are no conflicts of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Intra-Positional and Inter-Positional Differences in Agility Tests among Youth Female Volleyball Players

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Abstract

In their structure, indoor sports require quick changes of movement direction. Players should possess a high level of ability to change the direction and speed of movement in response to a stimulus, which is one of the major prerequisites for a high level of performance. During a volleyball match, players are involved in different defensive and offensive activities in which agility plays an important role. The aim of this study was to determine the differences between less successful and more successful youth female volleyball players, as well as their inter-positional and intra-positional differences in agility. The study was conducted on a sample of 204 youth female volleyball players whose mean chronological age was 14.11±0.84 years. The players were divided into 5 subgroups according to their playing position (setters, opposite players, passer-hitters, middle blockers, and libero players). The variable sample used to assess agility consisted of 3 tests: Side steps, 9-3-6-3-9 test, and Step-hop test. Methods of data analysis included the determination of metric characteristics for all three agility tests. The analysis of covariance revealed a significant impact of biological age indicators on all agility tests. Furthermore, discriminant analysis of differences showed that more successful volleyball players achieved better results in all three agility tests. High reliability of the test was determined by Cronbach's Alpha coefficient (0.87-0.96). The results of this study showed a positive effect of agility tests in differentiating less successful and more successful players regardless of their position. More successful players achieved better results than less successful players in all tests. Greater biological maturity and training experience represent great competitive advantage in this age group. The obtained inter-positional and intra-positional differences and the influence of the biological age indicator on inter-positional and intra-positional differences in agility tests imply that higher biological maturity and training experience are great competitive advantages in this age group. The primary goal of training in younger age groups should not be the current success in the competition, but rather the preparation for achieving the best possible results in senior competition..

Keywords: *team sport, discriminant analysis, skill, reactive agility, movement structure, biological age*

Introduction

Volleyball is a team sport played by men and women. According to the number of registered members, volleyball is one of the most popular sports game in the world (Varhagen, Van der Beek, Bouter, Bahr, & Van Mechelen, 2004). Furthermore, volleyball is part of the curricular and extracurricular program of physical education for students of both elementary schools and high schools (Podvalej & Gošnik, 2001). Volleyball is a complex sports game in which top performance is achieved through many years of training. In player specialization, it is necessary to consider the specifics of individual playing roles and make use of anthropological abilities

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and characteristics (Vujmilović, 2012). Determining inter-positional differences, but also the differences between more successful and less successful players in a certain playing position can improve the quality of the training process, primarily by developing those abilities and skills that are crucial for successful play in certain positions (playing role) (Milić et al., 2017). Selection for individual playing roles and training individualized according to those playing roles in volleyball should begin to be applied in the U15 age group (Vujmilović, 2012).

Agility is a skill that plays an important role in achieving success in all segments of play (Schaal, Ransdell, Simonson, & Gao, 2013). In volleyball, agility comes to the fore in movement structures that are an integral part of matches during rapid changes of movement direction, acceleration, sudden stops, and jumps (Katić, Grgantov, & Jurko, 2006; Sekulić, Spasić, Mirkov, Ćavar, & Sattler, 2013; Lima, Rico-González, Pereira, Caleiro, & Clemente, 2021). Agility has a reactive and a planned component (Krolo et al., 2020). The reactive component of agility is extremely important in volleyball because players must react quickly and accurately to visual and auditory stimuli during the game (Šimonek, Horička, & Hianik, 2016). Lloyd et al. (2013) emphasize the importance of first developing the preplanned agility in prepuberty and puberty. The authors suggest that the focus in prepuberty should be on fundamental movement skills to achieve a proper movement pattern. In later development, the focus should shift to reactive agility training. However, in children, agility training should vary with consideration to the growth and development of children to reduce the risk of injury (Lloyd et al., 2013).

Previous studies were mainly conducted on a sample of senior players or did not analyze inter-positional and intra-positional differences mainly due to the small sample (Bojikian 2003; Gabett & Georgieff, 2007; Milic, Grgantov, & Katic, 2013). It is characteristic for the age group of youth players (14-15 years) that some players are still in the phase of accelerated growth and development, while others are already near the end of that phase or have finished it. Therefore, in analyzing inter-positional and intra-positional differences, it is necessary to control the possible influence of biological age (Malina et al., 2005). All of the above implies an increase in the number of studies conducted in younger age categories.

Grgantov, Milić & Padulo (2016) analyzed inter-positional and intra-positional differences among female volleyball players using the Step-hop agility test and found no significant differences. Additionally, they found differences between more successful and less successful players in some playing positions. Afterward, the same authors concluded that there are differences between less and more successful female players in all playing positions using one agility test (Katić et al., 2006; Gabbett & Georgieff, 2007; Melrose, Spaniol, Bohling, & Bonnette, 2007; Milić, et al., 2017). There can be found other studies that indicate these inter and intra-positional differences but without controlling the influence of biological age indicators (Schaal et al., 2013; Paz et al., 2017).

Therefore, the aim of this study is to determine the differences in non-specific and specific agility in less successful and more successful female volleyball players. Furthermore, the aim is to examine the relationship between their playing position and individual performance level by controlling the influence of biological age indicators, due to the fact that it is a period of accelerated growth and development and that the tempo of growth and development of young volleyball players is not the same.

Methods

Sample of participants

The study was conducted on a sample consisting of 204 youth Croatian female players whose mean chronological age was 14.11±0.84 years and mean biological age indicator was 14.12±0.76 years. Players' mean body height was 170.10±7.41 cm, body mass 58.92±9.28 kg, and body mass index (BMI) 20.3±2.67 kg/m2. The players are divided into two groups, less successful (119) whose mean chronological age was 13.89±0.79 years with a mean biological age indicator was 13.82±0.65 years and more successful (85) players whit chronological age of 14.43±0.81 years and mean biological age 14.53±0.70. The competitive performance of the players was determined on a Likert scale from 1 to 5. For the representativeness of the sample, volleyball players from all regions, with emphasis on the highest quality clubs at the state level, were included. The players were divided into 5 subgroups according to their playing roles (setters, opposite players, passer-hitters, middle blockers, and libero players). The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the declaration of Helsinki and has been approved by the research Ethics Committee of the Faculty of Kinesiology, University of Split, Croatia (approval No.:2181-205-02-05-18-002 as of January 8, 2018).

Research procedure

The variable sample used to assess agility consisted of 3 tests: Side steps, 9-3-6-3-9 test, and Step-hop test. In all tests, measurements were performed three times, and the average result was used as the final result. More detailed descriptions of the tests can be found in previous studies (Grgantov, Milić, & Padulo, 2016). Biological age was calculated by a method adopted from Mirwald et al. (2002): age at peak height velocity (PHV) and mean PHV were calculated for all participants and then summed up with or subtracted from the chronological age to define the biological age indicator variable (Milić, 2014). Body height, body weight, body mass index were also measured.

Statistical analysis

Data analysis methods included the determination of metric characteristics for all three agility tests and the calculation of descriptive indicators: arithmetic mean (AM) and standard deviation (SD). The Kolmogorov-Smirnov test (KS test) was used to test the normality of distribution.

The inter-positional and intra-positional differences were determined by applying the analysis of covariance (ANCOVA) with a post hoc test of differences (Tukey Unequal N HSD test).

Discriminant analysis was used to analyze the differences in agility tests between less successful and more successful youth female volleyball players. The data were analyzed by the Statistica Ver.12.0 computer program and a PHV calculator (http://taurus.usask.ca/growthutility/phv_ui.cfm?type=2). The statistical significance for all tests was set at $p<0.05$.

Results

The reliability of the tests was confirmed by Cronbach's alpha (CA) coefficient of internal consistency between items presented in Table 1. In all tests, there was a trend of improving the results during three consecutive performances. Inter item variability was analyzed using the coefficient of variation (CV) and the inter-item homogeneity of the applied agility tests was analyzed by the F-test The normality of distribution

was determined by the Kolmogorov-Smirnov test, whose critical value was 0.12. There are no significant deviations from the normal distribution in any of the variables, which means that all tests are suitable for further multivariate parametric statistical analysis. The minimum value was used as the final result of the agility tests.

Table 1. Metric characteristics of specific and non-specific agility test

	Mean±SD	CA	CV	IIR	F-test	p
Side steps (s)	8.83±0.87	0.96	0.03	0.88	48.68	0.00
9-3-6-3-9 test (s)	8.33±0.56	0.87	0.04	0.73	23.19	0.00
Step-hop test (s)	9.74±0.99	0.93	0.04	0.83	235.45	0.00

Legend: (CA – Cronbach Alpha, IIR – inter-item-correlation, F-test among trials)

Descriptive indicators, i.e., arithmetic means and standard deviations of less successful and more successful youth volleyball players, as well as the results of discriminant analysis (discriminant function, canonical correlation coefficient, Wilks' lambda coefficient, degrees of freedom, discriminant function significance test, and group centroids) of the defined subgroups of participants are presented in Table 2.

Table 2. Discriminant analysis of agility tests in less successful and more successful youth female volleyball players (N=204)

Variables	Less successful N=119	More successful N=85	DF
	AM±SD	AM±SD	
Side steps ¥ (s)	9.02±0.86	8.59±0.982	0.64
9-3-6-3-9 test ¥ (s)	8.50±0.58	8.12±0.45	0.91
Step-hop test ¥ (s)	10.01±0.98	9.37±0.90	0.87
Centroids	-0.32	0.45	CanR = 0.36
Wilks' lambda = 0.87			p=0.00

Legend: N – number of participants, AM – arithmetic mean, SD - standard deviation, ¥ - inversely scaled variable, DF – coefficients of correlation between the discriminant function and the variables, CanR – coefficient of canonical correlation, Wilks' lambda – Wilks' lambda coefficient, p – statistical significance level of the discriminant model.

Discriminant analysis of the differences between less successful and more successful youth volleyball players revealed one significant discriminant function, whose coefficient of canonical determination is 0.36.

Based on the value and sign of the group centroids, as well as the value and sign of the projections of individual motor skill variables on the discriminant function, it can be concluded that more successful volleyball players achieved better results in all the applied tests.

The results of inter-positional differences obtained by applying ANCOVA and using the biological age indicator as a covariate on the total sample of participants are presented and more successful in Table 3. Post-hoc analysis (Tukey's Unequal N HDS test) was additionally applied to the tests that significantly affect inter-positional differences. The analysis of the results of inter-positional differences shows a significant influ-

Table 3. Analysis of inter-positional covariance (ANCOVA) with post-hoc analysis of agility tests in the total sample (N=204) and in the sample of more successful volleyball players (N=85), covariate: biological age indicator

Variables (total sample)	Setters N=35	Opposite players N=33	Passer-hitters N=57	Middle blockers N=43	Libero players N=36
	AM±SD	AM±SD	AM±SD	AM±SD	AM±SD
Side steps ¥ (s)*a	8.84±0.78	9.02±0.94	8.50±0.69‡†	9.00±0.96°	9.01±0.91°
9-3-6-3-9 test ¥(s)*a	8.31±0.54	8.48±0.53	8.16±0.44	8.46±0.66	8.37±0.61
Step-hop test ¥ (s)*a	9.91±1.18	9.84±0.97	9.55±0.93	9.71±0.98	9.82±0.98
Variables (more successful)	**Setters N=12**	**Opposite players N=13**	**Passer-hitters N=30**	**Middle blockers N=22**	**Libero players N=8**
	AM±SD	AM±SD	AM±SD	AM±SD	AM±SD
Side steps ¥ (s) *b	8.55±0.60	8.69±0.97	8.36±0.51	8.92±1.09	8.41±0.81
9-3-6-3-9 test ¥ (s)*b	8.06±0.45	8.17±0.31	8.00±0.31	8.29±0.64	8.07±0.45
Step-hop test ¥ (s)*b	9.72±1.32	9.75±0.81	9.69±0.80	9.92±0.99	9.75±0.49

Legend: N – number of participants, AM – arithmetic mean, SD - standard deviation, ¥ - inversely scaled variable, * – significant inter-positional difference between variables obtained by analysis of covariance (ANCOVA), level of significance p≤ 0.05. a - the covariate has no significant difference in relation to the applied motor variables; b- the covariate has significant difference in relation to the applied motor variables; Post hoc analysis Tukey Unequal N HDS test, level of significance p≤ 0.05: ° - significant difference in relation to passer-hitters; ‡ - significant difference in relation to middle blockers; † - significant difference in relation to libero players;

ence of the covariate biological age indicator on all agility tests on the total sample of youth female volleyball players.

On the total sample (N=204), the Side step test was found to have a significant inter-positional difference using covariance analysis. Further, post-hoc analysis (Tukey's Unequel N HDS test) a significant difference was found between passer-hitter and middle blocker (F=12.43; p=0.016) and between passer-hitter and libero player (F=12,51; p=0.014). And the Side step test has no significant difference with the applied biological age variable.

The motor variables 9-3-6-3-9 test and the Step hop test have a significant inter-positional difference on the total sample, but additional post hoc analysis did not establish a difference between the playing positions. The covariate biological age indicator has no significant difference in relation to the 9-3-6-3-9 test and the Step hop test.

Analyzing the results of ANCOVA on a sample of more successful female volleyball players (N=85) using analysis of covariance, a total significant inter-positional difference on the Side step test and 9-3-6-3-9 test was obtained. While the Step hop test has no significant difference by covariance analysis. The covariate biological age indicator has a significant difference in relation to all three applied motor tests. With further post hoc analysis (Tukey's Unequel N HDS test) no significant difference was found in the relationship between the playing positions.

The obtained results show that the indicator of biological age has a significant difference in relation to the applied motor tests in the sample of more successful volleyball players (n=85) which is not determined in the total sample.

The results of intra-positional differences in agility tests between less successful and more successful youth players obtained by applying ANCOVA with the biological age indicator as a covariate are presented in Table 4.

Table 4. Analysis of intra-positional covariance (ANCOVA) of agility tests between less successful and more successful youth female volleyball players (N=204), covariate: biological age indicator

Variables	Setters				Opposite players			
	Less successful N=23	More successful N=12			Less successful N=20	More successful N=13		
	AM±SD	AM±SD	F-test	p	AM±SD	AM±SD	F-test	p
Side steps ¥ (s) D	8.99±0.83	8.55±0.60	1.68	0.11	9.24±0.88	8.69±0.97	0.13	0.43
9-3-6-3-9 test ¥ (s)	8.44±0.54	8.06±0.45	4.32*	0.04*	8.68±0.55	8.17±0.31	6.85*	0.01*
Step-hop test ¥ (s)	10.16±1.09	9.44±1.26	1.93	0.09	10.04±0.92	9.17±0.71	0.62	0.28
Variables	**Passer-hitters**				**Middle blockers**			
	Less successful N=27	More successful N=30			Less successful N=21	More successful N=22		
	AM±SD	AM±SD	F-test	p	AM±SD	AM±SD	F-test	P
Side steps ¥ (s) D	8.64±0.83	8.36±0.51	0.75	0.26	9.08±0.82	8.92±1.09	2.78	0.07
9-3-6-3-9 test ¥ (s)	8.34±0.50	8.00±0.31	6.03*	0.01*	8.63±0.68	8.29±0.64	0.44	0.33
Step-hop test ¥ (s)	9.97±0.97	9.17±0.71	7.38*	0.00*	9.93±0.93	9.50±0.99	0.17	0.44
Variables	**Libero players**							
	Less successful N=28	More successful N=8						
	AM±SD	AM±SD	F-test	P				
Side steps ¥ (s) D	9.18±1.088	8.41±0.81	2.86	0.07				
9-3-6-3-9 test ¥ (s)	8.46±0.63	8.07±0.45	2.07	0.08				
Step-hop test ¥ (s)	9.96±1.04	9.35±0.66	1.29	0.14				

Legend: N – number of participants, AM – arithmetic mean, SD - standard deviation, F-test – test value when testing the significance of intra-positional differences of AM, p-value, ¥ - inversely scaled variable * - significant difference at the level of p≤0.05. D - covariate has a significant difference in relation to the applied variable Opposite players; SB - covariate has a significant difference in relation to the applied variable Middle blockers; L- covariate has a significant difference in relation to the applied variable Libero players.

Regardless of their playing position, players that are more successful achieved better results in all three agility tests due to biological maturity.

A significant intra-positional difference was found in the 9-3-6-3-9 test. ANCOVA revealed that the position of the passer-hitter, according to the performance level criterion, does not differ significantly only in the Side steps test, noting that the F-test coefficients and significance levels were partially corrected under the influence of covariates. The biological age indicator significantly affects the side steps test in middle blockers, whereas in libero players, it significantly affects the Side steps and the 9-3-6-3-9 test.

Discussion

In this study, the analyzed metric characteristics of agility tests had high values. Descriptive indicators and the differences between less successful and more successful players, along with inter-positional and intra-positional differences in all tests, were also analyzed.

The discriminant analysis results showed a positive impact of agility tests in differentiating less successful and more successful players regardless of their playing position which can be compared with similar findings of Gabbett et al. (2007) for male and female volleyball players where they demonstrated differences among different abilities and one of them was agil-

ity. This indirectly emphasizes the importance of universality (versatility) in volleyball players. All positions except libero players participate (to a greater or lesser extent) in the performance of all volleyball elements, both at the net (spike block, lifting for spike) and away from the net (serve reception, field defense, service). Both explosive power and agility are important for the successful performance of these elements (Katić et al., 2006; Milić et al., 2012; Singh, 2016).

The biological age indicator significantly affects inter-positional differences in agility tests across the entire sample of female players. It affects those differences even in a more homogeneous subsample of more successful volleyball players. Therefore, coaches must take into account participants' biological maturity when analyzing positional specifics in terms of agility (Milić et al., 2017).

The analysis of individual playing positions and inter-positional differences among players shows that the players at the passer-hitter position achieve the best results. Similar findings exist in the study of Paz et al. (2017) where hitters were significantly faster than setters and middle blockers. That is confirmed by the fact that 45% of the total actions in the game and 80% of all points in top-level volleyball competitions are won by spike and block (Voight & Vetter, 2003; Stanković, Ruiz-Llamas, Peric, & Quiro-Escudero, 2019) because, in this age group, the play in attack is mainly based on passer-hitters. Besides having to spike very often against a set block, the ability to quickly switch (transition) from serve reception to spiking is very important for the passer-hitters. To be successful in their tasks, they must have good vertical jumping, good starting accelerations, and fast movement direction changes. This study is in agreement with the previous studies of these differences without including biological age indicators (Paz et al., 2017).

The biological age indicator affects the differences between less successful and more successful volleyball players in all positions. More successful volleyball players at all playing positions achieved better results than less successful players in all agility tests. The results are congruent with previous research that used the same individual player performance level (Milić et al., 2012; Grgantov et al., 2013; Milić et al., 2013).

Sudden accelerations and stops, movement direction changes, and vertical jumping are at the basis of quality performance of all technical-tactical elements during a volleyball match (Trajković et al., 2012; Nimphius et al., 2018). These abilities enable reaching the ball in time, which is a prerequisite for successful technical and tactical performance (Katić et al., 2006; Stanganelli et al., 2008; Günay et al., 2019).

This study presents some limitations: (i) The attempt was made to neutralize the influence of the biological age indicator on the inter-positional and intra-positional differences of young volleyball players. The obtained information should not be used as an exclusive criterion for assessing the ultimate potential of young volleyball players. Due to the fact that the dynamics of the development of individual abilities is different for athletes of different biological development. (ii) Although the total sample is large when the entire sample was divided into subsamples by positions and by performance, the resulting subsamples are significantly smaller. (iii) An increase in the results from trial to trial has been observed in the Step hop test because players had a problem caused by two changes in the direction of movement, which were performed with a half turn with the same leg. Therefore, it can be recommended that before the implementation of the test, a training session should be provided to learn correct performance.

Conclusion

The obtained inter-positional and intra-positional differences and the influence of the biological age indicator on inter-positional and intra-positional differences in agility tests imply that higher biological maturity and training experience are great competitive advantages in this age group. However, the primary goal of training in younger age groups should not be the current success in the competition, but rather the preparation for achieving the best possible results in senior competition. If we consider the obtained differences in biological maturity and training experience between less successful and more successful volleyball players in this light, we see a possible problem. During training, not enough attention was paid to biologically younger volleyball players with shorter training experience, and during competition, they do not have enough playtime, which prevents them from gaining the necessary competitive experience. Coaches working with younger age groups need to be aware that greater biological maturity and training experience do not imply a higher level of talent in a particular playing position.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Generic and Specific Fitness Profile of Elite Youth Greco-Roman Wrestlers; Differences According to Quality and Weight Category

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Abstract

This study aimed to investigate the validity of the Specific Wrestling Fitness Test (SWFT), correlating it with generic anaerobic tests in elite youth wrestlers and determining whether wrestlers differ according to quality and weight categories in all tests. The research included 23 advanced-level Greco-Roman wrestlers (aged 16-19 years) who were divided into two quality categories (National team members and Non-team members) and two weight categories (lighter and heavier). Variables included anthropometric characteristics, generic fitness tests, and SWFT. Results evidenced that only vertical jump height was associated with SWFT (Pearson's R=0.48, p<0.05). Team members had higher results in the vertical jump height (p=0.02, moderate ES), while wrestlers from the heavier category had higher body mass (p=0.001, large ES) and body height (p=0.01, large ES) than lighter wrestlers. Moreover, wrestlers did not differ in the SWFT according to quality and weight categories. SWFT was not associated with generic fitness tests, possibly because of its high specificity. Furthermore, team members and non-team members did not differ in the SWFT, which could be explained by the fact that only advanced-level wrestlers were included in this study. Thus, future studies should include lower-quality wrestlers and different testing protocols.

Keywords: *combat sports, physical capacities, selection, youth athletes*

Introduction

Two wrestling disciplines that are included in the Olympic games for men are Greco-Roman and freestyle wrestling. Greco-Roman wrestlers are allowed only to perform actions on the upper body and movements under the waist are forbidden, while freestyle wrestlers are permitted to use the whole body for actions (Ulupınar et al., 2021). Both wrestling disciplines are characterized by intermittent actions, with periods of high-intensity activity interspersed with short recovery periods (Ulupınar et al., 2021). It has been reported that during the World Greco-Roman wrestling championship, the activity-to-rest ratio was approximately 2.5:1 (Nilsson et al., 2002). Namely, wrestling is characterized by constant and repeated shifts of sudden defense and offense movements in the submaximal and maximal physiological zones, which means that wrestling mainly relies on anaerobic energy systems (Horswill, 1992). Precisely, the activity during the match is 90% performed in anaerobic-alactate and anaerobic-glycolytic metabolic processes, while only 10% relies on the aerobic energy system (Kell, 1997).

The anaerobic system provides quick energy for performing explosive actions such as lifts and throws and maximal intensity actions like pushing and pulling the opponent (Chaabene et al., 2017). As the beforementioned actions are the ones that determine the match outcome, it could be hypothesized that well-developed anaerobic capacity is the most important factor

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for success in wrestling. Thus, the main aim of the practitioners and scientists is to develop and determine the most appropriate test that tackles anaerobic metabolic pathways and determines the wrestler's level of preparedness. Sport-specific tests enable determining current levels of physical and physiological indices of their athletes (Chaabene et al., 2018).

As throwing wrestling manoeuvres are the most demanding ones as the wrestler has to lift and quickly throw the opponent, throwing actions employ an anaerobic energy system the most. Thus, several wrestling-specific tests that consist of consecutive wrestling throwing movements have been recently developed. Specific Wrestling Performance Test (SWPT) and Specific Wrestling Fitness Test (SWFT) both consist of throwing a dummy by a supplex technique, with SWPT consisting of two 3-minute segments and SWFT composed of three segments of 30 seconds (Markovic, 2017; Markovic et al., 2021). Thus, even though SWPT mimics actual combat duration, SWFT has better practical applicability as it is of a shorter duration, and a larger number of athletes can be measured. Also, it is considered that SWFT sufficiently tackles the anaerobic capacities of wrestlers and can be used to determine their physiological capacities (Markovic et al., 2021). SWFT has previously been proven reliable (Markovic, 2017) and valid in predicting specific wrestling preparedness in wrestlers aged 20-24 years (Markovic et al., 2021).

Studies conducted on older wrestlers (20.3±2.7 years) displayed differences in SWFT according to quality categories. Precisely, Serbian first-league wrestlers had a higher number of throws of more than 30% compared to second-league wrestlers (Markovic et al., 2018). Moreover, national team wrestlers outperformed first-league wrestlers (32.40±1.8 vs. 28.30±1.7 throws), and first-league wrestlers exceeded second-league wrestlers (28.30±1.7 vs. 23.04±3.2 throws), indicating good discriminative validity of the SWFT (Marković et al., 2022). Further, wrestling is a sport where the weight of the athlete is extremely important (Karninčić et al., 2013). Therefore, it could be expected that wrestlers would differ in physiological and physical capacities according to their weight. However, few previous studies did not record differences according to weight in maximal muscle strength (bench press and squat exercise) and power tests (Izquierdo et al., 2002; García-Pallarés et al., 2011), but studies investigating weight differences in sport-specific tests are lacking.

From the brief overview of the previously conducted studies, it could be suggested that SWFT was not thoroughly checked for its metric characteristics and was mainly conducted on older wrestlers (older than 20 years) (Markovic et al., 2021). This research aimed to investigate the validity of the SWFT with protocol index calculation modification, correlating it with other generic anaerobic tests in elite youth wrestlers. Additionally, the aim was to determine whether wrestlers differ according to quality categories (national-team members vs. non-team members) and weight categories in all tests. The results of this study would enable coaches and scientists to determine whether some more simple anaerobic test could be used as a tool for determining wrestling performance apart from SWFT, which could potentially save time and enable coaches to identify a quality wrestler.

Methods

Participants

This research included 23 Greco-Roman wrestlers aged 16-19 years who were participating in a national team training camp in preparation for international competitions during the 2022 season. All wrestlers were medalists in national championships and had international experience. All wrestlers successfully completed the tests, and no injuries or illnesses were reported prior to and during the tests. Wrestlers were divided into two categories according to quality. The first category (n=12, age=17.92±0.9 years, body height=175.04±7.19 cm, body mass=74.07±9.85 kg) included wrestlers that were included in the national team (Team members), and the second category (n=11, age=17.5±1.18 years, body height=173.68±3.17 cm, body mass=70.33±8.61 kg) included wrestlers that were in the broader team selection but were not included in the final team (Non-team members). Also, wrestlers were divided into two weight categories: lighter (55-67 kg) and heavier (72-87 kg). Participants signed informed consent before the study began, and parents/legal guardians signed informed consent for participants under 18 years old. This study was approved by the Editorial Board Faculty of Kinesiology, University of Split (Ref.no 2181-205-02-05-22-0012; Date of approval: 11/03/2022).

Variables and procedures

Anthropometric variables, generic fitness tests, and specific fitness tests were included in the research.

Anthropometric variables consisted of body height, body mass, and percentage of body fat calculated as a sum of skinfolds measured on triceps and calf muscles by Harpenden skinfold caliper (British Indicators, Burgess Hill, England), using the Slaughter-Lohman formula.

Generic fitness tests included countermovement jump, consecutive jumps during 30 seconds, Wingate test on the rowing ergometer, and running 300 yards.

Countermovement jump (CMJ) and consecutive jumps during 30 seconds (CJ30) were measured using the Optogate system (Microgate, Bolzano, Italy). For the CMJ, Wrestlers stood in a shoulder-width stance with hands on their hips. Wrestlers had to jump upwards maximally by first bending their knees and moving downwards, followed by a maximal jump upwards. They performed three jumping trials, and the best one (i.e., the highest jump) was taken into further analysis. For the CJ30, wrestlers stood in a shoulder-width stance and could freely move their hands during the jumps. They had to perform consecutive jumps during the 30 seconds. The parameters used for analysis were the highest jump, reactive strength index, and the number of jumps.

Wingate test on the rowing ergometer (WINGATEROW) was performed on the Concept 2 rowing machine, which was previously shown as valid and reliable (Mikulic et al., 2010). Variables from the WINGATEROW test included maximal power output and average power output.

A three hundred yards shuttle run test (300 yd) was performed in the school gymnasium. Two lines were placed 25 yards apart. Participants were instructed to take the high starting position behind the first line. They had to run to the 25-yards line, touch it with their foot, turn, and run back to the first line. They performed the same scenario six times. The test result was recorded as time for running the 300-yard distance.

Specific-fitness test was the SWFT. All participants were given a dummy according to their weight category. Wrestlers in weight categories 55-67 kg performed the test with a 23 kg dummy, while wrestlers in 72-87 kg categories performed

the test with a 25 kg dummy, and wrestlers over 90 kg performed the test with a 30 kg dummy. However, wrestlers with more than 97 kilograms were excluded from the analysis as they have to move higher absolute mass in throws which is more anaerobically demanding for producing relative to body weight. The weight of the dummy was determined according to instructions of the test's authors, with slight alliterations (Markovic, 2017). Wrestlers had to perform a maximum number of throws using the supplex technique in three periods of 30 seconds, with 20 seconds of rest between throwing periods. Wrestlers had visual and acoustic feedback on time, i.e., a large stopwatch was placed in their sight, and researchers were informing wrestlers about the time. The total number of throws was recorded. Each participant wore a POLAR H10 heart rate monitor (Polar, Inc., Lake Success, NY, USA). Heart rate was recorded immediately after each throwing period (i.e., when the test finished) and after the first and third minutes of rest and included following variables: Heart rate 1 – Sum of heart rate at test end and 1-minute rest, Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest.

The modification in the calculation of the SWFT index was made; the authors of this study propose that the simpler formula should be used as the original formula in calculating the SWFT index using blood lactates is time-consuming and expensive, and often coaches do not have certified equipment. The index of the SWFT was calculated similarly to the SJFT index (Drid et al., 2012), as a sum of heart rates at the end of the test and after one minute of rest divided by the total number of throws. Additionally, another index was calculated as the sum of heart rates at the end of the test, after one minute of rest, and after three minutes of rest divided by the total number of throws.

Testing protocol

Testing was conducted during two testing days.

The first day included anthropometric measurement, which was conducted before wrestlers performed warm-up. General warm-up lasted for 15 minutes and consisted of light running, followed by mobility exercises. After the warm-up, wrestlers first performed the CMJ test and, after a 10-minute break, performed the CJ30 test. After, WINGATEROW was conducted. Wrestlers firstly performed a familiarization trial of 5-minute light rowing, even though they had good rowing technique as rowing is included in their physical conditioning preparations. After 5-minute light rowing, they had 1-minute rest and performed a 30-second maximal test.

The second testing day included SWFT and 300 yd test. General warm-up lasted for 15 minutes and consisted of light running, mobility and stretching, and their regular warm-up on the wrestling mat. Afterward, wrestlers underwent a 20-minute familiarization process for the SWFT test that consisted of theoretical and practical explanation and practice. After a 10-minute rest, participants performed a maximal SWFT test. After a 30-minutes break, wrestlers performed a 300 yd running test once.

Statistical analyses

The normality of the variables was checked by the Kolmogorov-Smirnov test. Descriptive statistics included arithmetic means and standard deviations. Pearson's correlation coefficients were used to determine the correlation between SWFT and other anthropometric and fitness variables. To determine the differences between quality categories and weight classes, a t-test for independent samples was used. Additionally, Cohen's d effect sizes (ES) were calculated for differences in quality and weight category in the studied variables, and were interpreted as: <0.02 = trivial; 0.2–0.6 = small; >0.6–1.2 = moderate; >1.2–2.0 = large ES (Cohen, 2013). The p-level of 0.05 was applied for all analyses. A minimum level of significance of $p<0.05$ was established.

Statistical package Statistica ver.13 (Tibco, Palo Alto, California) was used for all analyses.

Results

Descriptive statistics and differences in anthropometric and fitness variables according to wrestlers' quality are displayed in Table 1. Team members had higher results in the maximal height during CJ30 (t-value=2.52, p=0.02). There were no significant differences in any other variable.

Table 1. Descriptive statistics and differences in anthropometric and fitness variables according to wrestlers' quality.

	Team members (N=12)		Non-team members (N=11)		T-test	
	Mean	SD	Mean	SD	t-value	p-level
Body mass (kg)	74.07	9.85	70.33	8.61	0.97	0.35
Body height (cm)	175.04	7.19	173.68	3.17	0.58	0.57
Body fat percentage	11.95	1.75	11.35	2.75	0.62	0.54
30s maximal height (cm)	31.38	2.03	28.31	3.60	2.52	0.02
30s maximal power (W)	40.22	5.21	38.14	4.82	0.96	0.35
30s maximal RSI (index)	1.48	0.21	1.37	0.21	1.18	0.25
Broad jump (cm)	243.00	22.42	233.20	19.11	1.09	0.29
Countermovement jump (cm)	39.23	4.66	36.63	6.16	1.13	0.27
Push up jump (cm)	11.87	4.30	10.77	3.90	0.62	0.54
300 yards (sec)	63.60	3.76	63.20	2.07	0.28	0.78
Wingate average power (w/kg)	6.31	0.82	6.00	0.79	0.79	0.44
Wingate peak power (w/kg)	7.54	0.94	7.29	0.76	0.61	0.55

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Table 1. Descriptive statistics and differences in anthropometric and fitness variables according to wrestlers' quality.

	Team members (N=12)		Non-team members (N=11)		T-test	
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p-level**
SWFT repetitions total	28.42	2.39	26.33	3.43	1.64	0.12
Heart rate 1	334.00	15.14	336.56	10.24	-0.44	0.67
Heart rate 2	450.25	21.30	458.22	17.82	-0.91	0.38
SWFT index 1	11.85	1.33	12.97	1.71	-1.69	0.11
SWFT index 2	15.97	1.76	17.68	2.50	-1.84	0.08

Note: RSI - Reactive Strength Index, SWFT – Specific Wrestling Fitness Test, Heart rate 1 – Sum of heart rate at test end and 1-minute rest, Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest.

Figure 1 shows effect size differences between team members and non-team members in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters. The moderate effect size was found for the CJ30.

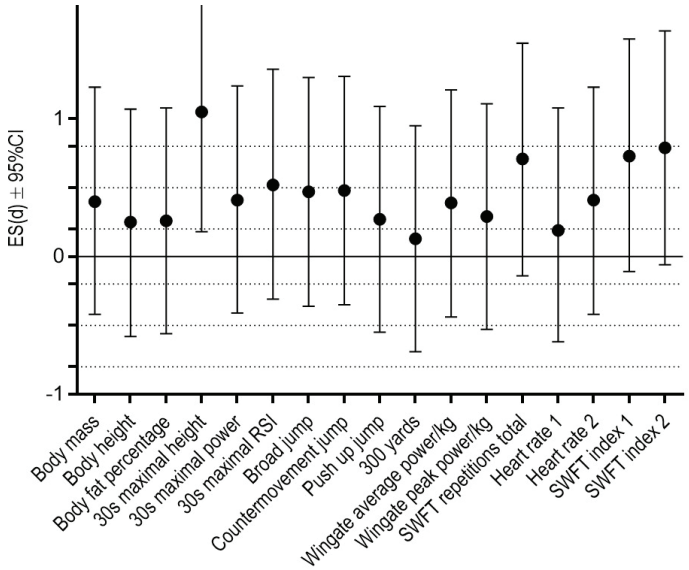

FIGURE 1. Effect size differences between team members and non-team members in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters.

According to the weight category, wrestlers from the heavier category had higher body mass (t=4.33, p=0.001) and body height (t=2.99, p=0.01) than lighter wrestlers. They did not differ in any other variable (Table 2).

Table 2. Descriptive statistics and differences in anthropometric and fitness variables according to weight categories.

	Heavier category (N=15)		Lighter category (N=6)		T-test	
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p-level**
Body mass (kg)	76.90	7.47	62.65	4.48	4.33	0.00
Body height (cm)	176.67	5.22	169.67	3.66	2.99	0.01
Body fat percentage	11.96	2.35	11.30	1.87	0.61	0.55
30s maximal height (cm)	29.72	3.38	30.38	2.74	-0.39	0.70
30s maximal power (W)	38.22	4.11	39.56	6.06	-0.55	0.59
30s maximal RSI (index)	1.36	0.19	1.50	0.20	-1.38	0.19
Broad jump (cm)	245.14	20.68	224.40	12.74	2.08	0.05
Countermovement jump (cm)	39.44	5.92	36.22	3.30	1.14	0.27
Push up jump (cm)	11.19	3.53	12.04	6.56	-0.37	0.72
300 yards (sec)	62.49	1.95	64.93	4.29	-1.66	0.12
Wingate average power (w/kg)	6.18	0.67	6.11	1.14	0.15	0.88

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Table 2. Descriptive statistics and differences in anthropometric and fitness variables according to weight categories.

	Heavier category (N=15)		Lighter category (N=6)		T-test	
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p-level**
Wingate peak power (w/kg)	7.49	0.73	7.27	1.17	0.48	0.64
SWFT repetitions total	27.53	2.80	27.50	3.73	0.02	0.98
Heart rate 1	336.53	14.28	331.50	9.27	0.79	0.44
Heart rate 2	457.07	21.84	445.17	10.72	1.26	0.22
SWFT index 1	12.36	1.51	12.26	1.87	0.13	0.90
SWFT index 2	16.80	2.21	16.46	2.47	0.30	0.76

Note: RSI - Reactive Strength Index; SWFT – Specific Wrestling Fitness Test; Heart rate 1 – Sum of heart rate at test end and 1-minute rest; Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest.

Figure 2 shows effect size differences between team members and non-team members in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters. Large differences are noted for the body mass and height.

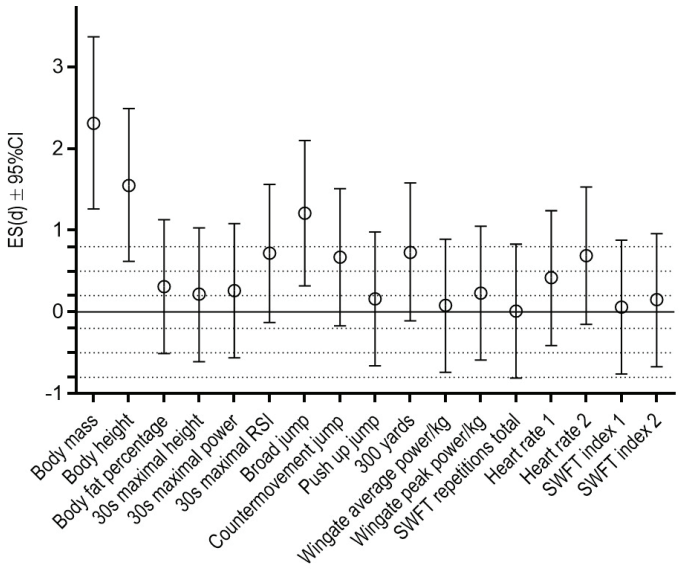

FIGURE 2. Effect size differences between lighter and heavier weight categories in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters.

Pearson's correlation coefficients are shown in Table 3. Body fat percentage was positively associated with all SWFT parameters except for SWFT repetitions for the total sample. Moreover, maximal height during 30 seconds of consecutive jumps and the CMJ test was positively correlated with SWFT repetitions. The CMJ test was negatively correlated with SWFT index 1 and SWFT index 2, where the lower index represents the better result. When looking separately among team members, only body height was negatively correlated with SWFT parameter Heart rate 1. Among non-team members, body height and body fat percentage were positively correlated with Hearth rates 1 and 2.

Table 3. Pearson's correlation coefficients between Specific Wrestling Fitness Test parameters and anthropometric and generic-fitness variables.

Variable	SWFT repetitions total	Heart rate 1	Heart rate 2	SWFT index 1	SWFT index 2
			Total sample		
Body mass	0.14	-0.02	0.08	-0.15	-0.11
Body height	0.23	-0.43	-0.35	-0.34	-0.31
Body fat percentage	-0.43	0.58*	0.61**	0.59*	0.60*
30s maximal height	0.48	-0.01	-0.06	-0.47	-0.48
30s maximal power	0.48*	0.11	0.11	-0.44	-0.42
30s maximal RSI	0.34	0.23	0.17	-0.26	-0.26
Broad jump	0.14	-0.31	-0.22	-0.26	-0.23

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Table 3. Pearson's correlation coefficients between Specific Wrestling Fitness Test parameters and anthropometric and generic-fitness variables.

Variable	SWFT repetitions total	Heart rate 1	Heart rate 2	SWFT index 1	SWFT index 2
Push up jump	0.28	0.05	0.03	-0.25	-0.25
Countermovement jump	0.49*	-0.20	-0.15	-0.54*	-0.51*
300 yards	-0.26	-0.05	-0.17	0.24	0.18
Wingate average power/kg	0.26	0.17	0.17	-0.20	-0.18
Wingate peak power/kg	0.17	0.16	0.19	-0.12	-0.10
Team members					
Body mass	0.27	-0.33	-0.29	-0.42	-0.41
Body height	0.36	-0.67*	-0.64	-0.60	-0.60
Body fat percentage	-0.49	0.56	0.55	0.61	0.63
30s maximal height	0.07	0.18	0.22	-0.01	0.00
30s maximal power	0.62	0.30	0.39	-0.42	-0.39
30s maximal RSI	0.31	0.48	0.50	-0.06	-0.05
Broad jump	0.22	-0.44	-0.39	-0.39	-0.38
Push up jump	0.26	0.16	0.17	-0.14	-0.14
Countermovement jump	0.27	-0.36	-0.31	-0.38	-0.37
300 yards	-0.60	-0.05	-0.20	0.54	0.48
Wingate average power/kg	0.42	0.15	0.11	-0.28	-0.30
Wingate peak power/kg	0.51	0.11	0.08	-0.38	-0.40
Non-team members					
Body mass	-0.10	0.64	0.69	0.24	0.30
Body height	-0.19	0.75*	0.74*	0.37	0.41
Body fat percentage	-0.45	0.74*	0.73*	0.66	0.68
30s maximal height	0.54	-0.26	-0.18	-0.60	-0.57
30s maximal power	0.22	-0.51	-0.42	-0.38	-0.38
30s maximal RSI	0.18	-0.51	-0.42	-0.34	-0.34
Broad jump	-0.03	0.00	0.14	-0.06	-0.02
Push up jump	0.32	-0.18	-0.17	-0.38	-0.37
Countermovement jump	0.65	0.01	0.06	-0.67	-0.62
300 yards	0.04	-0.06	-0.03	-0.09	-0.08
Wingate average power/kg	-0.01	0.20	0.34	0.01	0.06
Wingate peak power/kg	-0.32	0.31	0.44	0.31	0.36

Note: RSI - Reactive Strength Index; SWFT – Specific Wrestling Fitness Test; Heart rate 1 – Sum of heart rate at test end and 1-minute rest; Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest; * $p<0.05$; ** $p<0.01$.

Discussion

This study aimed to investigate the validity of the Specific Wrestling Fitness Test (SWFT), correlating it with other generic anaerobic tests in elite youth wrestlers and determining whether wrestlers differ according to quality and weight categories in all tests. According to the aims of the study, the most important findings are: (i) generic fitness tests are not associated with SWFT, (ii) wrestlers did not differ according to quality categories, and (iii) wrestlers did not differ according to weight categories.

Generic fitness tests and specific wrestling fitness test

The finding that generic fitness tests were poorly or not associated with SWFT could be explained by the fact that SWFT is a highly sport-specific test that includes complex movements of the whole body, with constant changes in body positions (Markovic et al., 2021). Specifically, the throwing manoeuvre starts in an upright position and finishes in the lying position, after which wrestlers have to stand up quickly and repeat the throwing. Thus, this test relies on the synergistic functioning of the whole body in a very specific movement. To support our findings, anaerobic performance variables accounted for less than 60% of the variance in a somewhat similar test for Brazilian judo athletes - Special Judo Fitness Test (SJFT) (Paulo Lopes-Silva et al., 2021). Supportively, SJFT was not correlated with upper-body Wingate test mean (R=-0.28) and peak power (R=-0.26) in Iranian judokas (Hesari et al., 2014).

However, our results did evidence weak to a moderate association of SWFT with vertical jumping capacity. Indeed, probably the most powerful movement of the SWFT is when

wrestlers have to explosively lift the dummy off the mat, which is mainly enabled by powerful movement from the lower extremities (Markovic, 2017). Similar to our study, a study on youth Tunisian wrestlers aged 16-17 years found an association between peak power of legs evaluated by the Wingate test and a specific wrestling test that consisted of throwing a partner, similar to SWFT (Melki et al., 2019). Thus, our results could lead to a hypothesis that lower-body power capacity determines performance in SWFT and potentially better performance in the wrestling match. Therefore, it could be proposed that wrestling coaches focus on developing muscle power in the lower extremities to enhance wrestling performance.

Differences according to quality groups and weight category

The SWFT did not differentiate team members and non-team members, implying that the test is not sensitive enough for this specific sample. Precisely, all participants in our study were advanced-level athletes; Besides selected team wrestlers, even non-team members were close to entering the team, meaning the differences between those quality groups are probably very small. Indeed, one potential reason could be the subjective evaluation of the team selector on the decision of which athlete to include in the team and which not to include, which can be based on the selector's self-perception of the wrestler. Opposite to the results of our study, a study conducted on Serbian wrestlers aged 20-21 years noted that wrestlers from different competitive levels (1st vs. 2nd Wrestling League of Serbia) differed in the wrestling-specific performance test, i.e., 1st league wrestlers outperformed 2nd league wrestlers (Markovic et al., 2018). However, the reason we recorded opposite results could be because we included only advanced-level wrestlers.

The research conducted on Croatian advanced wrestlers supports the results of our study. Specifically, top-level (national-team members) and high-level (non-selected for the national team) wrestlers did not differ in strength parameters (pull-ups and bench press) (Karnincic et al., 2015). Even though strength level is crucial for determining the fitness status of wrestlers, it can only discriminate lower-quality from high-quality wrestlers (García-Pallarés et al., 2011), while it does not efficiently differentiate advanced-level wrestlers. This has also been proven in numerous studies (Horswill et al., 1989; García-Pallarés et al., 2011). Specifically, a study on elite and amateur wrestlers from five countries recorded that elite wrestlers reached significantly greater results in most physical performance variables, including maximal grip strength, upper-body Wingate test, jumping height, and maximum muscle strength, than amateur wrestlers (García-Pallarés et al., 2011). Moreover, a study on youth wrestlers aged 16-17 years recorded that elite wrestlers had better results than non-elite wrestlers in the upper-body and lower-body Wingate test (Horswill et al., 1989).

However, advanced-level wrestlers have similar strength levels because they must possess a high level of strength and power, or they will not be categorized as advanced wrestlers. Indeed, a study on Polish wrestlers noted that successful wrestlers had higher muscle power, strength, and endurance levels than unsuccessful wrestlers (Cieśliński et al., 2021). Thus, to determine whether SWFT is sensitive for discriminating performance and quality levels, future studies should include wrestlers of lower quality (e.g., club-level wrestlers) and not only elite wrestlers.

Finally, wrestlers did not differ according to the weight categories in the SWFT, which could be explained by the fact that the test was performed with a dummy with a specifically determined weight according to their weight category (Markovic et al., 2021). Thus, by matching the weight of the dummy to the weight of the wrestler, the impact of an athlete's lower or higher mass was somewhat diminished. Moreover, there is another additional explanation for the lack of differences between the weight categories. It is possible that the quality of wrestlers interfered in the results and that they were of similar physical capacities regardless of weight. Similar to the results of our study, a study on wrestlers aged 20-22 years noted that elite wrestlers from three weight categories did not differ in maximum muscle strength in the bench press and squat exercise (García-Pallarés et al., 2011). The authors explained such findings by hypothesizing that neural activation patterns and twitch tension per muscle mass during maximal concentric contractions are similar between elite wrestlers, irrespective of the weight category (Izquierdo et al., 2002; García-Pallarés et al., 2011). Therefore, matching the dummy to the wrestler's weight and probable similarity in the physical capacities between wrestlers most likely led to not finding differences between the weight categories in the studied wrestlers.

The study's main limitation is the cross-sectional character and the inability to conclude the relationship between success and physical capacities. Therefore, intervention studies that include exercises and training protocols that tackle capacities included in this study should be performed in the future. Further, we included a relatively small sample size. However, we have to mention that we included advanced-level wrestlers, and, as such, it was hard to collect more wrestlers of this level. Precisely, 170 wrestlers competed at cadet and junior championships (which corresponds to the age category of our participants). Thus, as we included wrestlers that were top performers in those competitions, this could also be the strength of this study. Indeed, including athletes at the top performance and testing their physical capacities could aid in creating more specific training programs for enabling less successful wrestlers to become more successful.

To conclude, SWFT was not associated with generic-fitness tests, possibly because of its high specificity. Furthermore, team members and non-team members did not differ in the SWFT, which could be explained by the fact that only advanced-level wrestlers were included in this study. Thus, future studies should include wrestlers of lower quality. Also, the authors propose that future research/testing should consist of two consecutive SWFTs, with only a few minutes of rest between the trials. This way, wrestlers of greater quality will probably display better results and will be able to maintain higher performance levels during both testing trials compared with wrestlers of less quality.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Evaluation of Ocular Injuries among Athletes in Albania

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Abstract

It is important to evaluate ocular traumas in athletes as they can cause visual loss as blindness. This study aims to evaluate the epidemiology of ocular injuries and their characteristics in students aged from 19 to 23 years old in Albania. This is a 3-month study that started in November 2021 and ended in February 2022. 489 students of the University of Sports participated in the study. They answered a questionnaire about their demographic data and history of ocular injuries during sports activities. Students who reported ocular injuries underwent ocular examinations to evaluate their vision and ocular injuries characteristics. Only 7% of students reported that they had ocular injuries. Ball and teammates were reported with high frequencies as cause of eye injury. Only one student appeared to have reduced vision and damage to the structure of the eye. Sports-related ocular injuries can cause decrease of vision and the use of protective equipment during sports activities would prevent these injuries. Football and boxing were most commonly sports associated with ocular injuries among students in our study. This study points to the importance of preventing eye damage during sports activities by using preventive equipment, and opens the door for taking initiatives regarding the rules of using preventive equipment during sports activities.

Keywords: *ocular injuries, students, sports activities, Albania*

Introduction

Ocular trauma is one of the causes of vision loss and blindness in the world. Ocular traumas in athletes are considered important as they can cause significant visual impairments at a young age. Many studies today determine that the causes of ocular trauma in athletes also include not wearing protective equipment during sports activities (Braham, Finch, McIntosh, & McCrory, 2004). Other studies have shown that athletes are a population group that is especially at risk of ocular trauma (Zhang et al., 2021). Visual loss can change the quality of life (Krasniqi & Trebicka, 2020) and is important to prevent as much as we can eye injury during sports activity. Estimates of the incidence of sports-related concussion in the US vary from 200,000 a year up to 3.8 million a year; the highest numbers include rough estimates of injuries that are not evaluated in a hospital or otherwise reported (Mao, 2021b). According to the studies, the data would be largely underestimated due to the vague symptoms that do not always impose a medical evaluation on the athlete. Nearly 1 in 5 athletes who play contact sports suffer from a concussion during the sporting season, of which 20% of contact sports participants have concussion over the course of a season (Mao, 2021a). Trauma to the head frequently produces ocular signs that are important both as regards diagnosis and treatment. Such signs, which are of equal interest to neurologists and ophthalmologists, cannot be evaluated intelligently unless they are integrated with the other signs of head injury; with this in mind it has seemed worthwhile to present a reasonably detailed account of observations concerning cases of acute trauma to the head (King & Walsh, 1949). Giving a brief overview of the sports most affected by cranial traumas that are also related to eye injuries and their importance of

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preventing eye trauma caused by the practice of these sports activities such as, football, volleyball, basketball and boxing, some of the most practiced sports in the world, all at risk of ocular trauma. Although obviously not all sports have the same risk. In fact, there is a subdivision into some categories with high risk, moderate risk, low risk, eye safe (American Academy of Ophthalmology, 2013). With a high risk sport of ocular trauma in addition to boxing and kick-boxing, karate which in themselves involve intentional trauma, they are all those sports that in their practice involve the use of small and fast objects.

Although some research dealt with this topic, there are no studies in our country. In this regard, in our study, we focused on the epidemiology of ocular injuries and the characteristics of injuries in athletes among students aged from 19 to 23 years old in Albania. The study results will help us to prevent ocular injuries in athletes by planning preventive methods during sports activities in the sports disciplines most susceptible to these injuries.

Methods

Study design

This is a 3-month study that starts in November 2021 and ends in February 2022. The study was conducted in two phases. In the first phase, a cross-sectional study was conducted, in which 489 sports students participated. The first phase of the study was conducted at the University of Sports in Tirana. 489 students completed a questionnaire, and data were collected and analyzed. There were only 34 students who reported stories of ocular trauma. All 34 students were asked to participate in the second phase of the study by the consent of the students in offering them a free ophthalmologic visit. The second phase of the study, which began in January 2022, was carried out at the "At Luigi Monti" polyclinic in Tirana.

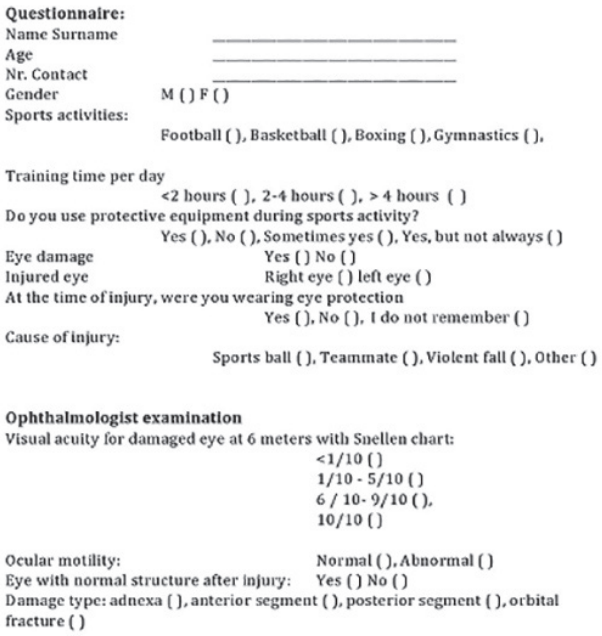
Participants

489 sports students participated in the research. Out of 489 students in total that were included in the study, it was observed that 78% were male and 22% female with an average age of 19.2±2.9 years old. 36% of them were footballers and only 18% boxers. 49% of students reported that they performed over 4 hours of sports activities per day. The students participated in the research process with their voluntary consent, and this research was also conducted in accordance with the Declaration of Helsinki.

Measuring instruments

In the first phase of the research, a questionnaire (Figure 1) was conducted with data about the profile of sports studies, gender, age and history of eye trauma during sports activities.

In the second phase, students underwent a detailed ocular examination by an ophthalmologist. All the students with stories of ocular trauma (34 students) went to At Luigi Monti policlinic in Tirana. During the eye visit, the distance visual acuity was evaluated with the Snellen chart table (Currie, Bhan, & Pepper, 2000). Evaluation of the anterior segment was performed using a biomicroscope, and fundus oculi with 90D lens and dilated pupil by cycloplegic drops.



Questionnaire:
Name Surname _____
Age _____
Nr. Contact _____
Gender M ( ) F ( )
Sports activities:
Football ( ), Basketball ( ), Boxing ( ), Gymnastics ( ),

Training time per day
<2 hours ( ), 2-4 hours ( ), > 4 hours ( )
Do you use protective equipment during sports activity?
Yes ( ), No ( ), Sometimes yes ( ), Yes, but not always ( )
Eye damage Yes ( ) No ( )
Injured eye Right eye ( ) left eye ( )
At the time of injury, were you wearing eye protection
Yes ( ), No ( ), I do not remember ( )
Cause of injury:
Sports ball ( ), Teammate ( ), Violent fall ( ), Other ( )

Ophthalmologist examination
Visual acuity for damaged eye at 6 meters with Snellen chart:
<1/10 ( )
1/10 - 5/10 ( )
6 / 10- 9/10 ( ),
10/10 ( )

Ocular motility: Normal ( ), Abnormal ( )
Eye with normal structure after injury: Yes ( ) No ( )
Damage type: adnexa ( ), anterior segment ( ), posterior segment ( ), orbital fracture ( )

FIGURE 1. Example of the questionnaire

Statistical processing of data

All collected data were analyzed by SPSS 2019 (Statistical Package for Social Sciences, v19.0, SPSS Inc., Chicago, IL, USA), and the results were compared according to different sports profiles. The risk factors were represented in numerical and percentage values. Also, the obtained results are presented in tabular and graphic form.

Results

With regards to eye protection, most of them (58%) disclosed that they did not use protective equipment during sports activities and only 6% reported using protective equipment during sports activities.

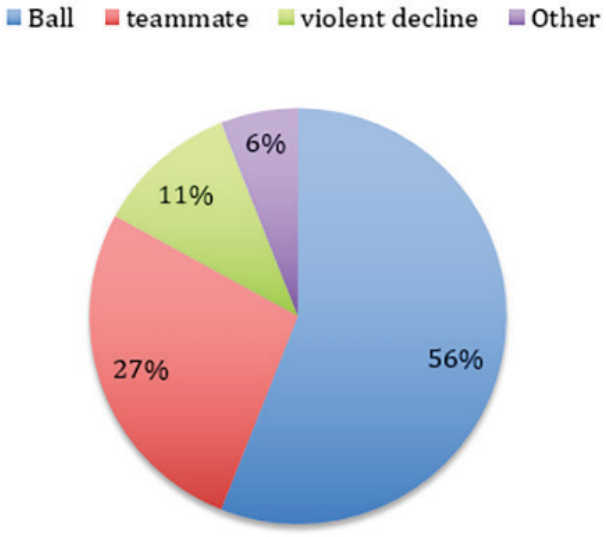
Out of the 489 students who completed the form, only 34

of them (7%) reported that they had been injured in the eye (see Table 1). Injury of the right eye was reported more with a frequency of 73% (25 students) from 34 students with eye injury in total.

Table 1. Demographic data of the students in the study

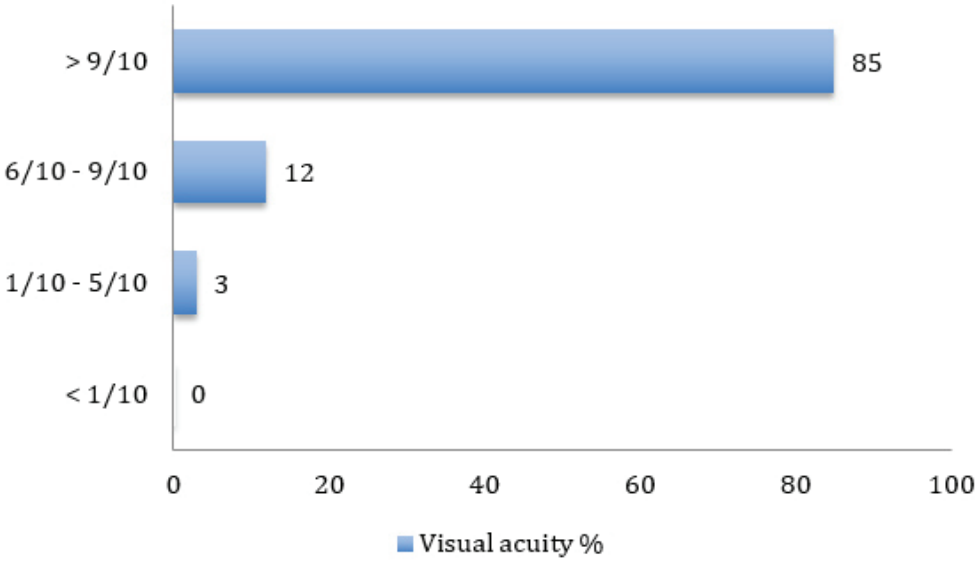
Gender	No.	%
Female	108	22
Male	381	78
Type of sports activities		
Basketball	120	25
Football	178	36
Boxing	89	18
Gymnastics	102	21
Total	489	100
Daily training time		
<2 hour / day	132	27
2-4 hour / day	117	24
> 4 hour / day	240	49
Use of protective equipment		
Yes	29	6
Yes, but not always	78	16
No	285	58
Sometimes	97	20
Eye injury		
Yes	34	7
Right eye	25	73
Left eye	9	27
No	455	93

Graph 1 shows the causes of eye injuries during sports activities; in which 56% of them are caused by the ball, 27 % by a teammate, and 11% by violent falls. All the students who reported eye injuries form the self-completion of questionnaire underwent eye examination. Visual acuity was valuated with Snellen chart table in 6 meters.

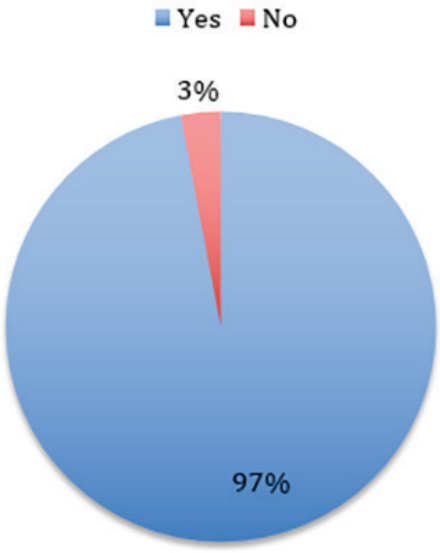


GRAPH 1. Graphic presentation of the causes of ocular injuries

Graph 2 shows the visual prevalence in injured students. As we can see, over 84% of the patients have good vision and only 3% of them have reduced vision, less than 50%. 12% of students with ocular injuries had a 60-90% vision.



GRAPH 2. Visual prevalence of students with ocular impairment



GRAPH 3. The appearance of the eye structure after injury

In graph 2 we have represent the prevalence of visual acuity in students who reported eye injuries. As we can see, 85% of them have good visual acuity (students read 9-line form 10 in Snellen chart table). Only 3% of students with eye injury had reduced visual acuity and they read from 1 to 5 lines in Snellen chart table. 12% of students with ocular injuries had a visual acuity that was from 6 lines to 9 lines in Snellen chart table. From the detailed ophthalmological visit, it was evidenced that 97% of students with ocular injuries showed regular ocular structure and only 3% (1 student) had damage to the structure (graph 3). The student who had structural damage had suffered an orbital fracture during the boxing match and had limited ocular motility and retinal damage.

Discussions

Ocular injuries can cause visual loss and blindness which will influence in life quality and work activity. Sports activities increase the risk of ocular injuries (Moon et al., 2016), as the factors that favor these injuries are present. In our study, factors of eye damage during sports activities were the sports ball and teammates, with a lower prevalence of violent falls. In other studies ball and teammates have shown a risk factor for eye injury (Cassell, Kerr, & Clapperton, 2012; Lee et al., 2021). The use of protective equipment during sports activities reduces the risk of ocular injuries. Stealing Haring in his study in 2016 reported that the use of protective equipment during sport prevents ocular damage (Haring, Sheffield, Canner, & Schneider, 2016). In our study, only 22% of students claimed through the questionnaire that they used protective equipment during sports activities. The latest studies suggests that the right protective eyewear is available, but not mandatory, by high-performance athletes often choose to use them to be safe during the development of certain sports disciplines (Micieli, Zurakowski, Ahmed, 2014). While the conventional use of the helmet is protective for the head, for some sports disciplines such as boxing and kickboxing, its protective capacity for the face is reduced at the zygomatic and maxillary level of the face and for eye injury. Particularly on the face, these blows manifest as soft tissue injuries, including lacerations, abrasions, and contusions, and skeletal injuries, such as fractures. This shows

the effect they have only on the head part and they do not provide comparable protection to the exposed face. It should be taken the fact that during various sports incidents, protective helmets serve to reduce the risk of injury, although not in the entire cranial and facial area. It is worth noting that, in most cases, the greatest care for the use of these protective equipment during various sports competitions is shown by athletes competing for medals, who require a high performance even in important national and international competitions in which they also participate. However, facial injuries occur at a similar rate to head injuries and the protective ability of the helmet is reduced specifically for the areas mentioned above. Studies have reported that their use prevents ocular damage (Haring et al., 2016). In our study, only 22% of students claimed through the questionnaire that they used protective equipment during sports activities.

The ophthalmological examination showed a decrease in vision in students who had ocular injuries during sports activities (15%). Parmar in her study in 2020 have shown a decrease in the vision of students who have suffered injuries during sports activities (Parmar, Martin, Davies, & Daniel, 2020).

Out of 489 students, only 7% of them responded that they had a history of ocular injuries during sports activities. Different studies have reported the same percentage for eye injury during sport activity (Motlagh et al., 2021), and other studies have reported a lower prevalence of eye injury (Zhang et al., 2021). This difference is because of strict rules of using preventive equipment during sport activity.

The strength of this study consists in preventing eye damage during sport activities by using preventive equipment. After data collected in our study, another study will open the door to undertake initiatives regarding the rules of using preventive equipment during sports activities.

Limitation of this study is the sample size, in which this study was limited only in University of Sport.

Conclusions

In conclusion, we can say that sports activities can lead to ocular injuries with reduced vision up to its total loss. In our study, it was observed that the use of protective equipment during sports activities was low, although wearing the protective equipment would prevent these injuries. Only 7% of students reported that they had ocular injuries. Ball and teammates were reported with high frequencies as cause of eye injury. Boxers and football players have the highest prevalence of ocular injuries in our study, albeit this is an isolated study limited to the University of Sports in Tirana.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

Impostor Syndrome in Physiotherapy Students: Effects of Gender, Year of Study and Clinical Work Experience

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Abstract

Impostor syndrome (IS) manifests as fear of being exposed as incompetent, despite exceptional professional achievements. The purpose of this study was to determine the prevalence of IS among physiotherapy students and to investigate whether there are significant differences according to demographic variables. Data were collected using the Clance Impostor Phenomenon Scale (CIPS), and participants were categorized into one of four groups based on the expression of IS characteristics. We found that IS occurs in the majority of physiotherapy students. Females achieve higher overall CIPS scores compared with males, but the proportion of males and females in each category of IS characteristics is similar. The expression of IS decreases with increasing age, length of clinical work experience, and year of study. Physiotherapy students with clinical work experience have fewer IS characteristics than those without clinical work experience. Study programs and clinical settings in which physiotherapy students receive practical training should pay more attention to raising awareness of IS in order to protect individuals who are particularly vulnerable to the negative consequences of IS.

Keywords: *imposter syndrome, impostor phenomenon, physical therapists, students, well-being*

Introduction

Imposter syndrome (IS) manifests as a constant fear of failure and fear of being exposed as incompetent, despite exceptional professional achievements (Chapman, 2015; Freeman & Peisah, 2022). People with IS cannot internalize their accomplishments and abilities. They perceive themselves as less intelligent and less capable than others perceive them (Villwock et al., 2016). They are afraid that others will discover that they are actually intellectual frauds whose success is due to random events, such as luck or perfect timing (Mainali, 2020). They usually attribute their success to external factors (e.g., luck) and their failures to their professional inadequacy (Bravata et al., 2020). IS is associated with perfectionism and setting unattainable goals. The sense of achievement and relief after a successfully completed task is short-lived for these individuals, as a new challenge repeats the cycle of worry (Thomas & Bigatti, 2020). IS is often reflected in workaholic behaviors that can lead to exhaustion and increase the risk of burnout (Parkman, 2016).

A person with IS typically responds to a particular task that trigger feelings of anxiety and self-doubt, in two ways: by extreme over-preparation, or initial procrastination followed by frenzied preparation. When people with IS over-prepare, they believe that their success is due to hard work rather than their actual abilities. In the case of initial procrastination, they usually attribute their success to luck (Sakulku & Alexander, 2001). Feenstra et al. (2020) concluded that IS develops in response to various social factors (society, organizations, relationships) that covey that the individual's ideas, knowledge, and insights are not accepted, worthwhile or valued. Feelings of not belonging and stereotypes often held in society about women in leadership positions and members of ethnic minorities may also contribute to impostor feelings (Feenstra et al., 2020).

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IS is observed primarily in women from diverse professional fields, but can also occur in men (Freeman & Peisah, 2022). It tends to be present in highly successful individuals and high-achieving students (Chapman, 2015; Gottlieb et al., 2020). However, impostor feelings can appear in anyone who fails to internalize their achievements and are not limited to successful individuals (Sakulku & Alexander, 2001). It is believed that approximately 70% of the general population is affected by this syndrome at some point in their lives (Rivera et al., 2021). It is possible that there is a healthy level of "impostorism" that is associated with increased drive and career success, but above a certain threshold, IS can lead to negative outcomes regarding mental health, such as burnout, depression, anxiety and substance abuse (Gottlieb et al., 2020; Freeman & Peisah, 2022). Individuals with IS are more likely to report low self-esteem, dissatisfaction and emotional exhaustion (Gottlieb et al., 2020).

A culture of perfectionism often prevails in the health professions, in part because of fear of making mistakes that can lead to severe clinical consequences. Students are particularly stressed psychologically, as they face the clinical environment and perform procedures on real patients for the first time. The constant supervision and questioning by mentors, often right in front of the patient or medical team, also contributes to stress in this population (Ng & Tay, 2021). After reviewing the scientific literature, we found a dearth of studies examining IS among physical therapists. We found only one study that examined the prevalence of IS among graduate physical therapists (Kansara et al., 2021). Therefore, our aim was to determine the prevalence of IS among physiotherapy students in Slovenia and to investigate whether there are significant differences according to demographic variables. We hypothesize that the prevalence of IS will be higher among female physiotherapy students, younger students, lower year students, and students with no clinical work experience or shorter clinical work experience. The results of our study will help to raise awareness of the prevalence of IS among physiotherapy students, which may help to identify and address IS in these individuals within undergraduate and master's programs or in clinical settings where students are interning.

Methods

Participants

The sample consisted of 106 physiotherapy students who answered the questions in an online survey (see below). Among them, 17 were men (16%) and 89 were women (84%). The mean age of the men was 25±4 years. The average age of women was 24±4 years. Seventy-five (70.8%) participants had previous clinical work experience, apart from practical training in their college studies. Most participants had less than 6 months of clinical work experience (28.3% of all participants). All physiotherapy degree programs in Slovenia follow the Bologna education system, which provides 3 full years for the bachelor's degree and another 2 years for the master's degree. In between, students often take an additional year to write the bachelor's thesis. In this study, most participants attended the 3rd year of the bachelor's degree (23.6%) or the additional year after the bachelor's degree (23.6%), followed by those who attended the 1st year of the master's degree (21.7%). A smaller proportion of participants also attended the following programs: first year of bachelor's program (1.9%), 2nd year of bachelor's program (10.4%), 2nd year of master's program (13.2%) and additional year after master's program (5.7%). The participants were requested to acknowledge their consent for the data to be used for the purposes of this study. Participants acknowledged their voluntary participation at the beginning of the survey. The study was approved by the National Medical Ethics Committee of Slovenia (approval number 0120-690/2017/8) and was conducted in accordance with the Declaration of Helsinki.

Study design

This was a cross-sectional survey-based study. In November 2022 the online survey was sent via social networks and e-mail to physiotherapy students from all faculties in Slovenia. Participants were informed about the purpose of the study and that the participation in the study was voluntary and anonymous. We used the CIPS questionnaire, which has been previously translated into Slovenian and used to assess the prevalence of IS among kinesiologists and sport (Petrič, 2022).

Questionnaire

The first part of the questions was related to demographic data (gender, age, year of study) and previous clinical work experience in the field of physiotherapy, in addition to practical training as a part of collage program. No personal data was collected and the survey was completely anonymous. The second part of the questions consisted of the imposter syndrome scale (Clance Impostor Phenomenon Scale – CIPS; Clance, 1985), which is used to determine the degree of IS characteristics in individuals. The scale consists of 20 items that refer to the impostor feelings. Examples of items include »I rarely do a project or task as well as I'd like to do it.« and »At times, I feel my success has been due to some kind of luck.«. The answers of the CIPS scale are on a five-point scale (from 1 = not at all true, to 5 = very true), and the result is the total sum of the answers (maximum possible score = 100 points). Depending on the score, participants are classified into one of four groups of IS characteristics: (a) few IS characteristics (less than 40 scores), (b) moderate IS experiences (scores between 41 and 60), (c) frequent impostor feelings (scores between 61 and 80), (d) intense IS experiences (scores above 81). Total sum of answers (CIPS total score) and categorized scores (CIPS-IS category) were separately compared with demographic variables. Previous studies have reported a high level of internal consistency of the CIPS, Cronbach's α=0.85-0.96 (Mak et al., 2019). The results of the pilot study with 90 participants also showed very high internal consistency (α=0,92) of the CIPS for a Slovenian sample as well (Šavrič, 2018).

Statistical analysis

Data were analyzed statistically using IBM SPSS software (version 27.0). Descriptive statistics were presented with frequencies and frequency proportions, and numeric variables as means and standard deviations. Where necessary, the normality of the distribution was checked with the Shapiro-Wilk test. The correlation of the CIPS total score and the CIPS-IS category with age, year of study and length of clinical work experience was checked with the Spearman correlation coefficient which was interpreted as very low ($0<r\leq0.19$), low ($0.2\leq r\leq 0.39$), medium ($0.4\leq r\leq0.59$), high ($0.6\leq r\leq0.79$) or very high ($0.8\leq r\leq1.0$). Gender comparison and comparison between students with or without clinical work experience were performed using the Mann-Whitney test because of the non-normal distribution of the CIPS total score. We calculated the effect size from the Mann-Whitney U statistic and converted it

to the Cohen's d measure, which was interpreted as small (0.2-0.4), medium (0.5-0.7), large (>0.8), or no effect (<0.2) (Cohen, 1988). To determine the relationship between the independent variables (gender, presence of clinical work experience, duration of clinical work experience) and the CIPS-IS category, we used the Chi2 test or Fisher's exact test when the expected frequencies previously examined were less than 5. For all analyses, the threshold for statistical significance was set at $\alpha<0.05$.

Results

Most students had moderate IS experiences (45.3%), followed by students with frequent impostor feelings (34.9%), students with few IS characteristics (17.0%) and students with intense IS experiences (2.8%).

Gender

Table 1 shows the distribution of participants by gender and CIPS-IS category. Most women (46.1%) and men (41.2%) had moderate IS experiences. A small number of women (3.4%), but no men (0.0%) were categorized as having intense IS experiences. Only 4 men (23.5%), but 33 women (37.1%) had frequent impostor feelings, whereas the proportion of men in the "few IS characteristics" category was higher (35.3% of men and 13.5% of women). Because 3 cells had an expected count of less than 5, we used Fisher's exact test to determine whether the across CIPS categories differed between men and women. Although the proportions indicated that women were more often classified into categories associated with a higher degree of IS, the differences in proportions were not statistically significant (p=0.209). On the other hand, the CIPS total score was statistically significantly different between men (48.8±13.3 points; range: 31-76) and women (56.4±13.4 points; range: 31-85) (U=512.0; p=0.035), although the effect size was small (d=0.42).

Table 1. The distribution of participants according to gender and CIPS-IS category.

			Men	Women	Total
CIPS categories	Few IS characteristics	n	6	12	18
		%	35.3%	13.5%	17.0%
	Moderate IS experiences	n	7	41	48
		%	41.2%	46.1%	45.3%
	Frequent impostor feelings	n	4	33	37
		%	23.5%	37.1%	34.9%
	Intense IS experiences	n	0	3	3
		%	0.0%	3.4%	2.8%
	TOTAL	n	17	89	106
		%	16.0 %	84%	100%

IS – impostor syndrome

Age and year of study

There was no statistically significant correlation between age and total CIPS score (r=−0.13; p=0.177). Similarly, there was no correlation between year of study and CIPS total score (r=−0.14; p=0.168). On the other hand, there was a small (r=−0.20), but statistically significant (p=0.039) negative correlation between age and CIPS category. This indicates that higher student age is associated with smaller degree of IS. Similarly, there was there was a small (r=−0.19), but statistically significant (p=0.048) negative correlation between year of study and CIPS category, which indicates that higher year of study is also associated with smaller degree of IS.

Clinical work experience

Table 2 shows the distribution of participants into CIPS categories according to the presence of previous clinical work experience. The distribution suggests that clinical work experience is associated with a greater likelihood of lower IS traits.

Table 2. The distribution of participants according to gender and previous clinical experience.

			Clinical Work experience		Total
			YES	NO	
CIPS categories	Few IS characteristics	n	17	1	18
		%	22.7%	3.2%	17,0%
	Moderate IS experiences	n	35	13	48
		%	46.7%	41.9%	45,3%
	Frequent impostor feelings	n	22	15	37
		%	29.3%	48.4%	34,9%
	Intense IS experiences	n	1	2	3
		%	1.3%	6.5%	2,8%
	TOTAL	n	75	31	106
		%	100,0%	100.0%	100.0%

Only one participant (3.2 %) with no clinical experience had few IS characteristics, while there were 17 (22.7%) of participants with clinical work experience in this category. While the percentage of participants with moderate IS experiences was similar for students with (46.7%) and without (41.9%) clinical work experience, students without clinical work experience were more likely to be in the "frequent impostor feelings" category (48.8% vs. 29.3%) and "Intense IS experiences" category (6.5% vs. 1.3%).

Because 3 cells had an expected count of less than 5, we used Fisher's exact test to determine whether the distribution across CIPS categories differed between students with and without clinical work experience. The Fisher's test was statistically significant ($p=0.015$), indicating that students with clinical experience were more likely to be placed in CIPS categories reflecting a lower level of IS. In addition, students with clinical experience had a statistically significant ($U=725.0$; $p=0.002$) lower CIPS total score (52.7±13.5 points; range: 31-83) compared to students without clinical work experience (61.3±12.2 points; range: 38-86), with the difference being moderate ($d=0.62$).

For additional analysis, we also categorized the students by clinical experience into additional categories: a) no clinical experience; b) <6 months; c) 6-12 months, d) 1-2 years and e) >2 years). We found a statistically significant negative correlation between the clinical work experience category and the CIPS category ($r=-0.34$; $p<0.001$), and between the clinical work experience category and total CIPS score ($r=-0.31$; $p<0.001$).

Discussion

To date, there has been very little research on the prevalence of IS among physiotherapy students. The aim of our study was to determine the prevalence of IS among physiotherapy students in Slovenia, regardless of the faculty attended, and also to investigate whether there are significant differences in the expression of IS depending on certain demographic variables.

General results

Our results indicate that some degree of IS occurs in 83% of physiotherapy students. The majority of students had moderate characteristics of IS (45.3%), followed by frequent impostor feelings in 34.9%. On the other hand, 17.0% of the students showed few IS characteristics. Only 2.8% of the students showed intense IS experiences. Very little research has been done on the prevalence of IS among physiotherapy students, so we compared our results with respect to the general population in Slovenia and with related professions.

Šavrič, (2018) reported that 67.2% of participants from the general working population had moderate to intense IS experiences, which is 13% lower than our sample of physiotherapy students. The prevalence rate of IS in Slovenia is slightly lower in the general working population compared to our sample of physiotherapy students. The slightly higher prevalence of IS among students might be due to the fact that they do not have as much clinical work experience and are confronted with a clinical environment for the first time, which can be very stressful (Ng & Tay, 2021). Compared to our study, Šavrič (2018) had a slightly more even distribution of the sample in terms of gender, which could further influence the differences in the prevalence of IS between physiotherapy students and the general working population in Slovenia. The lack of data in Šavrič's (2018) research prevents us from quantifying the percentage of healthcare workers in her study. This data would allow us to compare physiotherapy students and health workers in Slovenia, where the culture of perfectionism is particularly prevalent (Ng & Tay, 2021). It may be that the proportion of moderate to high IS traits is higher among health care workers in Slovenia than in the general working population and is closer to our results.

In their research, Petrič (2022) included a sample of 115 sport trainers and kinesiologists (mean age 29.4 years), who were employed, unemployed or worked as students. They found that most participants were in the moderate (35.65%) and frequent (53.04%) category of feelings of IS. Less than 1% of the respondents had few IS characteristics. The results of their research indicate that kinesiologists and trainers are experiencing feelings of self-doubt. When we compare our results with the research findings of Petrič (2022), we find a similar prevalence of IS expression in physiotherapy students and kinesiologists (in both cases, the largest proportion has moderately and frequently expressed IS characteristics). Also in their study, the prevalence of IS was highest with the category of moderate (35.65%) and frequent (53.04%) expression, but when comparing, we must take into account that their study had a more heterogeneous population than ours, in which the participants were only students.

Gender

The results of our study show that moderate expressions of IS are prevalent in both female (46.1%) and male (41.2%) participants. Females scored statistically significantly higher on the CIPS total score, but the proportion of females and males across CIPS - IS categories was similar. Therefore, it is difficult to say at this time whether the gender difference in mean CIPS total score is clinically relevant.

However, unlike us, Šavrič (2018) found significantly more pronounced features of IS in women compared to men. However, their study was conducted on a sample of the general working population and not physiotherapy students. Research conducted on a sample of 115 kinesiologists and trainers reported a prevalence of IS that was similar in both genders (Petrič, 2022). Kansara et al., (2021) examined the prevalence of IS among graduate physical therapists in India. 200 physical therapists participated in the study. They found that among 68 male participants, 58.8% had moderate IS features, 29.4% frequent, 8.82% few characteristics, and 2.94% intense IS experiences. In 132 female participants, it was found that 6.81% had few IS characteristics, 57.5% showed moderate characteristics, 33.3% frequent characteristics, and only 2.27% of the female population had intense characteristics. Also, no statistically significant differences were found between genders in terms of the expression of IS.

Villwock et al. (2016) conducted a pilot study of IS prevalence among 138 medical students in New York, who completed "The young impostor scale – YIS". They found that female gender was significantly more likely to be associated with IS. No less than 49.4% of females and only 23.7% of males reported IS symptoms. Cusack et al. (2013) attributed the reason for the higher prevalence of IS to the fact that modern women have several different roles in society in which they are expected to excel. In summary, previous research on the prevalence of IS as a function of gender is not entirely consistent. However, our findings are consistent with most studies that also show similar prevalence of IS in men and women (Leary et al., 2000; Rohrmann et al., 2016; Kansara et al., 2021; Kuppusamy et al., 2022).

Age

In our study, we found that older age of students was associated with lower expression of the IS characteristics, but not with the CIPS total score. Šavrič (2018) reached similar conclusions based on a sample of the general labor force, finding that young people report more pronounced IS traits in the early stages of their careers. Younger people who are at the beginning of their careers feel much additional pressure (Lane, 2015). During these sensitive years (18-25 years), people are between adolescence and adulthood. In this population, stress can come from feeling caught between two phases or from entering the workforce (Murphy et al., 2010). Polach (2004) states that unexpected and ambiguous situations and being surrounded by more experienced peers are additional factors that contribute to the emergence of IS traits. In his research, Lane (2015) notes that the expression of IS in young adults is as high as 79.3%. He conducted in-depth interviews and found that the feelings of IS are most prevalent when individuals are given new tasks at work. In addition, he notes that early in their careers, young people have a strong fear of others noticing that they are not capable enough. Petrič (2022), who studied the prevalence of IS among kinesiologists and coaches, finds that the prevalence of IS is more pronounced early in a career. As a limitation, he notes that the coaching profession is rarely practiced by older representatives. Many years of work and life experience may help older people overcome the characteristics of IS in their careers, which could explain a lower expression of IS.

Year of study and Imposter syndrome

We found that with a higher year of study, the expression of IS decreased. However, we did not find a statistically significant association between year of study and total CIPS score. Our results may be related to the fact that older individuals have more clinical work experience and have completed clinical training, which has given them more confidence in the clinical setting. Greater life experiences may also give older adults more self-confidence, which can be reflected in the prevalence of IS. On the other hand, Šavrič (2018) found in the general working population that employees with a higher education also have higher IS characteristics. This can be attributed to the fact that individuals with higher levels of education usually hold higher positions that require greater responsibility, and their decisions have a significant impact on the organization of work in the company. Therefore, they are under greater pressure than individuals with lower levels of education (Šavrič, 2018). Shahjalal et al. (2021) also found that third- and fourth-year medical students are more likely to be under pressure than other students due to increased academic workload, anxiety about studies and performance, and concerns about the future, and therefore are at significantly higher risk of developing IS than younger students. However, Khan & Khan (2021) found no significant differences in the characteristics of IS between dental students in their preclinical (1st, 2nd) and clinical (3rd, 4th) year.

Clinical work experience and Imposter syndrome

In our study, we found that there are statistically significant differences in the expression of IS depending on the presence of clinical work experience. Students with clinical work experience have a less pronounced IS and achieve a significantly lower CIPS total score than students without clinical work experience. We also found that a longer period of clinical work experience decreased the expression of IS traits and the overall CIPS score. The lower prevalence of IS in physiotherapy students with more clinical work experience may be attributed to greater self-confidence, boosted by many successfully rehabilitated patients during their working years.

Limitations

The main limitation of our study is the small sample size. With a larger sample, the associations between variables might be more pronounced and the results might be different. Another limitation refers to the gender bias of the sample. Many more women than men participated in our study. However, this reflects the fact that more women are enrolled into physiotherapy programs.

Conclusion

We found that IS occurs in the majority of physiotherapy students. Females achieve higher overall CIPS scores compared with males, but the proportion of males and females in each category of IS characteristics is similar. Therefore, it is difficult to say at this time whether the gender difference in mean CIPS total score is clinically relevant. The expression of IS decreases with increasing age, length of clinical work experience, and year of study. Physiotherapy students with clinical work experience have fewer IS characteristics than those without clinical work experience. The results obtained may be attributed to greater autonomy in the clinical setting and better perception of one's skills and knowledge with older age and more clinical work experience. Degree programs and clinical settings in which physiotherapy students receive practical training should pay more attention to raising awareness of IS in order to protect individuals who are particularly vulnerable to the negative consequences of IS. For example, they could draw inspiration from support programs and programs that help students identify IS tendencies, which are already being implemented by some universities around the world (MIT, California Technology). "Beating the impostor syndrome," developed by the Center for Creative Leadership, can also help raise awareness (Parkman, 2016). Feeling supported in one's social circle and being aware that other peers are also struggling with similar issues could potentially decrease the prevalence of IS among physiotherapy students.

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Author contributions

M.O. and K.K.K. conceptualized the idea. All authors worked on obtaining and analyzing the data. M.O. and K.K.K. wrote the first draft of the manuscript. All authors worked on finalizing the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Elite and Sub-elite Youth Soccer Players Show no Difference in Vertical Jump Performance

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Abstract

This study aimed to determine whether vertical jump performance differs among youth players with different performance levels. A total of 84 youth male soccer players from the U19 category were recruited. The players were divided into the elite (EG) and sub-elite (SEG) groups based on their performance level. The vertical jump (VJ) performance during countermovement jump with free arms (CMJFA) and drop jump (DJ) were measured using two force platforms Kistler B8611A at a sampling rate of 1000 Hz (KISTLER Instrumente AG, Switzerland). The following outcome variables were calculated in all participants: vertical jump height (VJH), vertical ground reaction force (VGRF), and force impulse (FI) in absolute and relative values. Data analysis showed no significant differences ($p>0.05$) with trivial to small effects in VJH for both jump types (CMJFA and DJ) between EG and SEG. $FI_{relative}$ provides a good indication of VJH in comparison with the other kinematic variables selected in this study. The leg muscle mass (LMM) ratio normalised to body mass provides a better association with VJH than the other selected morphological variables in this study, although a small effect size was observed. VJH does not appear to be a distinguishing feature among soccer players in the first two performance levels in the U19 category. Therefore, the results may not be sensitive enough to differentiate the performance levels, especially when the difference is only in one performance level. Future research should consider using other parameters, such as the eccentric rate of force development or reactive strength index, as recommended in a previous study.

Keywords: *lower limb strength, morphological variables, performance level, vertical jump performance, youth soccer*

Introduction

Defining elite performance levels remains elusive because of the wide range of descriptors used to distinguish elite from non-elite athletes, especially among youth (Lorenz et al., 2013). Elite athletes traditionally play in the higher divisions (Trecroci et al., 2018), sign for a professional club, or play as international youth athletes (Reilly et al., 2000). The assessment of performance in youth can be misleading because the process of growth and development is incomplete. This process is often burdened by the subjective assessment of the coach or scouts who select these players for the club or national team. The key characteristics that would predetermine success in soccer have been the subject of many scientific studies, although the conclusions are inconsistent. Elite youth soccer players have been found to have a greater physical ability than their lower-performing peers, giving them a higher chance of winning tackles, avoiding an opponent, or scoring a goal (Waldron & Murphy, 2013). Soccer requires players to have both great technical skills and optimal physical abilities, such as sprinting, acceleration, deceleration, jumping, and changing direction in a multidirectional manner (Loturco et al., 2020). The close relationship between vertical jumping (VJ) performance and sprinting abilities in soccer players has been previously reported, and it is hypothesized that players able to jump higher will also be more efficient at accelerating their bodies forward and therefore be able to achieve higher velocities over shorter distances (Loturco et al., 2015). The evaluation of VJ performance using a force platform is a professional method for investigating the activity of a closed kinetic chain (Castagna et al., 2013). The authors demonstrated that vertical jump height (VJH) could be a distinguishing criterion between youth soccer players at different levels of competition (Reilly et al., 2000; Gissis et al., 2006; Coelho

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et al., 2010; Trecroci et al., 2018; Trecrori et al., 2019). These differences in VJH performance may be due to differences in muscle strength, coordination patterns, or training experience (Zatsiorsky et al., 2020). In contrast, Cometi et al. (2001) found differences between elite and sub-elite adult players, although there were no differences between elite and amateur players. It should further be mentioned that VJH does not consider the high time requirement for the performance of competing scenarios. Because the ability to jump seems to be an integral part of successful participation in many soccer activities, identifying the independent variables that influence this ability could be useful for individualising training. Morphological factors that positively influence VJ performance include relative body fat, which stems from the fact that body fat is not a contractile tissue and therefore acts as an additional load to be carried against gravity. It should be noted that some morphological variables are relatively difficult to influence, although they can be useful in identifying talent.

Castagna et al. (2013) recommended the evaluation of VJ performance for the prediction of success in elite soccer from a chronological age of 17 years, given that physical fitness has been a covariate with maturation (Carvalho et al., 2011). With the above considerations in mind, it is important to assess whether VJ performance can differentiate between soccer players in late adolescence (under 19 years) at different performance levels. Therefore, this study aimed to determine whether VJH differs between youth athletes of different performance levels. Furthermore, we examined the relationship between individual kinematics, morphological and anthropometric parameters, and JH using the two types of VJ (countermovement jump with free arms (CMJFA) and drop jump (DJ)). We selected players from the 1st and 2nd highest youth leagues as the research object. We hypothesized a significantly higher VJH ($p<0.05$) in elite players compared to sub-elite players.

Methods

Study design

This study used a cross-sectional design. Data collection was conducted at the beginning of the summer pre-season part of the macrocycle. The measurements were performed under constant conditions during the morning hours. Before testing, the participants were familiarised with the experimental protocol and did not perform any high intensity physical activity lasting a significant duration for 48 h prior to testing.

Participants

A total of 84 young male soccer players from the U19 category (age=17.64±0.49 years) were recruited. Basic anthropometric data are presented in Table 1. The players were divided into two groups based on their performance level: the elite group (EG), comprising elite players of a team ranked 1st and 2nd in the first national youth league; and the sub-elite group (SEG), comprising sub-elite players part of a team ranked 1st and 4th in the second national youth league. Groups were classified as EG and SEG, according to the definition used by Lorenz et al. (2013), who considered elite athletes as those who played at a higher level than their peers within a sport. The exclusion criteria were any health issues that jeopardised participation or performance in the study, such as soft tissue injury, delayed muscle pain, recent illness, or recent recovery from injury. This study was approved by the Ethics Committee of the Faculty of Physical Education and Sport, Charles University (approval number 259/2020; 30.10.2020.), and all participants provided written informed consent. Measurement were carried out in accordance with ethical standards of Declaration of Helsinki and ethical standards in sport and exercise science research (Harriss et al., 2017).

Table 1. Descriptive characteristics of the elite and sub-elite groups.

Characteristic	Elite Group	Sub-elite Group	P
Number	42	42	
Age (years)	17.62 ± 0.67	17.68 ± 0.77	.69
Stature (cm)	181.59 ± 6.44	180.35 ± 5.54	.34
BM (kg)	73.71 ± 6.30	72.46 ± 8.33	.44
FFM (kg)	63.60 ± 6.34	63.05 ± 6.32	.68
LMM (kg)	21,39 ± 2.11	21.35 ± 2.15	.92
Training per week	5–6	4–5	

Legend: FFM: absolute value of fat free mass, BM: body mass, LMM: absolute value of leg muscle mass, p: probability

Stature and body composition

Stature was measured using a digital stadiometer Seca 242 (Seca, Hamburg, Germany) with an accuracy of 0.1 cm, and body mass was measured using a digital scale Seca 769 (Seca, Hamburg, Germany) with an accuracy of 0.1 kg. Body composition was assessed using a multi-frequency bioimpedance analyser MC-980MA (Tanita Corporation, Tokyo, Japan), according to the manufacturer's guidelines. Standardized conditions for bio-impedance measurement were maintained (Kyle et al., 2004). The following body composition indicators were selected: body mass (BM), stature, absolute and relative value of fat free mass (FFM), absolute and relative value of leg muscle mass (LMM).

Vertical jump

Before measurement, all tested participants completed a warm-up procedure (dynamic half squats, 3 sets × 10 repetitions; forward lunges 3 sets × 10 repetitions). All participants performed two types of VJs: CMJFA and DJ. For the CMJFA, the participants began with their arms free of downward movement until they reached a crouching position with a knee angle of approximately 90°, followed by a jump at maximal height. The DJ was started by instructing the participants to stand on a 20 cm high box with both legs stationary. The participant dropped from the platform, landed in front, and immediately jumped vertically (Yokoyama et al., 2019). The JH and kinematic parameters of each lower limb were measured using two force platforms Kistler B8611A at a sampling rate of 1000 Hz (KISTLER Instrumente AG, Switzerland). For JH, a calculation based on the flying phase time during the jump was used. Participants completed three trials for each type of

VJ performance, with instructions to jump as high as possible. The trial with the highest achieved JH value was selected for further result processing using the software BioWare 4.0.0 and MatlabR2013. The following outcome variables were assessed: JH (cm), vertical ground reaction force (VGRF, N), vertical ground reaction force in relative values ($VGRF_{relative}$, $N.kg^{-1}$), force impulse (FI, $N.s^{-1}$), and relative force impulse ($FI_{relative}$, $N.s^{-1}.kg^{-1}$) during the concentric phase of take-off.

Data analysis

Descriptive statistics (mean and standard deviation) were calculated for all dependent variables. The Shapiro–Wilk test was used to evaluate the normality of the data distribution, and Leven's test was used to assess the equality of variance. The statistical significance of the differences in the observed dependent variables between performance levels calculated by an independent sample t-test was used. Effect size was calculated using Cohen's d coefficient and classified as follows: large (d>0.80), medium (0.50<d<0.80), small (0.20<d<0.50), and trivial (d<0.20) effect sizes (Cohen, 1992). Pearson's correlation coefficient was used to determine the associations between the selected variables and JH for both types of vertical jumping. According to Hopkins (2000), the reference values for the effect size were nearly perfect (r>0.90), very large (0.70<r<0.90), large (0.50<r<0.70), moderate (0.30<r<0.50), small (0.10<r<0.30), and trivial (r<0.10). For all analyses, statistical significance was set at either p<0.05 or 0.01. Statistical analysis was performed using IBM SPSS v21 (Statistical Package for Social Science, Inc., Chicago, IL, USA, 2012).

Results

The descriptive statistics of JH, $VGRF_{relative}$, and $FI_{relative}$ for the elite and sub-elite groups are shown in Table 2. A higher VJH in DJ than in CMJFA for both groups was observed (2.1% for the EG and 2.75% for the SEG). No significant differences (p>0.05) with trivial to small effects in VJH and kinematic parameters relative to body mass between the elite and sub-elite groups were found.

Table 2. Vertical jump height and kinematic parameters of CMJFA and DJ.

Parameters		Elite Mean ± SD	Sub-elite Mean ± SD	P	d
CMJFA	JH (cm)	44.01±4.16	44.67±4.23	0.46	0.15
	VGRFrelative (N/kg)	2.62±0.14	2.63±0.21	0.92	0.05
	FIrelative (N·s·kg-1)	3.24±0.24	3.26±0.31	0.74	0.07
DJ	JH (cm)	44.95±4.49	45.93±4.70	0.33	0.21
	VGRFrelative (N/kg)	4.43±0.80	4.38±0.91	0.76	0.05
	FIrelative (N·s·kg-1)	5.06±0.32	5.04±0.27	0.73	0.06

Legend: CMJFA: countermovement jump with free arms, DJ: drop jump, JH: jump height, VGRF: vertical ground force reaction, FI: force impulse, SD: standard deviation, p: probability of significant differences in compared means, d: Cohen effect size.

The correlation between the JH of the CMJFA and DJ and the selected variables is shown in Table 3. Significant moderate positive associations were found between VJH (CMJFA and DJ) and $FI_{relative}$ (r=0.356 and 0.456, respectively, p<0.01). Positive significant correlations between VJH of CMJFA and $VGRF_{relative}$ (r=0.259, p<0.05) and LMMrel ratio (r=0.248, p<0.05) were found, but with a small effect size.

Table 3. Correlation among the vertical jump heights of CMJFA and DJ and selected variables.

Variables	CMJFA	DJ
Stature (cm)	-0.08	-0.12
Body mass (kg)	0.02	-0.11
FFM (kg)	0.09	-0.03
FFMrel	0.14	0.15
LMM (kg)	0.15	-0.00
LMMrel	0.24*	0.19
BF (%)	-0.13	-0.13
aVGRF (N)	0.16	-0.09
aVGRFrelative (N.kg-1)	0.25*	-0.13
aFI (N.s)	0.20	0.20
aFIrelative (N.s.kg-1)	0.35**	0.45**

Legend: a - data were calculated for each jump type (CMJFA and DJ), CMJFA: countermovement jump with free arms, DJ: drop jump, VGRF: vertical ground force reaction, FI: force impulse, FFM: absolute fat free mass, FFMrel: relative fat free mass, BM: body mass, LMM: absolute leg muscle mass, LMMrel: relative leg muscle mass BF: fat mass, *p<0.05, **p<0.01.

Discussion

This study was conducted to determine whether VJH differs between youth players of different performance levels, and to thereby further delineate variables that are related to VJH. Surprisingly the SEG (CMJFA=44.67±4.23 cm; DJ=45.93±4.70 cm) was found to have a better VJ performance (CMJFA and DJ) than the EG (CMJFA=44.01±4.16 cm; DJ=44.95±4.49 cm), although this difference was not statically

significant (p>0.05). We must point out that our players' VJH was higher in CMJFA than of their U19 peers in the study by Maly et al. (2015) (CMJFA=40.82±3.96 cm). According to a study by Torreblanca-Martinez et al. (2020), the U19 category of the highest Spanish league had slightly higher DJ values (46.34±5.94 cm) compared to our players. It should be mentioned that, although it was a DJ, the landing in the first phase took place with an elevated box of 45 cm instead of a height of 20 cm in our study. Greater performance may be related to greater motor unit recruitment (Dimitrova et al., 2002), possibly because of optimal eccentric phase forces (Andrade et al., 2020).

The results showed that among youth players in the U19 category, VJ performance could not differentiate between performance levels. Our findings are consistent with those of Cometi et al. (2001), who did not identify any differences between first-division players and amateur soccer players. One reason for this may be that the players jump only 15.5 times during the game (Reily et al., 2000), which means that this capacity cannot develop in match situations, and it can, therefore, be assumed that soccer training may be an inadequate training stimulus to develop jumping ability. Castagna et al. (2013) showed that VJs could not differentiate between competition levels in soccer players selected for the national team. The results of this study showed that in elite male players, VJ performance was not dependent on the competition level. Our finding is in contrast with those of other studies, which reported that elite players showed a better VJ performance (10–16%) during the CMJ test in U16 (Trecrori et al., 2019) and U15 (Trecroci, Milanović et al., 2018) and during the SJ test in U14 (Coelho E Silva et al., 2010) and U17 (Gissis et al., 2006) compared to that of sub-elite peers. Higher differences in elite and sub-elite players have been reported for CMJ (16%) than for SJ (10–14%), indicating a better ability of elite players to transition from downward-phase eccentric loading to upward-phase concentric power production (Król & Mynarski, 2012), although this trend was absent in our study.

In addition, in a study of adult players in the Greek League, Kalapotharakos et al. (2006) showed that players from the teams ranked in the first three positions of the table achieved higher performance in the height jump in CMJ than from the teams that were in the middle and at the bottom of the ranking table. One possibility to explain the lack of this trend in our study could be that our players are still undergoing growth and development, and therefore their potential may not be fulfilled yet. On the other hand, some studies do not find a difference between youth teams U17 (Castagna et al., 2013) and U18 (Mujika et al., 2009) as compared to senior players. It is also necessary to mention that the observed VJH is relatively high for both groups (elite and sub-elite), which may indicate an increase in the physical requirements of the players at both levels. Soccer is a developing sport in general, and even smaller clubs have access to quality training conditions with sufficiently educated trainers and a sophisticated training program for the development of individual strength components. Finally, the fluctuation of players in the youth categories was high; some players went through top academies in their youth categories and were transferred to other teams at the sub-elite level, which could have an impact on the overall results. Unfortunately, we did not analyse the players' history.

The current investigation showed slightly lower values than in other studies that identified associations between JH and kinematic parameters, such as VGRF or FI (McBride et al., 2011; Daugherty et al., 2021). Interestingly, only the $FI_{relative}$ associated with JH was observed during DJ. To jump higher, an athlete must quickly apply substantial force against the ground from the beginning of the movement to the point of projection (take-off) (Bosco et al., 1983). As the VGRF increases, the vertical velocity at take-off increases, and hence, the JH increases (Loturco et al., 2015). Percentage of fat mass was not associated with VJ performance and could not be used to explain jumping ability, which is inconsistent with the observations of other studies (Davis et al., 2006; Caia et al., 2016). One explanation for this is that there are higher differences in % body fat among amateur players, while players in our study were more homogeneous with similar training volumes (4–5 vs 5–6 training per week). Among the morphological variables, only the LMMrel ratio ($r=0.248$, $p<0.05$) had a positive association with JH during CMJFA, but with a small size effect. This finding indicates that the distribution of muscle mass in the lower extremities relative to the BM appears to be a better indicator of the selection of morphological variables in this study. These findings could aid training and conditioning trainers to estimate jump potential and prescribe individual interventions to maximise the potential. The morphological features linked to specific body regions (upper and lower limb) may be preferred over whole-body measures to interpret male players' physical potential in vertical jump and sprint performance (Bongiovanni et al., 2021). The idea to manage the training process by monitoring the multidimensional performance can work to the advantage of practitioners (Turner et al., 2019), especially if information based on an individual's anthropometric measures (e.g., morphological data of upper and lower limbs) can be associated (Rossi et al., 2022).

One of the limitations of this study was its cross-sectional design, which only allowed us to present the players' current status, but could not reveal the long-term development of youth players. Future research should consider the differentiation of player positions in soccer (Sporis et al., 2009). Furthermore, the results obtained in this research are applicable only to U-19 young soccer players. Recently, the eccentric rate of force development and reactive strength index have been recommended as variables to be evaluated alongside JH (Barker et al., 2018).

Conclusions

This study concludes the following: (1) VJH could not detect differences between players in the first two performance levels in the U19 category. (2) The $FI_{relative}$ normalised to body mass provided a good indication of JH in comparison with the other selected morphological variables in this study. (3) The LMMrel ratio provided a better association with JH than the other selected morphological variables in this study, although a small effect size was observed. When evaluating VJ performance in young soccer players, measurers should consider that the results may not be sufficiently sensitive to differentiate performance levels, especially when the difference is only one performance level. Further studies to delineate elite and sub-elite athletes in youth soccer should be encouraged to control for possible confounding factors.

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Conflicts of Interest
The authors declare no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

The Effect of Physical Activity on Burnout Syndrome in Emergency Room Nurses Working in Public Hospitals

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Abstract

The concept of burnout, and indeed its increasing prevalence in recent years, has been a matter of major concern among psycologists, sociologists and HR specialists. This research aims to explore the impact of physical activity on burnout syndrome experienced by emergency room nurses in public hospitals. The preliminary research sample consisted of 476 emergency room nurses working in the 3rd, 4th and 5th Health Regions of Greece. The participants' age ranged from 22 to 60years (age 42.49±9.5 years). The participants completed questionnaires that assessed burnout and physical activity. The Maslach Burnout Inventory was utilised, which comprises 22 symptom items and measures three dimensions: emotional exhaustion, personal accomplishment and depersonalisation. In addition, and for measuring physical activity, the International Physical Activity Questionnaire (IPAQ, short version) (recall period one week) (Craig, et. al., 2003) was used. The said questionnaire consists of 7 questions collecting information on the time spent each day in vigorous, moderate and walking physical activities as well as the time spent sitting over a period of seven days. The measurement method used was the Likert scale. The results showed that nurses experienced a high level of burnout, whilst the majority of them demonstrated a low level of physical activity and that physical activity is directly correlated to burnout, as is positively effects all three factors. It is therefore concluded that physical activity seems to have a positive effect on the emotional balance of the worker helping him/her deal with the symptoms of burnout.

Keywords: *burnout, physical activity, nurses*

Introduction

Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure above the basal metabolic rate. Sport is defined as a strictly structured physical activity, under rigorous rules, high levels of competition and specialisation, whose basic aim is to maximise athletic performance (Caspersen, Powell & Christensen, 1985). On the other hand, exercise is defined as each systematic bodily movement or participation in physical activities, that is time-limited, less competitive and where, mostly, the body's major muscle groups are involved (Berger, Pargman, & Weinberg, 2007).

The perception that physical activity delivers overall benefits is acknowledged worldwide (Török et al., 2006). That's what at least is implied given compulsory gym classes at schools, the great number of sports clubs and the high engagement of middle-aged and older people in fitness and sports, along with the immense growth of the sports equipment/sportswear industry. Also, participation in physical activities accounts for a decrease of death rates by 20-40% regardless of underlying causes (Khan et al., 2012). However, today, as people commute to work mostly by car or public transport, consume large quantities of food, and are obliged to live in densely populated urban areas lacking in green spaces, their body weight increases and their physical fitness levels decrease, leading to diseases associated with this lifestyle (Popkin et al., 2012).

Furthermore, the annual economic burden of physical in-

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activity in European countries is about 80 billion dollars for the four major non-infectious diseases (cardiovascular diseases, type II diabetes and breast and colon cancer). This amount accounts for 6.2% of all health care costs in Europe, and is five billion dollars higher than the amount spent worldwide for the treatment of cancer, an amount equivalent to 50% of Ireland's and Portugal's Gross Nation Product (GNP), while it is estimated, that by 2022 this amount will have reached 125 billion dollars (Allemani et al., 2015).

Exercise therefore, does not only help maintain a healthy body contributing to its well-being, but also cures the body and improves mental health, two components that invariably go hand in hand. In other words, the message that exercise conveys, is not directed solely to healthy but also to ailing individuals, with a view to prevent diseases and improve morbidity rates (Theodorakis, 2005).

Burnout, as a psychology term, was coined by Bradley (1969), to describe a phenomenon met in professions that provide services. However, it was Freundenberger (1974), who first highlighted the symptoms of burnout syndrome. To describe this phenomenon he chose the word burnout and described exhaustion as a state of fatigue or disappointment that arises by committing to a cause, a lifestyle, or by failing to obtain an expected reward. However the prevailing definition is that of Maslach & Jackson (1986), who described burnout as being a psychological syndrome caused by chronic stress experienced by professionals working in the area of services. More specifically, what is decribed here is a chronic strain arising from a fundamental disconnect or mismatch between the worker and the workspace (Leiter & Maslach, 2003).

What has been observed, is that the level of burnout among healthcare professionals differs depending on the department and the healthcare facility of work. The phenomenon is usually more intense in hospitals' emergency rooms, intensive care units and pathology departments. Emergency room nurses are often subjected to physical and verbal abuse due to unmanageable patient flow and understaffing that have exhausted them both physically and mentally (Adriaenssens et al., 2015). By the same token, the often sudden death of a patient causes emergency room nurses to question their capabilities, feel insufficient, feel like a failure, and perhaps experience feelings of guilt (Portero et al., 2020).

A significant percentage of emergency room nurses exhibit symptoms of burnout. Also, many researchers maintain that the percentage of burnout in emergency room nurses is higher than that of nurses working in other hospital departments, as intensive care units, surgery departments etc. (Robin & Leslie, 2006; Adrianenssens et al., 2015).

Anderson et al. (2014) studied the effects of a physical activity programme on the anxiety, depression, occupational stress and burnout syndrome of 580 nursing professionals. The method used was a structured physical activity programme conducted five times per week lasting 10 minutes for a period of three months.This physical activity programme did not yield any noteworthy results on the levels of anxiety, depression, burnout or occupational stress. However, after this interventional programme, the participants reported improved perceptions of bodily pain and the feeling of fatigue at work.

Furthermore a study conducted by Mohebbi et al. (2019), sought to determine the effectiveness of an aerobic exercise programme on the occupational stress of nurses.Sixty nurses working in hospitals affiliated to Shahrekord University of Medical Sciences in Iran took part. Based on the results, what was concluded was that a comprehensive exercise programme helps decrease work stress, and the prospect of incorporating physical activity in day to day life should constitute a new lifestyle and routine for nurses.

The purpose of this research was to investigate the effect of physical activity on burnout syndrome, as regards emergency room nurses in public hospitals. More specifically, the reseach had two sub-objectives. The first was to record and assess the levels of physical activity and burnout in workers, and the second was to detect the relationship between physical activity, as a health behaviour, and burnout in emergency room nurses. The results will also encourage public and private agencies to create and implement appropriate physical activity programmes with the scope to improve nurses' mental and physical health.

Methods

Participants

The research sample consisted of 476 nurses, both male and female, working in public hospital emergency rooms in the 3rd, 4th and 5th Health Regions of Greece. In total 476 questionnaires were filled out and used for statistical analysis. The sample consisted of 355 women and 121 men, with an average age of about 43 years (mean=42.49, SD=9.5). To facilitate date analysis, the participants were grouped in four categories based on data distribution. The first category consisted of nurses in the 22-32 age group, the second in the 33-43 age group, the third in the 44-54 age group and the fourth in the age group 55 and over. For their participation in the research, they should have at least one year of experience in the specific department and be permanent civil servants of the hospitals of the 3rd, 4th and 5th health districts.

Procedures

The participants were informed that all questionnaire answers would be confidential. The questionnaires were completed from January 2022 to April 2022. Each nurse completed three questionnaires, one on physical activity, one on burnout and one on their demographics.

Firstly, permission was requested from the Board and Scientific Council of each hospital for conducting the research, as well as from the Ethics Committee of the Democritus University of Thrace. Permission from the latter was granted on 16/12/2021 under permission no.25075/168. Thereafter, the head and director of the department was informed about the goals and the content of the research. After the briefing, participants were adviced that, a) their participation was voluntary, b) the questionnaires were anonymous, c) absolute confidentiality would be maintained and d) the results would be used solely for scientific purposes.

Measurments

For the assessment of physical activity, the International Physical Activity Questionnaire (IPAQ, short version) (recall period one week) was used (Craig et. al., 2003). Specifically, the said questionnaire consists of 7 questions collecting information on the time consumed daily in vigorous, moderate and walking activities as well as the time consumed sitting at rest over a seven day period. The daily physical activity was assessed in MET (MET is a unit that represents the energy spent sitting at rest. 1 MET=3.5 nil 02/kg body weight/minute,

which is the oxygen consumed sitting at rest), as per the official protocol of IPAQ Being. Three classification categories of physical activity were built based on the values: a) low physical activity, b) moderate physical activity, c) high physical activity.

For the assessment of burnout, the Maslach Burnout Inventory was used, which has been adapted to facilitate the Greek population (Kantas & Vassilaki, 1997). The questionnaire consists of 22 questions that measure three characteristic burnout dimensions: a) emotional burnout (9 questions), b) depersonalisation (5 questions), c) lack of personal accomplishments (8 questions). The answers given by the respondent are based on a seven-point scale: 0 – never, 1 – a few times annually or less 2 – once a month or less, 3 – a few times a month, 4 – once a week, 5 – a few times a week and 6 – every day. The level of burnout is high when we observe high values in the scales of emotional exhaustion and depersonalisation and low values in the scale of personal accomplishments. On the contrary, the level of burnout is low when we have low values on the scales of emotional exhaustion and depersonalisation and high values on the scales of personal accomplishments (Maslach & Jackson, 1986).

Statistical Analyses

Data analysis was run using the statistical package SPSS 17.0 for Windows. The internal consistency of tests and measures was assessed by using Cronbach's alpha reliability coefficient. Mean and standard deviation and/or medians were used for describing the quantitative variables. Absolute values (N) and relative frequencies (%) were used to describe the qualitative variables. To test the relationship between the three variables of burnout (personal accomplishments, depersonalisation, and emotional exhaustion) the Pearson (r) correlation coefficient was used. Correlation is considered low when the correlation coefficient (r) is between 0.1 and 0.3, moderate when the correlation coefficient is between 0.31 and 0.5 and high when the coefficient is higher than 0.5. Also, in order to examine whether there were differencesin factors between burnout (dependent variable) and the level of physical activity (independent variable) a two-way MANOVA was performed (multivariate analysis of variance), and to test differences between the groups, Scheffe's post hoc test was carried out. The significance level was set to $p<0.05$.

Results

Taking into account the results of the conducted research, the majority of participants (74.6%) were women (N=355) and 25.4% were men (N=121). The ages of the participants ranged from 22 to 60 years. 50.5% were married, 36.3% were single and 13.2% were divorced. 58% of the total sample indicated that they were parents.

As regards the educational level of the employees, most, 51%, were higher technological school graduates (N=245), 39% (N=185) were secondary school graduates, whilst university graduates were a mere 10% (N=46). The percentage of participants holding postgraduate degrees (both university graduates and higher technological school graduates) was only 15.5% (N=74).

The internal consistency of the burnout questionnnaire's factors was tested using Cronbach's alpha coefficient. The results showed that most variables had a high level of internal consistency. The reliability of the internal consistency of the questionnaire on burnout for the factor of emotional exhaustion for the nine questions, was determined to be a=0.86, for the factor of depersonalisation for the five questions it was a=0.80 and for the factor of personal accomplishments for the eight questions, it was determined to be a=0.80.

It was shown, as indicated by the research results, that emergency room nurses display a high level of burnout. The mean of the factor emotional exhaustion is equal to 29.5, the mean of the factor depersonalisation is equal to 13.5, whilst the mean of the factor personal accomplishments, is equal to 28.7 (Table1).

Table 1. Mean, standard deviation of burnout factors.

Factors	(Mean±SD)
Emotional exhaustion	29.5±12.3
Depersonalisation	13.5±7.8
Personal accomplishments	28.7±11.4

Table 2 indicates the participants' level of physical activity, which was divided into three categories (1 = low activity, 2 = moderate activity and 3 = high activity). Analysing the levels of physical activity, it was determined that 44.5% of nurses displayed a low level of physical activity, 33.4% displayed a moderate level of physical activity and 22.1% displayed high activity.

Table 2. Level of Participants' Physical Activity.

Level of activity	N	%
Low activity	212	44.5%
Moderate activity	159	33.4%
High activity	105	22.1%
Total	476	100%

To analyse the variance between burnout factors and physical activity, the Multivariate Analysis of Variance (MANOVA) technique was performed. The purpose of this research, was to examine the research hypothesis regarding the parallel effect of the level of physical activity on burnout dimensions.

This particular analysis is used to study the affect of two or more categorical variables, which in this case will be referred to as factors, on a multitude of quantitative variables. Categorical variables are to be understood as independent variables and quantitative variables are to be understood as dependent ones. The

categorical-independent variable in this specific study is physical activity in three levels (1=low physical activity, 2=moderate physical activity and 3=high physical activity), whilst the dependent variables are the scales of the questionnaires on burnout.

The results of this testing are presented in Table 3 and it was shown, that in all cases, when testing the variables independently, physical activity was a statistically significant factor as regards differences in means. In fact, the significance in all cases was quite high ($p<0.001$). Based on the above, we observe that the level of physical activity effects the factors of burnout. Nurses with a low level of physical activity had higher scores on the variables of burnout, and lower scores on the variables of quality of life, than their co-workers who had a moderate to high level of physical activity.

Table 3. The Effects of Physical Activity on Burnout and Quality of Life.

Physical activity		N	Mean	(±SD)	F(2,473)	P
Emotion exhaustion	Low	212	35.98	11.35	77.50	0.000
	Moderate	159	26.49	10.28		
	High	105	21.07	10.04		
Personal accomplishments	Low	212	24.14	12.21	35.70	0.000
	Moderate	159	31.68	9.63		
	High	105	33.46	8.90		
Depersonalisation	Low	212	16.84	7.60	47.80	0.000
	Moderate	159	12.13	7.06		

The last part of the analysis examines the relationship between the dimensions of burnout using the Pearson Correlation Coefficient. The results in Table 4 show a significant moderate and negative correlation between the participants' personal accomplishments and both emotional exhaustion ($r=-0.446$, $p<0.001$) and depersonalisation ($r=0.541$, $p<0.001$), i.e. the higher the emotional exhaustion or depersonalisation of research participants, the less personal accomplishments are mentioned by them. On the contrary, there was a significant high and positive correlation between emotional exhaustion and the participants' depersonalisation ($r=0.726$, $p<0.001$). This result shows that the higher the participants' emotional exhaustion, the higher the possibility of depersonalisation being mentioned.

Table 4. Pearson Correlation between dimensions of burnout.

	Depersonalisation	Emotional exhaustion	Personal accomplishments
Depersonalisation	1		
Emotional exhaustion	0.726***	1	
Personal accomplishments	-0.541***	-0.446***	1

*p-level=0.05 **p-level=0.01 ***p-level=0.001

Discussion

What we tried to record in this research, was the degree of burnout that emergency room nurses, both male and female, experience, and the benefits that a body activation model provides. It should however be notedthat the results of this research were based on data collected from a specific number of participants and not from the total number of nurses working in all the Health Regions throughout Greece.

As shown by data analysis, physical activity levels of emergency room nurses are not satisfactory – 44.5% of the sample displayed low physical activity and only 22.1% displayed a high one. These findings, are similar to those of the general Greek population but also to those of healthcare profession groups in Greece (Gerovasili, Agaku, Vardavas, & Filippidis, 2015).

A current research conducted in the United Kingdom by Blake, Narayanasamy, Batt & Khunti (2019), reached the same conclusions. 1.452 hospital workers including many nurses working in the National Health System (NHS) participated in the research. 45% of nurses did not meet the guidelines of the recent WHO protocols that recommended 30 minutes of moderate daily physical activity. Reasons mentioned for not taking part in physical activity programmes, were fatigue, non-existent free time as well as incentives. Also other factors causing them to refrain from exercising were lack of time, a feeling of tiredness, lack of incentive, working shifts and animosity at the workplace.

Specifically, in this research, the testing of the first statistical hypothesis, was to determine whether emergency room nurses, both male and female, developed burnout syndrome. It was ascertained that healthcare professionals displayed high burnout levels having a high score on the factors of emotional exhaustion and depersonalisation and low scores on the factor of personal accomplishments.

The results of this research coincide with the research of Portero et al. (2020), indicating that 56% of emergency room nurses experience burnout. Some causes leading to this is a very demanding job, an increased workload plus an emergency room packed with people causing confusion and frustration. However, in a study where 30 emergency room nurses participated, a manual of cultural change was introduced with specific interventions in the workplace, based on bibliographical suggestions. The subject matter of the manual was the fundamental acknowledgement of the employees and their participation in decision-making and leadership. Measurements of burnout were taken before and after the interventions, and results showed that the prevalence of burnout was significantly decreased (Adams, Hollingsworth, & Osman, 2019).

Furthermore, in this research, the statistical hypothesis, was tested, as to the degree to which the indiators of burnout differ when correlated to the level of physical activity.

Analysing the results, it was found that nurses with a high and moderate physical activity level display lower levels of burnout and score higher on the factor of quality of life, compared to nurses with low activity levels. Thusly, we confirm the hypothesis that the level of burnout and the quality of life of emergency room nurses, both male and female, differ when correlated to the level of physical activity.

The protective role that physical activity may have on the symptoms of burnout are also supported in the Peterson et al. (2008), research. On the other hand, the research of Papadimitriou et al. (2008), did not deem the correlation between physical activity and burnout to be statistically significant. It appears that exercise alone cannot alleviate the symptoms of burnout, but that in addition, a number of other preventive and coping strategies are also required to manage this multifaceted problem. Nevertheless, in Bährer's (2018), research, good eating habits and exercise combined with necessary rest, can build up the condition of the human body and prevent both the appearance and the evolution of burnout. These measures can, each in its own special way, perceivably lower the levels of stress build-up, that would lead nurses to experiencing chronic stress and burnout.

In conclusion, burnout is a serious problem in contemporary workplaces, in an era where public health is under the microscope of both society and the state. Public health cannot afford to be dysfunctional, ineffective or anunreliable tool of a modern state that continuously expects higher levels of attainment (Maslach & Leiter 1999).

Nurse burnout in the healthcare sector impacts work performance. The degradation of the quality of services directly impacts their physical and mental well-being. In particular, the last two years, due to the emergence of the SARS-CoV-2 pandemic, emergency room nurses are in the front line of healthcare services, working intensively under unprecedented clinical pressure due the increasing cases of Covid-19. Thus the early recognition of burnout syndrome, contributes to better professional behaviour and to the provision of high quality nursing care to patients.

Healthcare professionals, should engage in activities that provide psychological detachment from work, require no effort, and are harmonised with the latest protocols of therapeutic exercise. Physical activity can also be applied within the hospital premises, under the condition that appropriate structures, ensuring a better and more supportive environment, be put in place. This will result in professionals providing improved healthcare services (Manomenidis, Panagopoulou, & Montgomery, 2016).

Limitations

The sample size of the research was adequate for generalisation of the results as regards the population under study. However, generalising the results of the nurses as a whole, regardless of their level of education (University graduates, Higher technological school graduates, secondary school graduates) should be avoided. Moreover, even though the questionnaires were anonymous, it's impossible to verify the honesty of the answers of research participants. Therefore, future studies with a larger sample size are needed to confirm the results of this study. Nursing and Physical Education are scienceswhose main goal is to help individuals adapt to physical activity, extending advice and providing information on the benefits and potential dangers. Thus, within the framework of disease prevention, health maintenance and health promotion by exercising correctly and side stepping possible harmful exercises, individuals will indubitably experience an enhancement of their physical and mental well-being in their everyday life.

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Conflict of interest
The authors declare that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

Relationship between Match Running Performance and Physical Capacity in Malaysia Young Soccer Players

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Abstract

Monitoring players during match play has become a fundamental approach to gain understanding on soccer demands. Considering there has been growing interest in performances of young players, it is important to understand on young players training requirement. Therefore, the aim of this study was to examine the relationship between match running performance and physical capacities in U15 young soccer players. Twenty outfield players from sports school and academy (n=20, 1.63±0.8 m, and 56.1±9.5 kg) volunteered to participate in the study. Match running performance was analysed during two matches for each player using 5 Hz global positioning system. The participants performed the Yo-Yo Intermittent Recovery Level 1 (YYIR1), Countermovement Jump (CMJ) and 20 m Sprint to determine the physical capacities. The results showed there were no significant relationship between; total distance covered and YY1R1, sprint distance and leg power, maximum sprint speed during matches ($km.h^{-1}$) with 20 m sprint ($P>0.05$). These results suggest that physical capacity test should not be used as a single factor in recognizing a young player's potential to excel and to predict soccer performance. Young players may not need extraordinary capacity; however, they must possess a reasonably high level within all areas to be a good player.

Keywords: *GPS, football, adolescents, motion analysis, fitness*

Introduction

The overwhelming popularity of soccer has generated more attention on young soccer players compared with other youth team sports (Atan & Kassim, 2020). In recent years, millions of young soccer players have enrolled within development programs of soccer clubs (Goto & Saward, 2020). Various developmental programs can be found in many countries, some being quite extensive, with the number of clubs increasing and beginning to invest in the recruitment of young football players to facilitate their own team development (Wrigley, Drust, Stratton, Atkinson, & Gregson, 2014). There are several factors that have encouraged coaches and parents to invest in soccer development programs; general popularity, competitiveness and future career prospects are the most common (Atan & Kassim, 2019). Consequently, participation amongst young players is booming globally. Breaking down the numbers, 22 million players are recognised as youth players where 18.7 million are male players and 2.9 million are female players (Atan & Kassim, 2019).

Today, match analysis has become a predominant tool to gain substantial information on players' performance. It could provide information on the physiological and physical demands through noting the distance covered, time spent in each match activity, differences seen between the first and second half's or physical capacities irrespective of playing positions and fluctuations in exercise intensity (Atan, Foskett, & Ali, 2016). The general consensus is that adult soccer players with moderate ability cover distances between 8 to 12 km while elite players have been reported to cover between 9 to 14 km (Atan & Kassim, 2019). Previous studies have discussed the

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relationship between physical capacity and soccer match performances involving adults. These have shown relatively good correlations between aerobic capacity and distance covered, competitive ranking, quality of play, ability to maintain high intensity activity, number of touches of the ball in the match, maintaining physical condition at an optimum level during a match and ways to accelerate recovery processes (Bradley et al., 2013; Slimani, Bragazzi, & Miarka, 2018; Aquino et al., 2020).

Surprisingly, only a small number of studies have examined children and adolescents on match performance and physical capacity (Bellistri, Marzorati, Sodero, & Sforza, 2017; Impellizzeri et al., 2008). It is important to highlight these young soccer players possess unique characteristics and will undergo several challenges as they passage through distinct phases of physical growth and development (Atan & Kassim 2019; Hannon, 2020). It is evident that the term 'youth' is a transition period between childhood and adulthood age, also known as a stage of development characterized by physiological changes in the substrate utilization, aerobic and anaerobic capacity, musculoskeletal, cardiorespiratory and thermoregulatory systems of the body (Atan and Kassim, 2019). Therefore, the abilities and characteristics in comparison to adults are very different.

An understanding of the different adaptations during these different growth stages will help coaches or trainers to tailor age specific training that will aid in the optimal performance of these young players (Atan, Foskett, & Ali, 2016; Atan & Kassim, 2020). Laboratory and field test have been widely used to examine young players especially during talent identification process as predictors of performance that predispose promising players to selection into elite soccer development programmes (Carling, Gall, & Malina, 2011). This information's used to identify individual profiles of their respective strengths and weaknesses. Limited studies have conducted the relationship between match performance and physical capacity in young players especially in Asia Region. Therefore, the aim of this study was to examine the relationship between running match performance with Yo-Yo intermittent Recovery Test Level 1 (YYIR1), Countermovement Jump (CMJ) and 20 m sprint in U15 age-group soccer players.

Methods

Participants

Twenty young soccer players (n=20, Height: 1.57±0.8 m and body mass 57.1±4.5 kg) volunteered to participate. All participants were aged 15 years old based upon their chronological age. The sample size and the statistical power was calculated using the GPower software (Prajapati, Dunne, & Armstrong, 2010). With an alpha=.05 and power=0.80, GPower displays a proposed sample size of n=20 to detect this level of effect size (ES=0.5). This will be adequate for the main objective of this study. The inclusion criteria were outfield players only, currently active in soccer training and competitive in local and international tournament, free from injury and healthy. All participants provided assent and their parents gave their written informed consent. The research was conducted in accordance with the Declaration of Helsinki, and approved by the local institutional ethics committee.

Procedures

Data were collected during the competitive season and took place on natural grass pitches. Anthropometric measurements (height and weight) and field tests were performed on separate occasions to match analysis. Testing took place in the week before the match analysis was conducted and replaced the normal team training sessions. The tests include YYIR1, CMJ and 20 m Sprint. The participants were familiarised with the procedures and wearing running vest for GPS before the testing.

Testing

After a 10 min warm up, the participants performed the testing to measure their physical capacity. To measure the aerobic fitness, the participants performed the YYIR1. In YYIR1, participants repeated 2 x 20-m shuttle runs back and forth between the start and finish line at progressively increasing speed, controlled by audio bleeps from a MP3 player. The test was terminated when the participants failed to reach the starting line twice or unable to complete another shuttle at the dictated speed (Krustrup et al., 2003). Then, participants performed a CMJ using a timing mat (Just Jump System, 7610, Perform Better, USA) to measure the leg power. Participants stood on a mat in an upright standing position and squats down to the 90-degree leg bend position before immediately jumping vertically (see appendix). Jump height is measured which calculates flight height. Highest of all three jumps performed were recorded as maximum jump height. For speed, 20-m Sprint was administered, all participants completed three 20-m maximal sprints. Participants were fitted with the 5-Hz GPS (GPSports) units allowing a maximum sprint speed to be obtained for each individual.

Match Analysis

Each player was analyzed during four competitive matches. Before each game, participants donned the GPS units between their shoulder blades in a custom-made tight-fitting vest. All data were downloaded into the manufacturer's proprietary software (Team AMS; GPSports Systems). This software permits the quantification of total distance (TD) covered, frequency, duration, and distance in each match activity. The TD covered during the match was calculated as the sum of the distance covered during each type of activity. Match speed threshold were set based on Atan, Foskett and Ali (2016) and categorized into Standing, Walking, Low Intensity Running (LIR), Medium Intensity Running (MIR), High Intensity Running (HIR) and Sprinting All games were played in agreement with the rules outlined by the Fédération Internationale de Football Association (FIFA). The participants played 11-a-side games, on a full-sized pitch (60x100 m), in a 2x40-minute match.

Statistical Analyses

Results are presented as mean±SD. The assumptions and normality of the data were verified by the Shapiro-Wilks test. Relationship between physical capacity and match running performance was measured by using The Pearson's correlation coefficients (r). The magnitude for correlation coefficients were set between 0 and 1, where 1: perfect reliability, ≥0.9: excellent reliability, ≥0.8<0.9: good reliability, ≥0.7<0.8: acceptable reliability, ≥0.6<0.7: questionable reliability, ≥0.5<0.6: poor reliability,<0.5: unacceptable reliability and 0: no reliability. All statistical analyses were performed with SPSS software (version 21.0; SPSS, Inc., Chicago, IL, USA) with the level of significance set at $p<0.05$.

Results

Physical Capacities

The mean YYIR1 distance covered by participants was

1,376±308 m with the average speed level being 16.8±0.9. The participants estimated maximum oxygen uptake value ($\dot{V}O_{2max}$) from the YYIR1 was 47.9±2.59 (ml.kg.min-1) (VO_{2max}=distance in meterx0.0084+36.4, from Bangsbo, Iaia, and Krustrup 2008). For the CMJ, the results showed the participants leg power was 46.0±5.2 cm and maximum speed recorded was 25.6±1.93 km.h-1.

Total Distance in Absolute Value (m)

Figure 1 shows distance covered for each age group in terms of absolute values. The mean playing time for the participants was 69.6±12 min with the minimum time exposure being 40 min. The TD covered in absolute values was 6,981.8±1,333 m with the most distance covered in MIR being 2,280.3±795.1 and in LIR, 2,146.6±502.4m followed by walking, 1,659.0±349.3 m. Less distance was covered in HIR, i.e. 574.0±157.9 m and sprinting, 318.0±134.3 and inactivity or standing was 5.0±1.5 m. The average sprint distance was 16.6±2.9 m and they performed about 18.9±5.8 average number of sprints (NOS). It was observed that the NOS performed during the first half of the game was 10.5±4.1 compared to the second half of the game where it was 8.9±3.6. The match HRmax data recorded was 204.6±11.2 bpm.

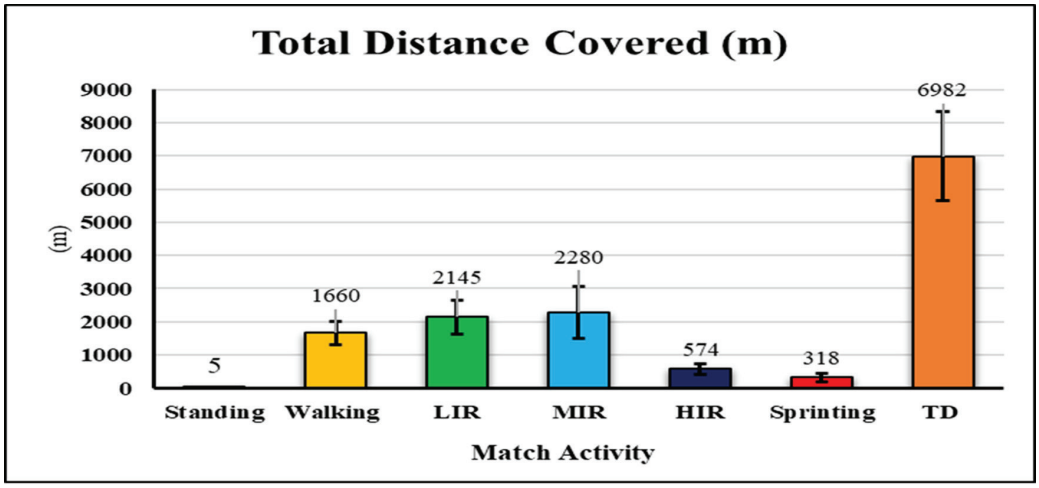

FIGURE 1. Mean (± SD) total distance covered in absolute values for each match activity in U15 soccer matches.

Match Running Performance and YYIR1

There is a weak relationship though not statistically significant between TD in YYIR1 with TD during match play (r=.115, n=20, P=.640), LIR (r=.088, n=20, P=.721), MIR (r=.076, n=20, P=.758) and HIR (r=.216, n=20, P=0.375). There was a negative correlation with sprinting (r=-.135, n=20, P=0.581) (see Figure 2). Overall, the p value was greater than the significance level (α=0.05). As such, it can be concluded that there was no significant linear correlation between TD in YYIR1 and TD in match activities. There was no correlation between the sprint distance in match and leg power (r=-.383, n=20, P=096) and maximum sprint speed in match to 20-m sprint (r =.161, n=20, P=.499).

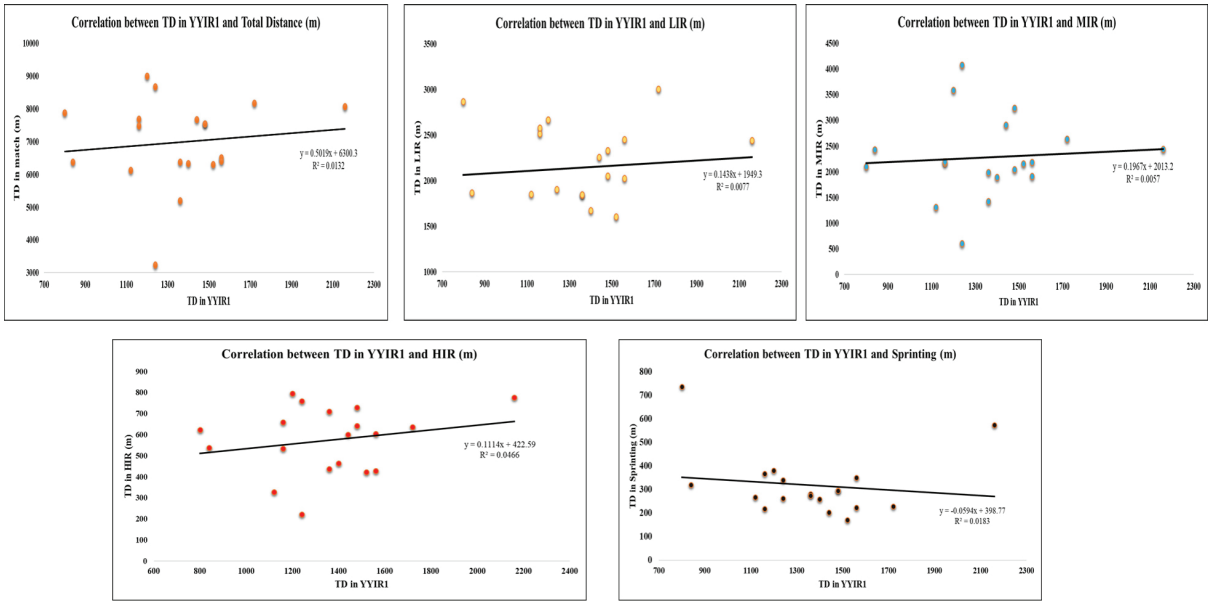

FIGURE 2. Correlation between total distance in YYIR1 and match activities in U15 match play.

Discussion

The aim of this study was to examine the relationship between physical match performance with YYIR1, CMJ and 20 m sprint in U15 age-group soccer players. The main findings from this study is there is no relationships found between the physical capacity and match running performance.

The commonest reported for match analysis is the TD covered. The data reported in this present study showed that the research participants covered about 6.9 km, indicating fairly similar distances to the absolute values of the TD that has reported as having been covered by other U15 players in different parts of the world. For instance, in Brazil, U15 soccer who played in the Sao Paulo First Division League covered about 6.9 km (Aquino et. al., 2018), English Premier League Academy players covered about 6.0 6.7 km (Harley et al., 2010; Goto, Morris, & Nevill, 2015) and in English Clubs, they covered 6.9 km (Abt & Lovell, 2009). Meanwhile in the Portuguese Football League, players covered about 6.3 km and in the New Zealand, Auckland Football Federation Metropolitan League, players covered about 6.6 km (Rebelo et al., 2012; Atan, Foskett, & Ali 2016). Nevertheless, it was typical to see variations in playing time in youth soccer matches due to the use of the rolling substitution policy (Lovell et al., 2009; Harley et al., 2010; Atan, Foskett, & Ali 2016). Therefore, it is recommended to use the relative TD (m.min-1) to make comparisons between studies without bias.

Previous studies have investigated the relationship between match running performance and physical capacities. The most prominent one is the relationship between VO_{2max} value and TD on the soccer match play. It is known that VO_{2max} is a very important variable of the match performance among soccer players because the vast majority of a game is performed utilising aerobic metabolism. There is some evidence regarding the benefits of the relationship between aerobic capacity and performance in young athletes. One study found a significant correlation between improvement in aerobic capacity and passing ability in young soccer players (n=26, Height 1.78±5 m, weight 74.5±6.9 kg) (Impellizzeri et al., 2008). Similarly, the findings from the study by Sawczyn et al. (2018) on artistic gymnastic athletes (Age 16.1±0.4 years, Height 1.68±1.5 m, Weight 61±1.1 kg) indicated that the greater the aerobic capacity among these athletes, the less likely the development of coordination fatigue. This finding can be attributed to lower cerebral hypoxia and less central fatigue when performing a gymnastics routine. Moreover, Tota et al. (2015) reported that running economy also improved with an improvement in VO_{2max} in thirty-five (n=35, 15 to 17 yrs. old) track middle and long-distance runners. In contrast, a small correlation was reported between the TD of running in match-play with incremental testing and YYIR1 (r=0.41). A similar trend was also observed where there was no significant correlation with the majority of field tests and match performance (e.g., zig-zag test, sprint test) (Aquino et al., 2018). In this present study, we found a similar result where there was a weak relationship between YYIR1 with TD covered and distance in each match running intensities.

Taking into account, coaches or sports practitioners should adopt an appropriate training plan that would adequately stress the cardiorespiratory system in soccer players to induce adaptation, with due respect to the players age, competitive level and period in the season. Even though the aerobic capacity in young players is lower than that of adults, it will increase significantly with the advancement of age and/or towards the end of the physical maturation stage (Slimani et al., 2018). Following physical maturation becomes more reliant on training effects. It has also been suggested that young players may not need to have an extraordinary capacity relative to adults within any of the areas of physical performances, but must possess a reasonably high level within all areas to be a good player (Reilly, Williams, Nevill, & Franks, 2010).

Furthermore, our findings found there was no correlation between the sprint distance in the match and leg power and maximum sprint speed in match to 20-m sprint. In contrast to adult's studies, there was a significant correlation between peak speed during the field test to the high intensity activities and match running performance. In this study, they also highlight the anaerobic activity is also dependant to aerobic capacity (Rampinini et al., 2007). Therefore, it is suggested to use test a specific test battery that replicates the specific demands of soccer. Soccer is characterised by multiple explosive high intensity bursts of activity over a prolonged game duration. Considering that aerobic capacity is the prerequisite to anaerobic capacity performance, it has been suggested to use anaerobic testing procedures that replicates the specific demands in the intermittent nature of football, for instance using a soccer simulation protocol designed specifically for the young soccer players (Atan & Kassim, 2020). Using a specific battery of tests has become very common in investigating athletes in different types of sports; ranging from combat to team sports (Brito et al., 2017; Courel-Ibnez & Franchini, 2018; Mancha-Triguero, Garc, & Ant, 2020) but not when investigating their anaerobic capacity. More recently, Mancha-Triguero et al. (2020) used a Specific Battery Fitness Test (SBAFIT) for basketball that includes accelerations and shots to investigate the aerobic and anaerobic capacities in young basketball players. For that reason, a specific performance test that induces physical fatigue is highly recommended as a measure of the anaerobic capacity in football players.

In addition, anaerobic capacity seems to be less developed in youths compared to adults since anaerobic power in young players is 50%, therefore this may also explain the low correlation between the physical capacity and match performance. Even so, anaerobic capacity will progressively improve as their age advances for which the main contributor is their anthropometric maturation (Mancha-Triguero et al., 2020) and after peak height velocity is achieved (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004). In addition, even though young athletes work mainly in aerobic mode, but under the influence of training, their body can adapt to an anaerobic mode, which begins to accumulate larger amounts of glycogen to be used in high intensity activities and better able to tolerate higher lactate concentrations (Hadzhiev & Dzimbova, 2020).

This present finding contributes to understanding of a young soccer player's performances. Young players should not be considered as little adults and there are few factors that may contribute to soccer performances. Compared to adults, young players possess unique characteristics associated with their physiological growth and development (Hannon et al., 2020). The most prominent difference found is the wide spread of biological age and variations in the development stages (Hill, Scott, Mcgee, Cumming, & Hill, 2020). With regards to youth football match play formats, players are always categorised based on their chronological age and not based on their maturity levels (Harley et al., 2010; Ballesta, Ramon, & Cruz, 2015; Atan, Foskett, & Ali, 2016; Goto & Saward, 2020).

In conclusion, physical capacity test should not be used as a single factor in recognizing a young player's potential to

excel and to predict soccer performance. Young players may not need extraordinary capacity; however, they must possess a reasonably high level within all areas to be a good player. Future studies could might address the differences capacity in positional, using a soccer specific testing that develops for young players to investigate their physical capacity and have a greater number of participants to investigate the young players.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Morphological Characteristics and Body Mass Status of School Girls according to Different Regional Zones

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Abstract

There are many factors that have an influence on obesity therefore, early regular monitoring of morphological characteristics and nutritional status of children is the best prevention method. This study aimed to examine the influence of two regional zones in Montenegro on morphological differences and the nutritional status of school girls. The sample of respondents was selected from several different primary schools. The sample was divided by regions (Vlada Crne Gore, 2011) into two groups, girls from the Central region (n-55, 10.21±.72 years), and the Coastal region (n-42, 10.33±.59 years). Morphological characteristics were assessed using a battery of four variables: body height (BH), body weight (BW), waist circumference (WC), and hip circumference (HC). BMI and waist-to-hip ratio (WHR) values were calculated. We used WHO cutoff points for the assessment of the children's nutrition status. For determining differences between children living in different regions we used a T-test for independent samples. 27.27% of girls from the Central region are obese compared to 23.81% of obese in the Coastal region. When comparing groups by regional regions, it is noticeable that there is no significant difference in morphological characteristics and body mass index. Although there is no difference in the morphological characteristics between girls of the Central and Coastal regions, for more detailed conclusions, a larger number of morphological parameters should be monitored on a larger sample of respondents.

Keywords: *anthropometrics characteristics, body mass index, level of nutrition, school girls, regional zones*

Introduction

Today's children are increasingly inactive, spending as much as half of their waking hours in a sedentary position (Colley et al., 2013). Such a sedentary lifestyle with poor nutrition can lead to obesity in children.

Childhood obesity is a hidden epidemic and is currently one of the major public health problems (Kumar & Kaufman, 2018). Childhood obesity is associated with various health problems such as diabetes, asthma, hypertension, atherosclerosis, and psychosocial disorders (Dikanovic & Vignjevic, 2009). In addition, obese (OB) children have weaker motor skills (Barnett et al., 2016; Banjevic, Aleksic, Aleksic Veljkovic, Katanic, & Masanovic, 2022) and lower levels of physical activity (PA) than healthy-weight (HW) children (Elmesmari, Martin, Reilly, & Paton, 2018). Nowadays, almost one-third (31%) of children in the world have body weight above healthy levels, which is quite alarming (Spiotta & Luma, 2008). According to World Health Organization (WHO), the prevalence of overweight (OV) and obesity has increased from 4% (1975) to over 18% (2016), and it is estimated that there are over 340 million obese children and adolescents aged 5 to 19 years today (World Health Organization, 2018). In response

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to this alarming situation, the WHO adopted the Global Strategy on Diet, Physical Activity, and Health (World Health Organization, 2021).

Child nutrition is assessed by anthropometric measurements (Zdravković, Banićević, & Petrović, 2009). Morphological and nutritional status are important predictors of health status throughout life (Park, Falconer, Wiener, & Kinra, 2012; Pokos, Lauš, & Badrov, 2014), and therefore monitoring morphological and nutritional status in school-aged children is of multiple benefits (Vasiljević, Bjelica, & Gardašević, 2018; Veljković, Katanić, & Ilić, 2020; Katanić, Veljković, Prvulović, Banjević, & Tomić, 2022). Special attention should be paid to monitoring the development of children's morphological characteristics in order to determine the progress of the measured characteristics, but also the individual progress of each child (Ugrinić et al., 2019).

It is known that in addition to endogenous (internal) factors, exogenous (external) factors such as geographical, climatic, social, health, and physical factors influence the occurrence of obesity (Đurašković, 2002). Accordingly, some domestic researchers have tried to investigate whether there are regional differences in the morphological and nutritional status of children in Montenegro (Banjević, 2019; Zovko, Mitrović, and Ćorluka, 2020; Bjelica et al., 2021; Katanic et al., 2021). Considering that there is limited research on this topic and the data are variable, we wanted to investigate the current situation in more detail. Therefore, the aim of this study was to determine the differences in the morphological and nutritional status of school children in different regions of Montenegro. In this regard, it will be possible to provide guidelines for the practice of sports and physical activities.

Methods

Sample of respondents

A total of 97 girls of sixth grade participated in this transversal study. The sample was divided by regions (Vlada Crne Gore, 2011) into two groups, girls from the Central (n-55, 10.21±.72 years), and the Coastal region (n-42, 10.33±.59 years). Students are voluntary and with parental consent participated in the research process, also this research was carried out following the Helsinki Declaration.

Measurements

The standard international biological procedure was used to determine morphological characteristics (Eston & Reilly, 2013). Morphological characteristics were assessed using a battery of four variables: body height (BH), body weight (BW), waist circumference (WC), and hip circumference (HC). An anthropometer, caliper, and measuring tape were used for morphological measurements. To evaluate the body weight, Tanita's body fat scale - model BC-418MA, was used. BMI and waist-to-hip ratio (WHR) values were calculated according to standard formulas. The body mass index was calculated based on the standard formula: BMI = BM (kg)/BH (m)2 (BM—body mass, BH—body height). WHR was calculated by dividing WC (in cm) by hip circumference (cm). The body mass index has a high correlation with the amount of body fat and for these reasons is used as an indicator of nutritional levels in children (Wilmore, Costill, & Kenney, 2008). We used WHO cutoff points for the assessment of the children's nutrition status (Onis et al., 2007).

Statistics

Basic parameters of descriptive statistics were calculated: arithmetic mean, standard deviation, and percentages. To determine differences in morphological characteristics groups, a t-test for small independent samples was used. For all statistical analyses, significance was accepted at $p<0.05$. Data processing was performed using the statistical program SPSS 26 (Statistical Package for Social Sciences, v26.0, SPSS Inc., Chicago, IL, USA).

Results

Table 1 shows that in the Central group, there are 58.1% normally nourished, 14.6% malnourished, and 27.3 obese, while in the Coastal region, 54.8% are normally nourished, 21.4% malnourished and 23.8% obese.

Table 1. Nutritional level for children expressed numerically and as a percentage by region.

	Central group n (%)	Coastal group n (%)	Total n (%)
Malnourished	8 (14.55)	9 (21.43)	17 (17.53)
Normal	32 (58.18)	23 (54.76)	55 (56.70)
Obese	15 (27.27)	10 (23.81)	25 (25.77)
Total	55	42	97

In Table 2, there is no significant difference between the girls of the central and southern regions in any variable of morphological characteristics and BMI (body height, body weight, waist circumference, hip circumference, waist-to-hip ratio, BMI).

Table 2. T-test for differences in morphological characteristics between groups.

	Central group Mean±SD	Coastal group Mean±SD	t	p
Body height	145.41±8.02	146.59±7.87	-.721	.473
Body weight	38.19±7.69	39.08±9.02	-.522	.603
Waist Circumference	65.49±7.22	64.87±7.97	.398	.692
Hip Circumference	78.51±7.09	78.42±8.73	.055	.422
Waist-to-Hip Ratio	.84±.85	.83±.55	.519	.251
BMI	17.99±3.00	18.04±3.13	-.85	.933

Legend: Mean = Arithmetic mean; SD = Standard deviation; t = t-test value; p = Statistical significance.

Discussion

This study aimed to examine the influence of two regional zones in Montenegro on morphological differences and the nutritional status of school girls. The sample was divided by regions into two groups, girls from the Central region (n-55, 10.21±.72 years), and the Coastal region (n-42, 10.33±.59 years). 27.27% of girls from the Central region are obese compared to 23.81% of obese in the Coastal region. When comparing groups by regional zones, it is noticeable that there is no significant difference in morphological characteristics and body mass index.

There are papers on this topic, but when it comes to comparing the results of this study, they should be compared to the results of other studies that included a similar sample of subjects. And such studies are not many.

The results of girls in the central region approximately correspond to the average values of obese children (27.3%) from previous studies (Đorić & Vukićević, 2020; Bjelica et al., 2021; Katanic et al., 2021), while the Coastal group had slightly lower values (23.8). Certainly, the percentage of obese children in both groups of our study was much lower than in the study conducted in Serbia on a large sample of ten-year-old children (n-344), where even 42% of the respondents were overweight (Stamenković, Danković, Stanković, Stojanović, & Paunović, 2020).

When analyzing the morphological parameters, it is noticeable that the height of our subjects corresponds to the height of the subjects from the study (Đorić & Vukićević, 2020), and is slightly lower compared to children from recent studies (Bjelica et al., 2021; Katanić et al., 2021). In contrast, higher values were obtained than in children one year younger (Vasiljević, Bjelica, & Gardašević, 2018). When body weight is observed, it is in line with previous children of that age (Vasiljević et al., 2018; Đorić & Vukićević, 2020; Bjelica et al., 2021; Katanić et al., 2021). Also, BMI approximately corresponds to the values of children from previous studies (Vasiljević et al., 2018; Đorić & Vukićević, 2020; Bjelica et al., 2021; Katanić et al., 2021). When it comes to the average values of hip and waist circumference in our research, they approximately correspond to the values in other studies (Đorić & Vukićević, 2020; Bjelica et al., 2021; Katanić et al., 2021). In general, it was indicated that the anthropometric values of our respondents are in accordance with the values of children from these areas.

However, it should be emphasized that there was no significant difference between the groups of children from the central and coastal regions in any morphological parameter. In the previous research (Bjelica et al., 2021) it was shown that children from Coastal had higher values in body mass and BMI, which was not the case in this research.

The obtained results indicate that every 4th-grade school child is overweight. Data variations also exist in relation to different EU countries, so the prevalence of obesity varies from 13% in Finland, 16% in the Czech Republic, 33% in Greece, to 36% in Italy (Cali & Caprio, 2008). So, it is clear that the prevalence of obesity in the world is constantly increasing in the last 2-3 decades (Lobstein & Frelut, 2003; World Health Organization, 2021).

Based on the given information, it can be concluded that it is not enough to just point out the problem, it is also necessary to offer a solution. Stankovic, Djordjevic, Hadzovic, Djordjevic, & Katanic (2021) based on a systematic review indicate that physical activities have a positive effect on obesity in children regardless of the age of the respondents. In line with that, other authors point out that physical activity is considered a key factor for healthy psycho-physical development of children (Dencker & Andersen, 2008; Ortega, Ruiz, Castillo, & Sjöström, 2008) and therefore it is necessary to promote children's sports and physical activities. In particular, the recommendations of Rodriguez-Martinez et al. (2020) emphasize that policies and interventions at home, at schools, in the community, and through the health system should be motivated to support the healthy growth and development of children, by improving nutrition and levels of physical activity.

In addition to several limitations that this study has, the main one relates to the narrower system of included morphological variables, as well as to the transversal study. Therefore, the proposal for further research is to carry out the treatment of physical exercise while examining the morphological and nutritional status.

Conclusion

The obtained results indicate that every fourth child is overweight. As well as that there is no difference between the groups of respondents in relation to the regional division. However, due to certain limitations, these results should be taken with a grain of salt. However, this does not diminish the value of this study, which actually indicated the great importance of monitoring certain parameters of growth and development in children of younger school age.

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Conflict of Interest
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

Attitudes towards Doping in Adolescent Athletes

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Abstract

This transversal study assessed the opinions of young athletes in martial arts regarding doping. The study involved 59 young adolescents performing judo and sambo at the Vologda region sport schools of the Russian Federation (average age=11.8±0.61 years old). The diagnostic was performed using a questionnaire. The respondents expressed their degree of agreement with 12 statements regarding the problem of doping and the use of illegal drugs in sports. Responses were assessed based on the 4-point Likert scale, and the sum of the points was interpreted in terms of the level of the value component of the anti-doping culture. This study showed that the respondents understand the importance of the doping problem for the modern international sports movement. However, a significant number of respondents tend to believe that without doping, sports competitions become less spectacular, and victory "at any cost" is still a victory. Our findings are of practical value for selecting content and methods for anti-doping education of young athletes before the beginning of their typical competitive experience.

Keywords: *anti-doping education, young athletes, martial arts, values, axiological approach*

Introduction

As one of the priority issues on the world sports agenda, the problem of doping opens up prospects for research in the field of sports pedagogy (Donzé, 2014). One important part of the multi-component anti-doping strategy is education that should be performed throughout the athlete's sports career and begins as early as possible, preferably before the first competition (Dvorak et al., 2014). Meanwhile, it is known that young athletes participating in international competitions are not often purposefully taught Olympic values, such as fair play and the need to oppose doping (Dervent & Çotuk, 2013).

An expert assessment of a number of anti-doping educational programs has made it possible to establish their positive effects on athlete awareness but also showed their low effectiveness in terms of changing doping behavior, with the exception of certain facts of a limited effect in deterring teenagers from using anabolic steroids. The researchers emphasized that positive trends in athletic awareness do not necessarily lead to an actual decrease in the use of doping (Wippert & Fließer, 2016). Hence, informing athletes about prohibited substances and methods, anti-doping rules, doping consequences, doping control procedures, and the rights and obligations of athletes is not sufficient to prevent doping. Therefore, the goal of anti-doping educational programs should be to create an attitude of intolerance for doping at the value–motivational level (Gretsov & Vorobiev, 2018).

Experts have considered the use of anti-doping educational programs for sports school students as the most promising area of pedagogical work. Sports motivation is a psychological variable that should be considered in anti-doping policies, programs, and interventions aimed at the adolescent population because motivation is linked to doping-related attitudinal variables and partially mediates the effect of achievement goal orientations in this regard (Mudrak, Slepicka, & Slepickova, 2018).

Consequently, this research stems from the contradiction between the growing demand for high-quality anti-doping educational programs and the lack of evidence-based information about adolescent athletes' attitudes towards doping.

Theoretical Framework

In the context of the problem of anti-doping education of young athletes, in this study, we focused on culturological, axiological, and activity approaches as priority methodological research principles. In addition to the significant theoretical pre-

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requisites for the development and implementation of anti-doping educational programs for young athletes, we include the theory of Olympic education and the concept of drug prevention via physical education and sports (Varfolomeeva & Kozyreva, 2018).

Based on the definition of "education", the goal of anti-doping education of young athletes is associated with the formation of an anti-doping culture of an individual, which, in turn, assumes zero tolerance to doping and is viewed as a part of the sports and humanistic culture. It is known that sports and humanistic culture is characterized by positive attitudes of individuals towards sports in terms of such ideals and values of humanism as an integral development of personality and humane social relations (Stolyarov & Barinov, 2009). Several longitudinal studies have revealed an inversely proportional relationship between sports ethical values and the duration of classes, i.e., with an increase in sports experience, respect for the opponent and the principles of a fair fight generally become less important (Shukis et al., 2005). Consequently, the researcher' attention should be focused on the questions of what place doping has in the context of the educational and socializing functions of sports, and, accordingly, how to prevent its negative impact and how to avoid its effects on the lives of young athletes (Shelkov et al., 2014).

Considering the abovementioned information in the framework of this scientific study, the main method used in this research was an axiological approach that allows anti-doping educational programs to focus on prevention and building them based on values.

It has been recognized that adolescence is the age period most perceptive to anti-doping education (Donzé, 2014). Scientific publications also highlight that the psychological roots of this problem can be found in the motivational sphere of athletes and their life values, and adolescence and young adulthood provide considerable potential for building a system of personal values and motivations (Gretsov & Vorobiev, 2018). In addition to the value-bearing potential of the sport itself as a competitive activity, we must underscore the health values in anti-doping education, especially because it is at the beginning of the sport career that doping constitutes the highest health risks for athletes (Henning, 2017).

According to Mudrak et al. (2018), adolescent athletes may be considered particularly vulnerable to the abuse of of performance-enhancing drugs (PEDs). A large-scale international meta-analytic study observed that approximately 3–6.5% of boys and 1–2% of girls reported current or past use of anabolic steroids. Other national surveys have found that, depending on the methodology used, 2.1–11% of adolescents reported past or current use of PEDs (Mudrak, et al., 2018).

Perhaps in certain cases, appeals to the said values will be more effective compared to appeals to ethical norms and values (Henning, 2017). Moreover, adolescent awareness of the health value largely depends on the rhythm of their life and on the system of requirements that they make to themselves (Tsvetkova, 2005).

Considering some similarities in the psychological mechanisms underlying drug use and doping, the existing conceptual models for the prevention of children and adolescent drug addiction in physical culture and sports are to some extent applicable in the field of countering doping among young athletes. In this case, physical education and sports are involved at three levels: as an alternative to "bad habits", as a tool for healthy lifestyle values, and as a method of upbringing and correction of personal qualities (Shelkov & Badrak, 2010).

A survey of adult athletes conducted in Slovenia revealed that often they do not completely trust coaches and doctors on doping issues: they are not convinced of the expert knowledge of their trainers/doctors regarding the problem of doping and/or they do not believe in their good intentions (Kondric et al., 2011). Meanwhile, teenage athletes tend to trust their mentors and are ready to imitate the behavior of their teachers, and this must be taken into account when selecting the content and methods of anti-doping education (Badrak, 2011). According to Nicholls et al. (2020), psychological variables, such as attitudes and susceptibility, also predict doping, as do the people that surround athletes, such as coaches, peers, and parents.

In recent years, scientists have focused on the importance of maintaining anti-doping efforts and the role of socio-cognitive variables in doping attitudes (Mudrak et al., 2018; Filleul et al., 2022). Some studies have been devoted to the attitudes toward doping in young athletes (15-year-olds and older) (Wang et al., 2020; Miskulin et al., 2021). However, similar data regarding younger adolescents are not available in the literature. The aim of this study was to assess attitudes toward doping among adolescent athletes that play individual sports.

Methods

This empirical research was aimed at assessing the opinions of young athletes in martial arts about doping. The survey was conducted remotely due to the COVID-19 prevention measures.

The study was performed using a survey, registration, scaling, and correlation analysis methods. The respondents had to agree or disagree with 12 statements regarding the problem of doping and the use of illegal drugs in sports. The statements were "direct" and "reverse", and the respondents expressed their agreement by choosing one of several options. Responses were assessed based on the 4-point Likert scale (for "direct" statements): 4 points – "definitely yes", 3 points – "yes rather than no", 2 points – "no rather than yes", and 1 points – "definitely no" (for "inverse" statements – vice versa).

Research Design

This study was part of the initiative research project "Formation of younger adolescents' anti-doping culture in the educational space of a sports school". Data were collected in May 2020 through an Internet survey using Google Forms. In total, five sport schools in the Vologda region of the Russian Federation participated in this study. The questionnaires were administered by the research team members. Prior to data collection, the adolescent athletes' coaches and parents were informed of the study. The data collection was voluntary and anonymous. Informed voluntary consent was obtained from the parents of each of the participants included in this study. The study met the standards of the Declaration of Helsinki.

Participants

The study involved 59 younger adolescent [52 (88.1%) boys and 7 (11.9%) girls aged 11–13 (with an average age of 11.8±0.61 years)], who perform judo (59.3%) and sambo (40.7%) at the Vologda region sport schools of the Russian Federation.

Data Collection Instruments

The diagnostic means were determine by a questionnaire compiled by the authors based on the materials of Badrak (2011), Mudrak, Slepicka, & Slepickova (2018), and Wang, Xu, & Zhang (2020).

Data Analysis

Statclass 1.4 based on IBM SPSS Statistics (©Predictive Solutions, Moscow, 2016) was used for data processing. Correlation analysis was performed through a Spearman correlation calculation.

Results

The opinions of the young athletes are shown in Table 1.

Table 1. The opinions of young athletes in martial arts about doping, in %.

Statement	Opinion, in %			
	Definitely yes	Yes rather than no	No rather than yes	Definitely no
Doping is a big problem for the modern international sports movement.	81.4	13.6	5.0	0
The development of international sports contacts does not depend on doping scandals.	6.8	6.8	15.3	71.2
High sports results can be achieved without the use of doping.	84.7	8.5	3.4	3.4
Without doping, sports competitions become less spectacular.	8.5	3.4	16.9	71.2
The use of doping contradicts the principles of "fair play".	89.8	6.8	1.7	1.7
To achieve victory, the use of doping is sometimes permissible.	5.1	18.6	15.3	61.0
"Victory is three times sweeter when obtained in an honest struggle ".	79.7	13.6	3.4	3.3
Victory "at any cost" is also a victory.	15.3	13.6	37.3	33.9
Doping is harmful to an athlete's health.	76.3	16.9	5.1	1.7
Martial arts athletes can use prohibited diuretics for weight loss.	5.1	11.9	22.0	61.0
An athlete himself should decide whether to take a prohibited drug or not.	59.3	20.3	6.8	13.6
If a coach or a team doctor allows the use of illegal drugs, then an athlete should follow his advice.	8.5	10.2	27.1	54.2

Table 1 shows that the respondents understand the importance of the doping problem for the modern international sports movement. The statement that high sports results can be achieved without the use of doping is also prevalent among young athletes, as well as the fact that the use of doping contradicts the principles of "fair play" and the fact that "three times sweet victory when obtained in an honest fight". However, some respondents tend to believe that without doping, sports

Table 2. Correlations between young athletes' statements about doping.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
2.	.104	--									
3.	-.026	0.338	--								
4.	.215	-.096	-.065	--							
5.	.487**	.065	.132	.456**	--						
6.	.118	.201	.154	.085	.039	--					
7.	.079	.075	.087	.085	.249	.072	--				
8.	.048	-.156	-.227	.217	.034	.413*	-.137	--			
9.	.368*	.005	.045	.163	.512**	.334*	.045	.203	--		
10.	.017	.219	.276	.133	.280	.519**	.166	.025	.160	--	
11.	.226	-.034	-.028	.007	.101	.020	-.010	-.145	.143	.057	--
12.	-.007	.165	.051	.212	.395*	.576**	.054	.319	.442**	.418**	-.001

Legend: 1 – "Doping is a big problem for the modern international sports movement"; 2 – "The development of international sports contacts does not depend on doping scandals"; 3 – "High sports results can be achieved without the use of doping"; 4 – "Without doping, sports competitions become less spectacular"; 5 – "The use of doping contradicts the principles of "fair play"; 6 – "To achieve victory, the use of doping is sometimes permissible"; 7 – "Three times sweet victory, obtained in honest struggle"; 8 – "Victory "at any cost" is also a victory"; 9 – "Doping is harmful to athletes' health"; 10 – "Martial arts athletes can use prohibited diuretics for weight loss"; 11 – "An athlete himself should decide whether to take a prohibited drug or not"; 12 – "If a coach or a team doctor allows the use of illegal drugs, then an athlete should follow his advice"; ** – correlation significant at $p<0.001$; * – correlation significant at $p<0.01$.

competitions become less spectacular, and victory "at any cost" is still a victory.

Although most respondents are confident that doping is harmful to athletes' health, some young athletes believe that martial arts athletes can use prohibited diuretic drugs for weight loss without harm to health. They also believe that if a coach or a team doctor considers the use of illegal drugs possible, then an athlete should agree. In addition, some young athletes are not sure that an athlete himself must decide whether to take the prohibited drug or not.

Correlation results are presented in Table 2.

The correlation analysis results are useful both for assessing adolescent opinions and for assessing the quality of diagnostic tools.

Discussion

This study revealed an ambiguous attitude of adolescent athletes towards doping and, in general, to Olympic values. For example, while agreeing that the use of doping contradicts the principles of "fair play", some teens believe that to achieve victory, the use of doping is sometimes permissible. Recognizing the idea of "victory is three times sweeter when obtained in an honest struggle" young athletes believe that victory "at any cost" is still a victory. Despite the recognition of the negative impact of doping scandals on the development of international sports contacts, the respondents agreed with the statement that without doping, sports competitions become less spectacular. Such results indicate a certain discrepancy between the real and declarative values of adolescents and the inconsistency in their opinions regarding doping in sports.

According to the results of this study, athletes who are beginners in sports are not fully aware that an athlete himself should decide whether to take or not to take a prohibited drug, believing that if a coach or a team doctor allows the use of illegal drugs, then an athlete should follow his advice. Thus, a gap is revealed in adolescent understanding of their responsibilities for anti-doping rule violations. In this regard, it is logical to envisage the development of the skills of reflection and self-regulation, as well as the ability to withstand the negative influence of the social environment in the formation of the foundations of an anti-doping culture.

Despite understanding the harm of doping to the health of an athlete, young judokas and sambists believe that martial arts athletes can use banned diuretics to lose weight. This likely indicates the careless attitude of respondents towards their health. Therefore, in the anti-doping education program, special attention should be paid to the health values and other life values that are incompatible with the use of illegal drugs.

The results of this study are comparable with data of other researchers in the field. For example, Badrak (2011) found that young athletes believe that it is impossible to achieve high sports results without the use of prohibited means. According to Miskulin et al. (2021), athletes who were engaged in sports for 1 to 5 years had more permissive attitudes toward PEDs ($p<0.001$), and current PED usage was more frequent among athletes playing individual sports ($p=0.001$). Henning (2017) recommends focusing on the value of health in the process of anti-doping education. Thus, the solution to the problem of preventing doping among young athletes provides for the correction of the value and motivation sphere of personality (Shelkov & Badrak, 2010).

Such conclusions are consistent with the results of the correlation analysis, which confirmed the diagnostic value of the compiled questionnaire. In general, based on the results of our study, we show a high level of the value component in the anti-doping culture of the adolescent athletes surveyed.

The pie chart shows the distribution of respondents regarding the levels of the anti-doping culture's value component in percentage (Figure 1).

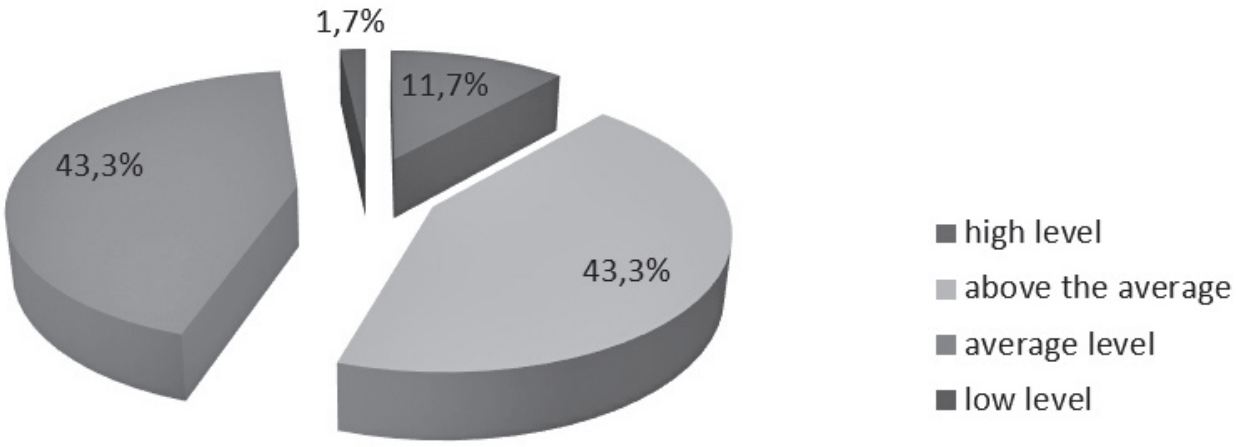

FIGURE 1. Distribution of the respondents regarding the levels of the anti-doping culture's value component, %

As show, the level of anti-doping culture's value component is high and above average for more than half of the respondents. Although a very small number of the respondents show a low level of anti-doping culture's value component, more than 1/3 of athletes had an average level of the anti-doping culture's value component. Therefore, the findings of this research are of practical value for adequate selection of content and methods of anti-doping education of young athletes before the beginning of their typical competitive experience.

There is a need to implement an anti-doping educational program in the process of sports training of young athletes, which includes the following pedagogical conditions: special study of Olympic values, formation of responsibility, habits to make decisions independently and predict their possible consequences, and increasing health value. Experimental verification of these conditions will be the next stage of our

research.

Our study has some limitations related to the distant form of the survey that should be considered. In our opinion, the choice of the adolescents' answers may be influenced by their parents. However, we are confident that these results reflect certain trends characterizing the adolescent athletes' attitudes towards doping. The data obtained provide the basis for following studies.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

Retention Process of Gymnastics Skills in Young School-Aged Children

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Abstract

The assessment of the level of motor skills in the retention phase is done to determine the impact of the process of motor learning on the process of memorization, and thus on the automation of motor skills. This study aimed at determining the differences in the levels of some gymnastics skills in retention points after different retention intervals. The sample of respondents consisted of a total of 56 first-grade pupils (6.5 years±6 months). The sample of variables consisted of 12 simpler gymnastics skills that were assessed by three independent judges on a 5-point Likert scale. After an experimental gymnastics treatment lasting for 9 months, the subjects were tested two months, and four years post treatment. Trends in the quality of skills retention can be organized into several groups: the first group of skills did not show the differences between different measurement points; however, in the second group, a significant deterioration in performance between measurement points was noted. The third group of skills, structurally the most complex one, showed the differences only after 4 years of the retention period. It can be concluded that no link between the skills has been established, which would precisely define the causes of different trends regarding the decrease in the level of skills. Namely, for some skills, a retention period of two months was sufficient to determine the actual level of acquisition, while some skills required a significantly longer time, in our case 4 years, to determine the actual level of their acquisition.

Keywords: *artistic gymnastics, motor skills, motor learning, automation of skills, acquisition*

Introduction

Participating in gymnastics from a younger age is important for multiple reasons. Besides the fact that it helps build self-morale, determination, and better communication skills, it improves focus and concentration necessary in the school environment (Kerr & Gross, 1997). From the physical aspect, gymnastics training emphasizes bodyweight strength to improve core strength, reflexes, whole-body muscle extension, flexion, as well as balance (Madić, Popović & Tumin, 2009; Akin, 2013). Gymnasts are some of the strongest athletes in the world, and gymnastics strength training can help tone all muscles and assist in decreasing chronic muscle soreness and pain (Kochanowicz, Niespodziński, Mieszkowski, Kochanowicz, & Sawczyn, 2017). Basic gymnastics elements are a combination of fundamental movement skills that are proven to play a vital role in the development of a child and later involvement in sports activities (Burton & Miller, 1998; Gallahue & Ozmun, 1998; Jurimae & Jurimae, 2000; Karabourniotis, Evaggelinou, Tzetzis & Kourtessis, 2002). Basic gymnastics skills include movements that appear throughout a gymnast's development and across various apparatus, and their mastery is crucial for advancement in the sport as well as for better everyday functioning since it develops coordination skills (Vandorpe et al, 2011). Participating in gymnastics programs results in motor proficiency improvement (Culjak, Miletic, Kalinski, Kezic, & Zuvela 2014).

According to Schmidt and Lee (2005), the success of the learning process can be assessed in different ways: 1) the method of calculating the differences in the achieved skills at a certain checkpoint (initial, transitive and final point of the

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learning process) concerning the previous point, and 2) the method of relative retention and the calculation of differences in the achieved skills which makes it possible to determine the "amount of lost knowledge" during the retention interval. The stated "amount of lost knowledge" is the difference between the level of skills at the final point of the learning process and one of the retention points. In this case, the term retention point is considered to be a checkpoint that follows a certain time of the non-repetition of the motor skill. According to Arthur, Bennett, McNelly, and Stanush (1998), forgetting the motor skill refers to the loss or deterioration of acquired skill after a period of non-use. Classical definitions of retention emphasize that retention is the degree to which people can remember (or perform) some previously practiced motor skills after a certain period without repeating them (Magill, 2011). The assumption is that the feedback on motor skills in the retention phase presents the formed motor programs that are, or are not, adopted at the automation level (Carroll & Bandura, 1987). Accordingly, the goal of assessing the level of learning motor skills in the retention phase is to determine the impact of motor learning on the process of memorization, and thus on the automation of the motor skill (Magill & Schoelfender-Zohdi, 1996). Skills are considered mastered if their retention level is the same as and/or similar to the level determined at the final point of the learning process (Schmidt & Lee, 2005).

Since the retention interval is the period in which a certain motor skill was not practiced, the length of this interval is positively related to the level of their decline (Magill, 2011). It is expected that longer retention intervals result in a greater decline in the level of skill compared to shorter retention intervals. The reasons for reducing the level/quality of performance of a particular motor skill are considered to depend on several variables: length of retention period or length of a period without motor skill practice, type of motor skill, and various disruptive activities before or during retention interval (Arthur et al., 1998). Several studies have concluded that the results of the retention test became progressively worse with increasing retention interval and that, to reduce forgetting skills, it would be necessary to increase the level of learning of analyzed motor skill if the length of retention interval increases (Gawron, 2019). It is considered that the level of acquisition of motor skills is one of the most important factors that determine the amount of "retained" knowledge or the estimated level of knowledge at the retention point. To determine as high a level of knowledge as possible in the retention point of projection, the available literature links the concept of "overlearning", and is defined as continuing learning, although those who learn have reached a certain level of skill (Stothard & Nicholson, 2012). The learner continues to practice even when the skill is learned and thus encourages the achievement of the highest levels of acquisition of skills or their automation. Achieving automated performance reduces cognitive requirements when performing this skill, and enables better long-term functioning. Following the above, a higher level of the acquisition of certain skills (preferably automated performance) defines higher retention or determination of higher levels of analyzed motor skills in the retention point. This is the reason why gymnastics skills should be regularly monitored in retention periods; this could also be used as guidance in future planning and programming of the training process.

Researches on retention in gymnastics are rare and mostly focused on the effect of a model of feedback on retention results (Shafizadeh & Shaban, 2018; Frikha, Chaâri, Elghoul, Mohamed-Ali & Zinkovsky, 2019). However, a few of the studies did focus on investigating the period for gymnastics skills retention and researchers have found no decline in the performance of simple gymnastics skills after two weeks of retention (Baudry, Leroy, Thouvarecq & Chollet, 2006; Proios, 2019). A retention period of more than two weeks has not been investigated; hence, this research is very important because it will make a great contribution to the understanding of the proces of long retention when it comes to gymnastics skills. To investigate the period in which the learned basic gymnastics skills are retained, this study aimed at determining the differences in the acquisition levels of some gymnastics skills at retention points after different retention intervals in first-grade pupils.

Methods

Participants

The sample of respondents in this research consisted of a total of 56 students (20 male and 36 female) of the first grade (chronological age 6.5 years±6 months). The male students averaged 126.9 cm in height and 26.7 kg in weight, while the female students averaged 125.9 cm in height and 25.7 kg in weight. The same sample was tested after four years when they attended fifth grade (10.5 years±6 months). According to their preferences, both during and after the experimental treatment, students were involved in extracurricular activities, except in gymnastics. All students who participated in gymnastics programs outside the experimental program were not included in the research. All of them gave verbal assent and their parents gave written informed consent. The Ethical Committee of the Faculty of Kinesiology – University of Split verified that this investigation complied with all ethical standards for scientific investigations involving human participants (approval number 2181-205-02-05-22-0040, 30.12.2022.).

Measurements

Gymnastics skills that were used in this research were chosen according to their structural complexity (simpler and more complex gymnastics skills): bridge, candlestick, forward roll, backward roll, cartwheel, beam walking, jump off the small beam, jump off the high mat, passes from the front bar hanging to the rear bar hanging and back, mount pullover on the bar, wall handstand and straddle sit on the vault. These skills are a part of the begginers school of gymnastics, and were therefore selected for this research. To avoid any subjective assessment, three independent judges (gymnastics experts) evaluated the subject's performances and were previously instructed on the criteria in performing gymnastics skills, which were rated on the Likert scale. Likert scale was used to assess the quality of performance according to the following criteria: (5) performance without technical and/or aesthetic mistakes; (4) performance with small technical and/or aesthetic mistakes; (3) performance with medium technical and/or aesthetic mistakes; (2) performance with large technical and/or aesthetic mistakes; (1) performance was not made at all.

The study was conducted over 35 weeks (23 weeks of treatment, 7-week retention period, and 5 weeks of performance assessment), with the addition of one week for the performance assessment after a 4-year retention period. Boys and girls practiced together three times per week for 45 minutes, during the PE class led by the same teacher. Totally, children practiced during 104 classes in 10 months' time. The classes consisted

of an introductory part of the class (warm-up), a preparatory part of the class (stretching), the main part of the class in which gymnastic skills were practiced, and the final part of the class (cool-down). Initial- and acquisition levels of performance have been assessed during the learning process, the final level of performance was assessed at the end of the experimental program, and the retention levels of performance have been assessed after the PE learning process. Overall, the quality of the performance was assessed five times, with the first retention point done two months after finishing the learning process, and the second retention point done four years after finishing the learning process. For this research, only the final level of performance and two retention points will be taken into analysis.

Statistics

Data were analyzed using the Statistica for Windows 14.0 (TIBCO Software Inc, USA) and statistical significance was set at $p<0.05$. Basic descriptive statistics were calculated for all gymnastics skills each measurement point (mean values and standard deviations (SD), minimum (Min), and maximum (Max) result). For determining the between-subject reliability of the gymnastics skills, Cronbach's alpha coefficients (α) and inter-item correlation coefficients (IIR) were calculated. Analysis of variance (ANOVA) with repeated measures for time with post-hoc Bonferroni test was used to check for differences in the acquisition level of gymnastics skills at retention points compared to the final point of measurement.

Results

The reliability of each analyzed gymnastics skill was checked by calculating inter-item correlation and Cronbach alpha coefficients (Table 1). A review of these coefficients in the final measurement point revealed mostly satisfactory values: IIR ranges from 0.70 to 0.90; Cronbach-alpha coefficient values range from 0.91 to 0.98. In the second measurement point (first retention point), which was conducted 2 months after the end of the teaching process, and during which the analyzed skills were not repeated, the following reliability parameters were determined: IIR ranged from 0.59 to 0.92; Cronbach-alpha values ranged from 0.86 to 0.98. In the third measurement point (second retention point), which was conducted 4 years after the end of the teaching process, and during which it was assumed that analyzed skills were not repeated since most of them were not a part of official curricula in physical education, the following reliability parameters were identified: IIR ranged from 0.60 to 0.94; Cronbach-alpha values ranged from 0.85 to 0.98. Due to satisfactory metric characteristics, most of the analyzed skills will be taken into further analysis, except for straddle sit on vault element, where poor reliability parameters were identified in the third checkpoint.

Table 1. Reliability Analysis (IIR, α) and Descriptive Statistics (Mean, Min, Max, SD) of Analyzed Gymnastics Skills in All Measurement Points

	IIR	α	Mean	Min	Max	SD
Candlestick F	0.76	0.93	3.81	1.40	5.00	0.86
Candlestick 1R	0.81	0.95	3.53	1.00	5.00	0.92
Candlestick 2R	0.88	0.97	3.52	1.00	5.00	1.18
Bridge F	0.75	0.92	3.99	1.50	5.00	0.89
Bridge 1R	0.76	0.93	3.48	1.60	4.80	0.87
Bridge 2R	0.87	0.96	3.39	1.00	5.00	1.15
Forward roll F	0.71	0.92	3.84	1.00	5.00	0.76
Forward roll 1R	0.69	0.91	3.31	1.70	4.80	0.72
Forward roll 2R	0.81	0.94	3.21	1.75	5.00	0.83
Backward roll F	0.83	0.95	3.79	1.00	5.00	0.84
Backward roll 1R	0.81	0.95	3.35	1.00	5.00	0.87
Backward roll 2R	0.85	0.95	2.82	1.00	5.00	0.98
Cartwheel F	0.89	0.97	3.20	1.40	5.00	0.97
Cartwheel 1R	0.76	0.93	2.96	1.10	5.00	0.96
Cartwheel 2R	0.84	0.95	3.12	1.00	5.00	1.08
Beam walking F	0.78	0.93	2.72	2.00	4.70	0.68
Beam walking 1R	0.75	0.93	2.80	1.50	4.70	0.61
Beam walking 2R	0.87	0.96	2.83	1.75	5.00	0.96
Jump-off the small beam F	0.70	0.91	2.97	1.00	4.70	1.03
Jump-off the small beam 1R	0.59	0.86	2.60	1.00	4.90	0.91
Jump-off the small beam 2R	0.72	0.90	3.13	1.50	5.00	0.87
Jump-off the high mat F	0.71	0.91	3.85	2.30	5.00	0.62
Jump-off the high mat 1R	0.70	0.91	3.36	1.20	4.90	0.81
Jump-off the high mat 2R	0.70	0.89	3.40	1.75	5.00	0.82
Passes hanging on the bar F	0.90	0.98	2.90	1.00	5.00	0.85

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Table 1. Reliability Analysis (IIR, α) and Descriptive Statistics (Mean, Min, Max, SD) of Analyzed Gymnastics Skills in All Measurement Points

	IIR	α	Mean	Min	Max	SD
Passes hanging on the bar 1R	0.85	0.96	2.74	1.00	4.90	0.92
Passes hanging on the bar 2R	0.94	0.98	2.08	1.00	5.00	1.41
Mount pullover F	0.90	0.98	3.23	1.00	5.00	0.90
Mount pullover 1R	0.91	0.98	3.21	1.00	5.00	0.88
Mount pullover 2R	0.94	0.98	2.06	1.00	5.00	1.36
Handstand F	0.85	0.96	3.62	2.00	5.00	0.84
Handstand 1R	0.92	0.98	3.45	1.00	5.00	1.00
Handstand 2R	0.94	0.98	2.42	1.00	5.00	1.36
Straddle sit on vault F	0.84	0.96	3.07	1.00	5.00	0.90
Straddle sit on vault 1R	0.81	0.95	3.09	1.00	5.00	0.86
Straddle sit on vault 2R	0.60	0.85	3.13	1.75	5.00	0.78

Legend: F – final measurement, 1R – 1st retention point, 2R – 2nd retention point

The level of acquisition of each analyzed skill was determined by the method of summation, i.e., calculation of the mean value for each skill at each checkpoint (Figure 1). The highest level of acquisition in the first checkpoint (at the end of the teaching process) was determined for the bridge element (3.99), while the beam walking element had the lowest level of acquisition (2.72). Levels of acquisition of other skills were within the range of the two mentioned skills. When observed through the assessment criteria, some skills were performed for the school grade good (3), i.e., performed with medium technical and/or aesthetic flaws. Other analyzed skills were performed at the level of school grade very good (4), and generally had performances with minor technical and/or aesthetic errors.

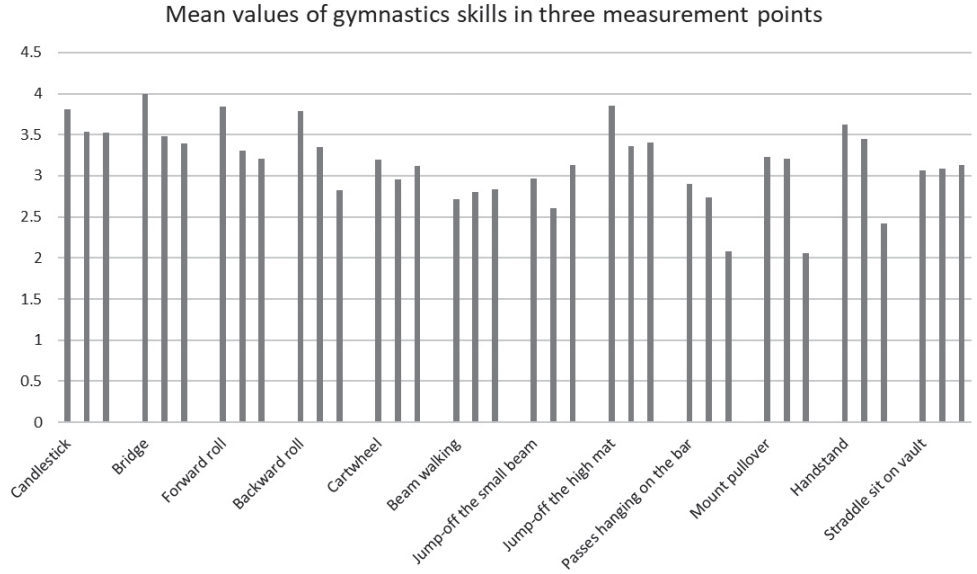

FIGURE 1. Comparison of Mean Values of Each Gymnastics Skill (Element) in Three Measurement Points (Final Point, 1st Retention Point, and 2nd Retention Point)

In the second checkpoint, which followed 2 months after the end of the program, the level of almost all the skills corresponded to the school grade good (3), or represented performances with medium technical and/or aesthetic errors. An exception to the above was the element of candlestick whose performance level was the highest, even after 2 months of non-repetition (3.53).

The level of the most of the analyzed skills after four years of retention continued to correspond to the school grade good (3). As in the second checkpoint, the candlestick element remained the best element performed (3.53). In addition, three elements that were categorized as structurally more complex skills (mount pullover, passes hanging on the bar, and handstand) had numerically much lower values than at the second checkpoint.

The differences between the levels of acquisition of the analyzed skills at different checkpoints were analyzed by ANOVA with the Bonferroni post-hoc test (Table 2). Trends in their values can be organized into several groups. Despite a certain numerical decrease in values between the checkpoints 1–3, they were not found to be statistically significant for the following elements: candlestick, cartwheel, and beam walking. Contrary to mentioned skills, the backward roll is the only skill whose level of performance has been constantly decreasing in the re-

tention period, so much that there are significant differences in the levels of mastery of this skill between all checkpoints. Some skills experienced a significant decrease in value from the first to the second, and the first and third checkpoints (bridge, forward roll, and jump-off the high mat). Although there was some further decline between the second and third measurement points, this decline was not found to be significant. The last group of skills is represented by structurally more complex skills: mount pullover, passes hanging on the bar, and handstand. The trend of their values is identical: despite a certain numerical decrease, no significant difference was found between the first and second checkpoints. Significant decreases in value occurred between the second and third, and consequently between the first and third checkpoints.

Table 2. Results of Analysis of Variance (ANOVA) With Post-hoc Bonferroni Test

	ANOVA		Bonferroni post-hoc		
	F value	p	F/1R	1R/2R	F/2R
Candlestick F					
Candlestick 1R	3.01	0.05	0.12	0.10	1.00
Candlestick 2R					
Bridge F					
Bridge 1R	13.00	<0.001	0.00*	0.00*	1.00
Bridge 2R					
Forward roll F					
Forward roll 1R	23.49	<0.001	0.00*	0.00*	1.00
Forward roll 2R					
Backward roll F					
Backward roll 1R	30.04	<0.001	0.00*	0.00*	0.00*
Backward roll 2R					
Cartwheel F					
Cartwheel 1R	1.18	0.31	0.40	1.00	0.97
Cartwheel 2R					
Beam walking F					
Beam walking 1R	0.33	0.72	1.00	1.00	1.00
Beam walking 2R					
Jump-off the small beam F					
Jump-off the small beam 1R	7.92	<0.001	0.02*	0.73	0.00*
Jump-off the small beam 2R					
Jump-off the high mat F					
Jump-off the high mat 1R	9.15	<0.001	0.00*	0.00*	1.00
Jump-off the high mat 2R					
Passes hanging on the bar F					
Passes hanging on the bar 1R	11.44	<0.001	1.00	0.00*	0.00*
Passes hanging on the bar 2R					
Mount pullover F					
Mount pullover 1R	26.17	<0.001	1.00	0.00*	0.00*
Mount pullover 2R					
Handstand F					
Handstand 1R	22.32	<0.001	1.00	0.00*	0.00*
Handstand 2R					

Legend: F – final measurement, 1R – 1st retention point, 2R – 2nd retention point; *p < 0.05

Discussion

The main goal of this paper was to determine the level at which some gymnastics elements can be "remembered" after a period of non-exercise. The information about the level of retained skill is the basis of its vertical and horizontal progress, but also the basis for planning and programming the learning process.

Analyzing the structural complexity of skills that were at a lower or higher level of acquisition at the first checkpoint, one can not draw a general conclusion that structurally simpler skills reach a higher level of acquisition, and structurally more complex skills reach a lower level of acquisition (Neljak,

2009) after six months of training. Namely, some presumably structurally simpler skills reached a higher level of acquisition, and vice versa. The first retention point generally revealed a certain decrease in the level of performance of gymnastics elements. However, reducing the level of skills acquisition at the time of non-repetition is an expected result of forgetting the performance of skills (Arthur et al, 1998). Although a period of 4 years elapsed from the second checkpoint to the third checkpoint, during which the analyzed skills were not repeated in physical education classes (according to the information obtained from the respondents' teachers), the third checkpoint yielded results very similar to the second checkpoint. The similarity of these results in most of the analyzed skills, regardless of the values of that level, confirm the actual level of their acquisition. Additionally, it can be concluded that a period of 6 months was enough for the structurally simpler gymnastics skills to reach a stable level of acquisition, which generally corresponds to performances with medium technical and/or aesthetic errors. An exception to this was found for three skills that were categorized as structurally more complex skills (mount pullover, passes hanging on the bar, and handstand), where they had numerically lower values than at the second checkpoint. Based on the obtained data, it can be concluded that the mentioned skills were acquired at a lower level. Furthermore, it is confirmed that a longer retention period is required to conclude the actual level of acquisition of certain structurally complex skills, since the level of their performance after a short retention period may lead to false information.

Results showed that the level of performance of some gymnastics skills (candlestick, cartwheel, and beam walking) didn't show a significant difference in retention points when compared to the final measurement point. Since such a result leads to the conclusion that these skills were less forgotten, the opposite assumption can be that those skills are acquired at a higher level compared to other skills, regardless of the values of these levels. Contrary to the mentioned skills, the backward roll was the only skill whose level of performance has been constantly significantly decreasing in the retention period. The reason for this can probably be found in the demands for certain motor abilities. In the time of non-repetition of this skill, motor abilities that children developed during the process of learning probably decreased, thus increasingly "spoiling" the performance of this skill. Such a decline in ability can be partly attributed to the growth of children in which the level of ability, achieved to enable the performance of the backward roll to the final point of the learning process, clearly decreased or was insufficient for increased limbs. All of the above is further related to the level of acquisition of this skill since it was found that motor abilities affect the level of performance of motor skills only during the first phases of motor learning, and with the automated phase of the acquisition of skills, they become insignificant (Delaš Kalinski, Jelaska, & Atiković, 2011). This skill was not acquired at a sufficient level compared to the other analyzed skills. Some skills suffered a significant decrease in value from the first to the second, and between the first and third checkpoints (bridge, forward roll, and jump-off the high mat). The obtained result could be analyzed from the point of the importance of determining the ideal length of the retention period to determine the actual level of acquisition of certain skills. Namely, it is likely that the period of two months (between the first and the second checkpoint) was long enough to significantly reduce the level of this skill's performance and that, after that time, the actual level of the acquisition of this skill is defined. The structurally most complex group of skills (mount pullover, passes hanging on the bar and handstand) was characterized by nonsignificant differences between the first and second checkpoint. Significant decreases in value occurred between the second and third, and consequently between the first and third checkpoints. Given that these are structurally complex skills, and that their level of acquisition decreased only after 4 years of non-repetition, it is assumed that, in addition to forgetting, some other factors caused this result, such as growth and maturation, which remains to be determined by further research.

Since retention tests are one of the strategies to determine the level of skills acquisition, based on the results of this research, it can be concluded that no link between skills has been identified. Namely, for some skills, a retention period of two months was enough to determine the actual level of acquisition, while some skills required a significantly longer period; in this case, a period of 4 years. Further research is needed to detect the factors that affect the length of the retention period as accurately as possible since some research suggest that different learning strategies define the successfulness of the retention period itself (Maleki, Nia, Zarghami, & Neisi, 2010; Shafizadeh, & Shaban, 2018; Frikha, Chaâri, Elghoul, Mohamed-Ali, & Zinkovsky, 2019).

The limitations of the current study can be found firstly in the lacking of the control group of subjects, and following investigations should include such a sample for more accurate and more valid results. Secondly, it is very difficult to interpret the results from this study since there is a lack of similar research with which we could compare them. Due to the fact that researchers suggest using the electronic programs and integrating them in the educational process because this enhances the level of retention among learners, especially in the basic school stages (Shatnawi & Al-Saeedin, 2021), this could be really helpful for future research of the retention of gymnastics skills.

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Conflict of Interest
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

Levels of Distress and Physical Activity of Adolescents during the Covid-19 Pandemic

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Abstract

The importance of physical activity, as one of the crucial resources for maintaining and improving physical health, was diminished during the Covid-19 pandemic. Except for the impact it has on physical health, physical activity may have various psychological benefits, especially during the development period of adolescence. The current findings of physical activity show that adolescents are more physically inactive during the pandemic than usual. Also, there are increasingly negative psychological outcomes in adolescents. The purpose of this study was to explore the levels of physical activity, negative affectivity, coping and preoccupation with the pandemic in an adolescent sample. The study involved 2409 adolescents (53.5% girls, 46.5% boys) from elementary and high schools aged 10 to 19. The Depression, Anxiety and Stress Scale (DASS-21) was applied, and information about levels of physical activity, coping and preoccupation with pandemic and isolation measures were collected. Participants answered on a Likert-type scale. Findings of this research show that on average male adolescents are more likely to engage in physical activities than females. Also, a relation of physical inactivity distress and preoccupation was obtained for adolescent girls. No similar finding was found for males. However, very high physical activity (five or more times a week) was a protective factor for coping and preoccupation with coronavirus infection. The conclusion of this research indicates that levels of physical activity have a different effect on male and female adolescents during the Covid-19 pandemic. It can be concluded that female adolescents that are less physically active are more at risk of depression, anxiety and stress.

Keywords: *distress, negative affectivity, levels of physical activity, Covid-19*

Introduction

The outbreak of the Covid-19 pandemic has put the human population's health at risk to the extent that nobody could have predicted. The usual people's lifestyle has significantly changed (Bajramovic et al., 2020). To prevent the spread of Covid-19 worldwide, including in the Federation of Bosnia and Herzegovina (B&H), restrictive measures such as isolation, mobility restrictions and confinement were imposed on people older than 65 and juveniles. Besides the previously mentioned measures, distance learning has significantly increased the time that pupils spend in front of screens. Physical exercise, movement, social contacts and interactions have been minimized. Drastic lifestyle changes of all pupils have increased the sedentary lifestyles (Caroppo et al., 2021). Consequently, their instinctive biological need for movement, physical exercise and social interaction, as one of the main preconditions for normal emotional and physical development, preservation of mental health and quality of life, has been threatened and neglected (Ravens-Sieberer et al., 2022). Children and youth have missed some of the most important moments of their lives, including making friendships and pursuing hobbies, due to school closures and lack of sports and cultural events. The usual sports activities and training have been cancelled. The occurrence of risk factors was increased – health issues such as hypokinesia, cardiovascular diseases, excessive stress (hyper stress), anxiety, depression, and many other psychosomatic symptoms as a result of irregular physical exercise and movement (Biddle & Mutrie, 2007).

The improvement of specific anthropological characteristics which are expressed through morphologically positive changes

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and the impact on the functional and motor abilities is common for all aspects of physical exercise (Cattuzzo et al., 2016). This results in many positive psychological changes, a decrease of somatic and cognitive tension, increased self-confidence and perception of one's capabilities (Bungić & Barić, 2009). Physical activity has many positive effects, not only on physical but also on psychological well-being (Edwardson, Gorely, Pearson, & Atkin, 2013). It can be assumed that physical activity and organized physical exercise programs directly improve an individual's quality of life (Mandolesi et al., 2018). Physical activity encompasses all aspects of children's and adolescents' lives and has a positive effect on their physical and psychological well-being (Biddle & Asare, 2011). Children and youth are very sensitive to the influence of sudden stressors during their developmentally vulnerable period, which consequently negatively affects their psychological well-being (Asmundson et al., 2013).

Current findings show that the occurrence of coronavirus infection could be a trigger for various psychological difficulties, such as anxiety and depression (Qiu et al., 2020). Anxiety, depression, distractibility, and fear of infection for family members are the most common problems among youth during the coronavirus pandemic (Jiao, 2020). Likewise, a sedentary lifestyle during the pandemic has led to an increase in negative physical and mental health outcomes (Cheval et al., 2021). According to the assessment of children and adolescents in the UK, poorer mental health occurred and a lack of support in a stressful situation of the coronavirus (Lee, 2020). Stress is moderately related to youth physical activity during the coronavirus pandemic. Hence, adolescents who exercise more often have lower levels of stress and loneliness (Ellis, Dumas, & Forbes, 2020).

Since stressful life situations lead to various negative outcomes of physical and psychological health, the relation between physical activity and levels of stress, anxiety and depression in males and females during the Covid-19 pandemic has been explored.

Methods

Participants

A total of 2409 male and female pupils from nine elementary and nine secondary schools in the Canton 10 of the Federation of B&H participated in the research. Agee ranged from 10 to 19 years (M=15.12, SD=2.25). A total of 1211 males (46.5%) and 1288 female (53.5%) attended elementary schools from 6th to 9th grade (n=1149, 47.7%) and secondary schools from 1st to 4th grade (n=1260, 52.3%). The gender and age structure of the sample are shown in Table 1.

Table 1. Structure of the sample regarding gender and age (N=2409).

		Males (n=1121)		Females (n=1288)	
		n	%	n	%
Elementary school	6th grade	127	11.3	131	10.2
	7th grade	114	10.2	144	11.2
	8th grade	175	15.6	166	12.9
	9th grade	143	12.8	149	11.6
High school	1th grade	163	14.5	187	14.5
	2th grade	167	14.9	186	14.4
	3th grade	147	13.1	194	15.1
	4th grade	85	7.6	131	10.2

Instruments

Within socio-demographic characteristics, data regarding gender, age, grade and school were collected information. Individual questions regarding the frequency of physical activity are formulated according to Zhang's et al. (2022) model of work. The frequency of physical activities was examined with the additional question ("How often have you engaged in a sports activity in the last week?"). The frequency of physical activity was assessed on a four-point scale (0 - inactivity-not once a week, 1 - moderate-1 or 2 times a week, 2 - high-3 or 4 times a week, 3 - very high-5 and more times a week).

Bogdan et al. (2020) published an edition on psychological aspects related to the coronavirus, based on which we designed questions to examine coping and preoccupation. Coping with a stressful situation, specifically dealing with isolation measures, was also examined ("How do you deal with isolation measures?"). Pupils were responding on a Likert-type scale (1 – very poor, 2 – poor, 3 – acceptable, 4 – good, 5 – very good) where the lower the score indicates that pupils are less able to cope with isolation measures. The level of preoccupation about the potential coronavirus infection was also examined ("Are you concerned that you might be infected with the coronavirus?"), and pupils rated their preoccupation on a scale: 0 - no, I don't think about it, 1 - rarely, 2 - occasionally, 3 - often, 4 - every day. A higher score indicates greater preoccupation.

Depression, Anxiety and Stress Scale (DASS-21)

The DASS-21 scale (Lovibond & Lovibond, 1995) consists of 21 items that are divided into three scales. Each scale contains seven items and assesses the level of negative emotional states - depression, anxiety and stress. The scale of depression includes symptoms of dysphoria, hopelessness, self-depreciation, apathy, and lack of interest. The anxiety scale assesses the excitability of the autonomic system and situational anxiety. The stress scale involves levels of chronic, nonspecific arousal, relaxation difficulties, disturbance and impatience. Participants answer by circling the appropriate number on a Likert-type scale, from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). A higher score indicates greater distress. The scale is suitable for the assessments of adolescents and adults in the non-clinical population. The Cronbach's alpha reliability coefficients are 0.82 for depression, 0.79 for anxiety, and 0.86 for stress.

Procedure

Before conducting the research, the approvals of the Ethics Committee of The Ministry of Science, Education,

Culture and Sports of the Canton 10 (Approval number: 06-01-39-673/20, 13.4.2020), school principals, parents and pupils were obtained. The research was conducted via the internet using a Google web form. A letter and an e-mail with instructions, the purpose of the study and a link to research were sent to The Ministry of Science, Education, Culture and Sports and all principals. Schools forwarded an e-mail with a link to research with accompanying detailed instructions and purposes of the research to all pupils from 6th to 9th grade in elementary schools and from 1st to 4th grade in secondary schools. The participation was anonymous and voluntarily in the period from April 21 to May 15, 2020. To participate, pupils first had to obtain parental consent to meet the ethical principles. Since the research was voluntary and anonymous, pupils could withdraw from participation at any time.

Statistical analysis

Conditions for the parametric statistics have been examined. The distributions of the results of depression, anxiety and stress vary from the normal distribution as expected ($p<0.01$), which is consistent with the studies of depression and anxiety on non-clinical samples. These distributions were verified by the Kolmogorov-Smirnov test. Visual inspection of the histograms shows that they are negatively asymmetric. Since there is a situational sensitivity of these measures, it is understandable that the distribution of results and stress scales are also asymmetrical. Such finding is not surprising, since the research was conducted during the coronavirus pandemic, as a new threatening situation. According to the values of the skewness and kurtosis index are acceptable, asymmetrical distributions can be included in the parametric data analysis (Kline, 2015). Results are shown with descriptive statistical parameters. Chi-square tests and analysis of variance were used. Data were analysed using the statistical package SPSS version 20.0 (IBM, Armonk, USA).

Results

Descriptive analysis

Descriptive data for all measured variables were calculated and presented in Table 2. A descriptive analysis of the frequency of physical activity showed that 36.7% of pupils engage in some physical activity five or more times a week (very high physical activity). Furthermore, 29.4% of pupils engage in physical activity three or four times a week (high physical activity), while 27.6% of pupils engage once or twice a week (moderate physical activity), and 6.1% of them do not engage in physical activity at all (physical inactivity).

Table 2. Descriptive statistics and coefficients of internal consistency of measured variables.

Variable	k	Min	Max	M	SD	IS	ISk	α
Depression	7	0	21	2.97	3.78	1.95	4.35	0.82
Anxiety	7	0	21	2.24	3.23	2.35	6.96	0.79
Stress	7	0	21	4.62	4.53	1.23	1.23	0.86
Coping	1	1	5	2.98	1.29	0.02	-1.07	-
Preoccupation	1	0	4	0.72	1.02	1.42	1.41	-
Physical activity	1	0	3	1.97	0.94	-0.38	-1.00	-

Note. k=number of particles, Min-the lowest result, Max-the highest result, IS-skewness index, ISk-kurtosis index, α=internal consistency coefficient Cronbach alpha

Examination of the descriptive results showed that pupils are highly physically active, and they engage on average three to four times a week in physical activities (M=1.97). Comparing negative affectivity, respondents are under the highest level of stress (M=4.62), less depressed (M=2.97) and anxious (M=2.24). Adolescents cope well with isolation measures (M=2.98) and generally are not preoccupied that they may become infected with coronavirus (M=0.72).

Table 3. Differences in physical activities regarding gender.

Gender		Physical activity				Total
		Inactivity	Moderate activity	High activity	Very high activity	
Males	Frequencies	85	252	321	459	1117
	Expected frequency	68.8	308.5	329.4	410.3	1117.0
	%(gender)	7.6%	22.6%	28.7%	41.1%	100.0%
	Standardized residuals	2.8	-5.2	-0.8	4.1	
Females	Frequencies	63	412	388	424	1287
	Expected frequency	79.2	355.5	379.6	472.7	1287.0
	%(gender)	4.9%	32.0%	30.1%	32.9%	100.0%
	Standardized residuals	-2.8	5.2	0.8	-4.1	
Total	Frequencies	148	664	709	883	2404
	Expected frequency	148.0	664.0	709.0	883.0	2404.0
	%(gender)	6.2%	27.6%	29.5%	36.7%	100.0%
Chi-square results				$\chi^2(3)=37.71$, $p<0.001$		

Physical activity regarding gender

To examine the differences in the levels of physical activity regarding gender, a Hi-square test was performed and standardized residuals were analysed (Table 3). The results of the Hi-square test show that there is a significant difference in the level of physical activity regarding gender ($\chi^2(3)=37.71$, $p<0.001$). For the analysis, a stringent significance level was used ($p<0.01$). The values of standardized residuals above 2.6 show significant differences.

There are significantly more males in the category of very high activity than expected, but also in the category of inactivity. There are significantly fewer of those who engage in physical activity moderately. On the other hand, there are significantly more girls who are moderately engaged in physical activities, and significantly fewer girls who are characterized by very high levels of activity, but also inactivity.

Differences in depression, anxiety, stress, coping and preoccupation regarding the level of physical activity

Table 4 shows the differences between the four groups of pupils regarding the level of physical activity (inactivity, moderate activity, high activity and very high activity) in depression, anxiety and stress, as well as coping and preoccupation of males and females. Analysis of variance and post-hoc tests were performed. A statistically significant difference was obtained for depressive symptoms ($F_{(3,1238)}=4.82$, $p<0.01$) – girls who are inactive and those who are moderately active show significantly more symptoms than girls who are highly physically active. Female pupils who are inactive show significantly higher levels of anxiety ($F_{(3,1238)}=3.35$, $p<0.05$) and stress ($F_{(3,1238)}=4.79$, $p<0.01$) than girls who are highly physically active. Girls who are engaged in very high physical activity are significantly better coping with isolation measures than inactive and moderately active girls, and highly active girls cope significantly better than inactive girls ($F_{(3,1238)}=8.94$, $p<0.01$).

There are no significant differences in the level of physical activity in depression, anxiety and stress for males. However, significant differences in coping and preoccupation were found. Very highly active males cope with isolation measures significantly better than inactive and moderately active males ($F_{(3,1113)}=6.44$, $p<0.01$). Furthermore, males who are very highly active are significantly less preoccupied with possible coronavirus infection than those males who are moderately and highly active ($F_{(3,1113)}=5.49$, $p<0.01$).

Table 4. Descriptive data and results of analysis of variance for depression, anxiety and stress regarding the level of physical activity.

		Males					Females				
Variable	**Level of physical activity**	**n**	**M**	**SD**	**F**	**df**	**n**	**M**	**SD**	**F**	**df**
Depression	Inactivity	85	3.22	4.62	2.50	3, 1113	63	4.76	5.37	4.82**	3, 1283
	Moderate activity	252	2.62	3.69			412	3.79	4.21		
	High activity	321	2.23	2.84			388	3.01	3.62		
	Very high activity	459	2.27	3.29			424	3.37	3.93		
Anxiety	Inactivity	85	2.07	3.97	1.57	3, 1113	63	3.92	5.19	3.35*	3, 1283
	Moderate activity	252	1.73	2.54			412	3.02	3.69		
	High activity	321	1.61	2.39			388	2.55	3.32		
	Very high activity	459	1.45	2.46			424	2.67	3.45		
Stress	Inactivity	85	3.94	4.77	0.21	3, 1113	63	6.98	6.43	4.79**	3, 1283
	Moderate activity	252	3.75	3.78			412	5.74	4.99		
	High activity	321	3.59	3.78			388	4.83	4.31		
	Very high activity	459	3.75	4.02			424	5.42	4.79		
Coping	Inactivity	85	2.81	1.42	6.44**	3, 1113	63	2.33	1.29	8.94**	3, 1283
	Moderate activity	252	2.86	1.26			412	2.76	1.25		
	High activity	321	2.99	1.28			388	2.99	1.24		
	Very high activity	459	3.25	1.35			424	3.06	1.24		
Preoccupation	Inactivity	85	0.42	0.95	5.49**	3, 1113	63	0.73	1.19	1.79	3, 1283
	Moderate activity	252	0.65	0.95			412	0.97	1.16		
	High activity	321	0.65	0.91			388	0.88	1.02		
	Very high activity	459	0.43	0.82			424	0.82	1.07		

Note. *p<0.05; **p<0.01

Discussion

The findings of this study indicate that adolescents are physically active three to four times a week. Results from earlier studies show similar results for adolescents' frequency of physical activity. Most of them exercise two to four times a week, regardless of the level of physical activity (Delisle, Werch, Wong, Bian, & Weiler, 2010). Other reports that most adolescents exercise two to three days per week (approximately 70%), and about 30% of them are physically active just one day or less per week (Moljord, Eriksen, Moksnes, & Espnes, 2011). The recommendations of various relevant institutions state that children and adolescents should be involved for at least 60 minutes a day in physical activity of moderate or high intensity (Rhodes, Janssen, Bredin,

Warburton, & Bauman, 2017). Data on the prevalence of adolescents' physical activity show that 81% of young people in Europe and North America are insufficiently physically active at this age (Currie et al., 2012). The Republic of Croatia has been involved in international research on pupils' health behaviour since 2002. Similar trends on the prevalence of physical inactivity were reported among pupils in Croatia - 85% of insufficient physical activity among elementary and secondary school pupils. According to the Health Behavior in School-Aged Children (HBSC) system, the physical activity of Croatian 15-year-olds decreases over time (Pavić et al., 2020). The highest recorded rate of physically active pupils at this age was 33.5% in 2002, and in 2014 it reduced to 25.4%, and in 2018 to 21.4%. Due to the outbreak of the Covid-19 pandemic and confinement measures, it is expected that data on the physical activity of children and youth around the world will be significantly devastating.

It should be emphasized that the obtained average values for depression, anxiety and stress are significantly lower in our study than the average for the population (Lovibond & Lovibond, 1995). The first studies of anxiety and depression levels during the Covid-19 pandemic reported an increase in these symptoms (Cao et al., 2020). Deng et al. (2020) confirmed the relation between habits and frequency of physical activity with levels of stress, anxiety, and depression (DASS-21). Those who were physically active regularly and maintained the habit of physical exercise, more than one to two times a week, more than an hour a day and had more than 2000 average walking steps during the Covid-19 pandemic, had significantly lower levels of stress, anxiety and depression. The obtained data indicate that regular physical activity which lasts long enough is associated with a lower risk of developing mental disturbances. This is in accordance with the results of our research and the results of previous studies which confirmed a positive effect on the quality of life (Moljord et al., 2011; Brière et al., 2018; Chekroud et al., 2018).

The results of our study are in accordance with the results of numerous previous studies that showed that males are generally more physically active than girls in various measured areas (Sallis, 1993; Norman et al., 2006; Duncan, Duncan, Strycker, & Chaumeton, 2007; Pearson, Atkin, Biddle, Gorely, & Edwardson, 2009). Most males who participated in this research stated that they engage in some physical activities five or more times a week, and significantly fewer of them are engaged once or twice a week. However, there are significantly more girls who engage in physical activity once or twice a week, and significantly fewer girls who never engage in physical activity, as well as those who exercise five or more times a week. There is a trend of increasing physical inactivity with age in adolescence. Data shows that 78.3% of females and 49.9% of males in eighth grade and 86.2% of girls and 66.8% of males in third grade in Croatian high schools are insufficiently physically active (Jureša, Musil, Majer, & Petrović, 2010). Many reasons contribute to this, including the social environment, biological or puberty, type and level of motivation (Edwardson et al., 2013). Girls, children and young people should be encouraged to exercise as much as possible due to the high prevalence of insufficient physical activity of girls compared to males (World Health Organization, 2013), vulnerable adolescent period and negative consequences of distress and maturation.

Physical activity of children and young people is crucial due to its multiple positive health effects, positive long-term effects on adults' health, as well on adopting the habit of regular physical exercise later in life (Boreham & Riddoch, 2001). Physical activity is a protective factor for the occurrence of stress, reduces stress and facilitates coping (Heaney, Carroll, & Phillips, 2014; Grošić & Filipčić, 2019). Our study examined the differences in depression, anxiety and stress regarding the level of physical exercise of males and females. Significant differences were obtained for depression, anxiety, and stress regarding the level of physical exercise in girls. Inactive and less physically active girls have higher levels of depression, anxiety, and stress. These findings are consistent with other studies conducted during the Covid-19 which indicate that girls are at higher risk for developing depression and anxiety (Chen et al., 2020; Sniadach, Szymkowiak, Osip, & Waszkiewicz, 2021; Živčić-Bećirević, Smojver-Ažić, Martinac Dorčić, & Birovljević, 2021). Youth often stayed home alone during the pandemic, which resulted in higher levels of depression and anxiety (Ellis et al., 2020). In addition, physical exercise has been shown as a protective factor in adolescents' mental health earlier before the pandemic (Chekroud et al., 2018). Numerous studies on the impact of various previous pandemics and epidemics confirm the negative impact on psychological health, examined through depression, fear, anxiety, preoccupation and risky behaviours of children and youth (difficulties in social relations, use of addictive substances, education problems) (Dubey et al., 2020; Imran, Zeshan, & Pervaiz, 2020; Meherali et al., 2021; Zhou et al., 2020). Female adolescents are significantly more depressed and lonelier than adolescent males (Ellis et al., 2020). Those adolescents who spent a lot of time online and on social media during the pandemic had high levels of stress and depression compared to those who spent less time online (Duan et al., 2020). There is no relation between the level of physical exercise and the occurrence of depression, anxiety, and stress for males in our study. This is consistent with findings of lower levels of depression and anxiety in males than females (Ellis et al., 2020).

Physical activity is a strong positive predictor of mental health improvement and well-being during a coronavirus pandemic (Wright, Williams, & Veldhuijzen van Zanten, 2021). The same is confirmed in our study – females and males who are more physically active estimate that they cope better with isolation measures than those who are less physically active or inactive. Higher levels of physical activity are related to lower preoccupation in males in our study. In general, the more adolescents engage in physical activity, the lower their levels of stress, anxiety, depression, and greater well-being are (Rodriguez-Ayllon et al., 2019; Gianfredi et al., 2020).

The findings of our study indicate the benefits of physical activity that can reduce the negative factors caused by the coronavirus. The advantage of this research is that it encompasses a large sample of participants, both males and females. The study limitations relate to the measure of physical activity, which is in the conducted research examined with one question, so it is not comparable with the recommendation for physical activity in youth. Furthermore, only the frequency of exercise was examined, but not included daily length and the intensity level to compare with other data. Results from this study imply the need for further systematic investigations which in turn may be beneficial for clarifying the effects of the coronavirus Practical implications manifest in guidelines for experts and legislators on the importance of effective and timely interventions to protect adolescents' mental health.

Conclusion

The results of this study show that adolescents engage in some physical activity on average three to four times a week. Males exercise more frequently than girls. Most girls exercise moderately, and most males exercise five or more times a week. Girls' physical inactivity is related to negative affectivity, but not in males. Girls that are less physically active have higher levels of depression, anxiety and stress. Coping and preoccupation in males are related to the level of physical exercise, so male adolescents who exercise five or more times a week are less preoccupied about being infected and cope better with isolation measures.

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Conflict of Interest
The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Development of a Digital-Based Tool to Measure Volleyball Players' Upper Limb Muscle Explosive Power

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Abstract

It is evident that manual tools used to assess volleyball players' upper limb muscles show some shortcomings in terms of time consumption, accuracy, and high concentration that forecast errors occur during measurement. To address such an issue, this Research and Development (R&D) aims to design and develop an effective digital-based instrument for measuring arm muscles' explosive strength. The participants of this study were 52 male students that were divided into a small group (n=12) and a large group (n=40). They are sports science students at Pahlawan Tuanku Tambusai University. There were also nine experts involved in this study. These experts are from some disciplines, namely volleyball, Information Technology (IT) media, as well as test and measurement. Data were collected by means of questionnaires adopting a 4-point Likert scale. After data analysis, results show that all nine-instrument development validators who are volleyball experts, IT media experts, as well as test and measurement experts confirmed that the product developed is Very Feasible (91.58%). Moreover, the reliability test conducted using the product-moment correlation obtained r of 0.652, while the results of the effectiveness test performed using the Independent Sample t-test was 1.000>0.05. The developed tool that functions as a digital-based tool for measuring volleyball players' upper limb muscle explosive power is considered Very Feasible by the experts. Thus, it can become a useful tool for mitigating errors and enhancing accuracy to measure arm muscle explosive power in various settings and purposes.

Keywords: *arm muscle development, digital instrument development, volleyball game*

Introduction

Being acknowledged as a world-famous sport, volleyball has become more popular in Indonesia. It is a sports game whose fans and spectators are larger in number than other games, for example, basketball. Competitions in volleyball have been intensified in different corners of the globe, therefore the World Cup, Asian Cup, Professional League, and inter village tournaments that are most popular in Indonesia are now getting more popular. For that reason, the achievement and interest in volleyball in Indonesia are exponentially increasing every year. This enables Indonesian volleyball athletes to compete at the international level (Rifki, Sazeli, & Syafrizar, 2017; Rifki, Sazeli, & Syafrizar, 2022).

However, this team sport is difficult to perform since it requires intermittent bouts of high-intensity exercise which is followed by periods of low-intensity activity like walking or standing (Vasić et al., 2021). Volleyball games have a variety of staple techniques that help players to perform well on the pitch such as service, passing, blocking with both hands, and smashing. Therefore, during a volleyball match, players are involved in various offensive jumps, blocks, knockouts, and sprints where power, strength, agility, and speed are demanded (Mielgo-Ayuso et al., 2015; Michalsik, 2018). Sports professionals in general and volleyball professionals in particular,

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along with some researchers view volleyball as a sport game that requires not only techniques and tactics but also arm and muscle strength. Pursuant to (Pratama, Bagas, & Sistiasih, 2021), despite the contribution of basic technical skills in the game previously highlighted, it is also very much needed to bear a high vertical jump ability to get more points and eventually win matches either through attacks, smashes, or blocks. In other words, a person's ability to perform a good vertical jump is mostly regulated by the strength of the upper limb muscles as well as the explosiveness of the upper limb muscles (Aouadi et al., 2012; Martinez, 2017). In addition, it is also important for volleyball players to strive to reach a maximum height above the net.

The combination of arm muscles to generate work in a very lapse of time is the definition of power upper limb muscle explosion (Fachrezzy et al., 2020; Fatoni, Muhad, Jariono, Subroto, & Triadi, 2021). However, it is reported that there is a lack of such skills in many Indonesian handball players (Fadilah & Wibowo, 2018; Sunawa et al., 2018). Other studies showcased that the obstacles that could hinder achievement in volleyball games are the coaching and conventional/classical training system administered. The cutting-edge technology existing so far is partially a good remedy for such shortcomings in volleyball players in Indonesia. In line with this statement, it can be understood that the presence and incorporation of technology in sports can help increase achievements since the use of technology has not been exploited to the maximum in different areas.

The use of technology is also closely related to tests and measurements, especially in data collection as a benchmark for determining exercise programs for both coaches and players (Komaim et al., 2022). To be able to achieve good performance, a coach or athlete must also be able to measure the extent of progress as training results by conducting a test and a regular measurement process (Sands & Stone, 2005; Ian Lambert & Borresen, 2010; Serrano et al., 2013). The existing test and measurement instruments to measure the explosive power of upper arm blow that have been employed are mostly developed by experts.

According to Wiriawan (2017), the test instrument used to see the explosive power of the arm muscles is the Two Hand Medicine Ball Put. The equipment used in this test is a Medicine ball of 3 kg for men, and 2 kg for women along with, a runway marked with a 30-meter line, a notebook, and trainees. As a matter of fact, these test instruments are still manually operated. Although they can still be used for tests and measurements of explosive power, they are not really effective, efficient, and reliable. Manual measurement may take a lot of time and require careful and highly concentrated human labor, especially if there are quite a lot of trainers observing. Subsequently, errors can occur during the measurement. For such inappropriateness, a digital-based test instrument should be developed to bridge that gap. It is a credible tool manufactured manually to measure the explosive power of volleyball players' arm muscles. However, this credible tool is rare to be found in the market. Even though making digital tools requires electronic devices and equipment, at the end of the day, it can operate properly and results in accurate data. The present research was carried out to develop a digital test instrument for measuring the arm muscle explosive power of volleyball players. The focus of this article is to present the development of the instrument and its appropriateness in terms of effectiveness and efficiency based on implementation results.

Methods

Research Design, Subject, and Setting

The design of this research is Research and Development known as (R&D) with which students from the department of physical education became the participants. Purposive sampling was employed to select 12 male students (for the small-scale population) and 40 male students (for the large-scale population) from Pahlawan Tuanku Tambusai University. Those students took a Volleyball course offered by the Sports Science study program.

In developing the test instrument named the digital-based test, the researchers adopted Borg and Gall's (2014) stages. The stages are 1) Problem and Potential, 2) Data or Information Collection, 3) Product Design, 4) Design Validation, 5) Design Improvement, 6) Product Testing, 7) Product Revision, 8) Product Testing, 9) Product Revision, and 10) Mass Production.

Apart from that, there had been also the development of research constructs/variables and indicators. Normally, the explosive power of arm muscles is measured manually using a medicine ball that requires a distance measurement process in meters. However, with this new digital tool, measurements are carried out automatically, and the results can be directly read on the monitor screen (LCD). The results show the explosive power that includes the aspects of strength and speed with units of kg. m/s. Then, when a volleyball hits the surface of the board it will be read by the sensor to be then forwarded to the Arduino Uno to be processed into information to be displayed on the LCD. Overall, the indicators and information obtained from the test are presented in Figure 1 below.

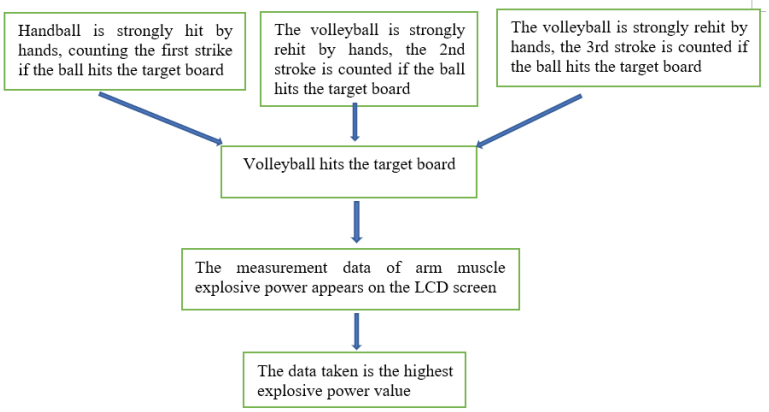

FIGURE 1. Flowchart Exhibiting the Tests Carried Out on the Developed Instrument.

Instrument and Scoring

To assess the content validity, questionnaires were developed to be then distributed to experts. The blueprint of the questionnaire contains variables of test on arm muscle explosive power indicators that include the developed tool's fitness, accuracy, convenience, practicality, reliability, and explosive power of the arm muscles. The instrument was developed based on a 4-point Likert scale where respondents are provided with answers that consist of categories of Very Good (4), Good (3), Fair (2), and Poor (1). To fill in the questionnaires, the respondents were asked to tick on the answer (Borg, 2014). The experts validating the developed test tool were from several disciplines, namely volleyball, test and measurement as well as IT. Data collected from the questionnaire were then analyzed and categorized into Very Feasible (76-100%), Feasible (56-75%), Not Feasible, 40%.

Small-scale testing was conducted with twelve students of Sports Science Education, Faculty of Education, Pahlawan Tuanku Tambusai University. This testing was done in two meetings (the first and second days), and repetition was done three times in each meeting. The categorization of the results of the reliability test is presented in Table 1 below.

Table 1. Category of r-product Moment Correlation Values

The values of 'r' Product Moment	Interpretation
0.000 – 0.199	There is a very low or very weak relationship.
0.200 – 0.399	There is a low or weak relationship.
0.400 – 0.599	There is a moderate or sufficient relationship.
0.600 – 0.799	There is a strong relationship.
0.800 – 1.000	There is a very strong relationship.

Data analysis

After addressing all data, an assessment was then carried out to obtain percentages to show the feasibility of the developed measurement device using the mathematical formula below.

$$Presentase\ (\%) \frac{Earned\ score}{expected\ score} X\ 100 \quad (1)$$

Then, quantitative data especially that from the Likert scale were qualitatively analyzed by SPSS software 26th edition based on an independent sample t-test (significance level=0.005) and Pearson correlation (Promthep et al., 2015; Isaac & Chikweru, 2018; Al-kassab, 2022).

Results

Product Description and Design

The expected final product is in the form of an electronic device to measure volleyball players' upper limb muscle explosive power (showing kg.m/s). The device has a sensor that reads the pressure generated by the field board. There is also a piece of microcontroller equipment to process the signal received from the sensor. Then, the processed information is displayed on the LCD screen, see Figure 4. The product developed as a digital-based tool is expected to be employed as a tool to measure volleyball players' arm muscle explosive power that

FIGURE 2. Censor Accelerometer.

FIGURE 3. Soccer Field Board.

FIGURE 4. LCD.

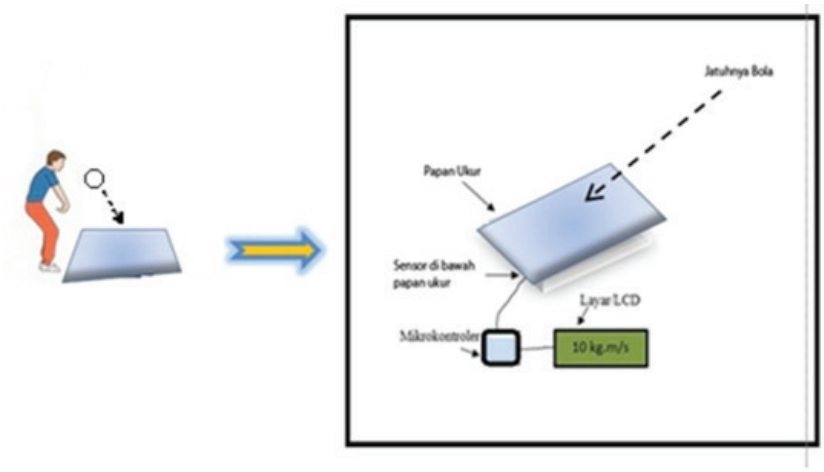

FIGURE 5. Product Proposed and Designed.

can be used in several settings such as in volleyball lessons at school, volleyball clubs, and sports science study program at university during the student admissions process.

This tool developed is equipped with other connectors and is operated together with software with an output server and LCD as depicted in Figure 5.

Volleyball Expert Validation

This developed tool was validated by experts, and the validity scores are presented below.

Table 2. Validation Results Obtained from Volleyball Sports Experts

No	Volleyball Expert Validation	Score Obtained	Max Score	(%)	Category
1	ALXL	14	20	70%	Good
2	SYXN	19	20	95%	Very Good
3	AAXN	16	20	80%	Very Good
Total		52	60	86.66%	Very Good

Based on the data shown in Table 2 above, the result of the expert judgment by volleyball experts toward the tool developed is Very Good (86.66%). It can be stated that according to volleyball experts, the aspect of the design feasibility belongs to the "Very Feasible" category.

IT-Media Expert Validation

Table 3 shows the extent of the IT-media expert validation. The total percentage obtained is 93.33%. Thus, it can be concluded that according to the IT Media Expert, the tool developed is Very Feasible.

Table 3. Validation Results from IT-Media Experts.

No	T-Media Expert Validation	Score Obtained	Score Max	(%)	Category
1	YXXH	39	40	97.5%	Very Good
2	MXXN	33	40	82.5%	Very Good
3	MXXR	40	40	100%	Very Good
Total		112	120	93.3%	Very Good

Test and Measurement Expert Validation

Table 4 shows that the cumulative result of the score obtained is 94.79%. Thus, it can be stated that according to the test and measurement experts, the tool developed is considered to be Very Feasible.

Profile of Field Trial Results (Small Group)

The rcount value (0.654) is the result of assessing the reliability which consists of test and retest. The result was obtained by correlating the best score during the first and the second days using product-moment correlation. Therefore,

Table 4. Validation Results Obtained from Test and Measurement Experts

No	Test & Measurement Expert Validation	Score got	Max Score	(%)	Category
1	IXXAZ	32	32	100%	Very Good
2	SXXDI	30	32	93.75%	Very Good
3	AXXIL	29	32	90.63%	Very Good
Total		92	96	94.79%	Very Good

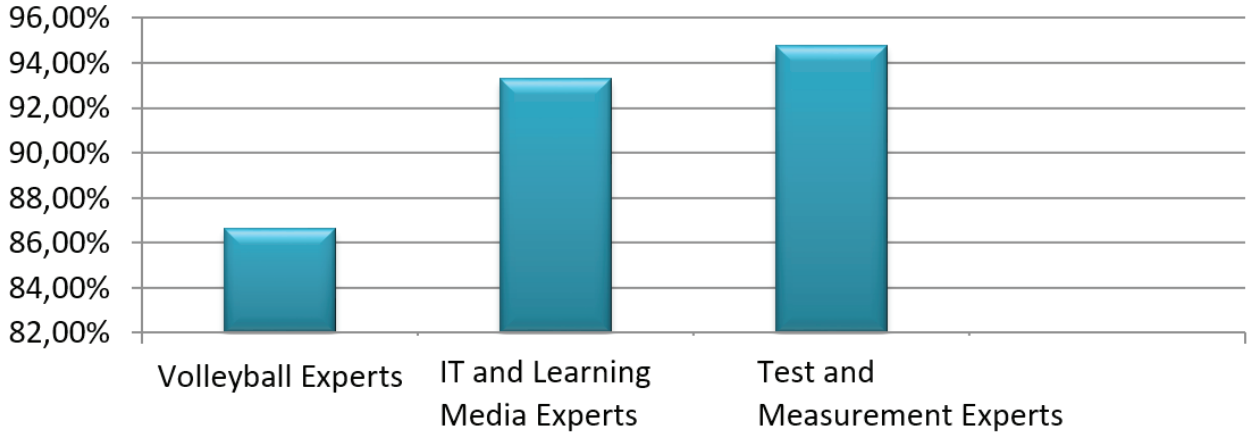

FIGURE 6. Chart Showing Data Obtained from All Experts.

the reliability score of the tool to measure arm muscle explosive power in the small group is 0.654. This latter value was interpreted according to (Date et al., 1999). A simple interpretation of the "r" product-moment (rxy) correlation index number is generally used as follows: Based on Table 1, it can be seen that the product-moment correlation results obtained

Table 5. Results of the Large Group Trial with Students

No	Coded Names	Rated Explosive Power (Kg. m/s)	
		Best Results on Day I	Best Results on Day 2
1	AXXI	7.57	7.08
2	RXXI	7.78	8.78
3	AXXA	8.93	8.81
4	FXXR	7.48	7.53
5	HXXZ	7.43	7.53
6	IXXL	8.43	8.54
7	KXXL	7.67	8.78
8	KXXK	8.03	8.14
9	SXXU	7.31	8.42
10	AXXF	8.79	8.81
11	AXXF	8.64	8.70
12	SXXL	8.88	8.95
		r_{count}	0.654

an r-value of 0.654. Thus, the reliability of the digital-based tool developed for measuring arm muscle explosive power is 0.654 and it is in the High category. Therefore, it can be concluded that the developed product can be used as a measurement tool.

Field Trial Results (Large Group)

Based on Table 6, the value rcount is 0.652. It indicates that the developed tool has high reliability. In other words, the digital tool developed is good enough to be used as a tool to measure arm muscle explosive power.

Table 6. Results of the Large Group Trial with Students

No	Coded Names	Explosive Power Score (Kg.m/s)	
		Best Results on Day I	Best Results on Day 2
1	AXXXX	8.79	7.97
2	XXXA	7.51	8.42
3	FXXXX	8.51	8.03
4	HXXXX	7.08	7.79
5	XXXXX	8.43	8.6
6	IXXXX	8.57	8.6
7	XXXXL	7.78	7.67
8	XXXXXK	7.93	7.86
9	MXXXXX	8.81	7.68
10	MXXXX	8.43	8.18
11	MXXXX	8.43	7.49
12	XXXXSXX	8.57	8.04
13	MXXXXX	7.93	8.6
14	FXXXXX	8.51	8.47
15	XXYXXX	9.79	8.79
16	XRXXXX	8.54	8.16
17	XXZXXX	7.93	7.41
18	XXAXXX	6.78	6.89
19	XXXCXX	9.40	8.6
20	XXXMXX	8.51	7.64
21	WXXXXX	7.54	7.15
22	RXXXXX	7.54	7.31
23	SXXX	8.78	8.61
24	XYXX	7.68	7.93
25	XXXX	7.93	7.86
26	WXXXX	7.79	7.51
27	WXXX	8.51	8.43
28	TXXX	8.79	8.43
29	AXXX	8.68	8.64
30	XXXIX	8.81	8.16
31	XXLXX	7.08	7.79
32	XXKXX	7.78	7.78
33	XXXY	8.57	7.73
34	AXXX	8.6	8.27
35	SXXXX	7.93	7.17
36	XDXXX	7.51	7.51
37	XXXHXX	8.08	7.94
38	XFXXX	8.43	8.66
39	XXXZX	7.51	7.21
40	XXVXX	7.79	7.85
		r_{count}	0.652

Testing the Effectiveness of the Product Developed

Based on the output in Table 7, power is shown as the value of Sig. Levene's Test for Equality of Variances of 0.792>0.05. This means that the data variance between digital tools and manual tools is homogeneous or the same. Therefore, the interpretation of the Independent Samples Test Output shown in Table 6 is in accordance with the values in the Equal Variances Assumed table.

Table 7. Output of Independent Sample T-Test

		Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
									Lower	Upper
Explosive Power	Equal variance assumed	0.07	0.0792	0	78	1	-0.001	2.236	-4.452	4.450
	Equal variances not assumed			0	78	1	-0.001	2.236	-4.452	4.450

Discussion

The explosiveness of the upper limb muscle power can be broadly understood as the ability of a cluster of upper limb muscles to produce necessary work in a very fast time (Maffiuletti et al., 2016; Rejc et al., 2018). In other words, muscles can acquaint with at a very high concentration speed. Meanwhile, muscle strength is the adaptability and ability of the upper limbs to generate maximum power concentration to defeat or overcome burdens/loads (Eston & Reilly, 2013; Saputra & Ihsan, 2020). Based on the findings explained above, the digital-based tool for measuring upper limb muscle power is very feasible to be used and can serve as an alternative measurement tool. The feasibility value was obtained by assessing the validity and reliability of the tool developed.

Several previous studies investigated and developed an appropriate tool to measure the upper limb power of volleyball players (Stockbrugger & Haennel, 2003; Cretu & Vladu, 2010; Muslimin et al., 2020; Zecirovic et al., 2021). In this present study, modifications have been made by adding a medicine ball to the previously manual procedure. These modifications were done by considering volleyball game regulations. In addition, this study is in line with previous research, but it involves android to measure volleyball players' smash skills, instead of bio motor-physical skills (Muslimin et al., 2020). Therefore, this study has objective advantages and novelty.

The main contribution of this study is that it developed a tool to measure volleyball players' explosive power of the upper limb. The external validity and test-retest were performed to increase the validity and reliability of the product developed. The tool can be used by athletes, coaches, P.E. teachers, and lecturers in sports science study programs to measure upper limb explosive power. Moreover, this new digital measurement tool was validated by IT media experts and is categorized as Very Good (86.66%). The steps of product validation conducted in this study were corroborated by Riddell & Wallace (2011) who stated that in product development research, all new products should pass through the expert judgment stage.

However, in this study, several limitations need to be acknowledged. First, mass production was not carried out due to limited research funds. Second, the range of the subject ages was limited, so the results cannot be generalized, especially to other age groups and females. Thus, further research needs to consider norms of specific values, athletes in each development stage, and other variations of bio-motor aspects, such as speed, endurance, and agility.

Conclusions

From the obtained results it could be concluded that the development of the digital-based physical exercise tool to measure volleyball players' upper limb muscle explosive power is widely welcomed by both expert's judgment and trainees in volleyball players. It was found that anthropometric profile like arm muscles and explosive power determines playing position, especially in elite female volleyball players, and influence physical performance (Mielgo-Ayuso et al., 2015; Paz et al., 2017). Moreover, height offers a performance advantage for middle blockers, whereas lower body mass, like lower fat mass, seems to perform better than setters and liberos. As a matter of fact, the designed and developed digital-based tool was assessed by three teams of validation experts, namely volleyball experts, IT media experts, as well as test and measurement experts. Based on the judgment of these experts, the measurement tool is considered to be Very Feasible (91.58%). Thus, it can be stated that the tool developed can be used for physical education purposes.

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Conflict of Interest
The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Effects of Running Intensity on Forefoot Plantar Pressure Elevation

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Abstract

Running had been known producing a posterior muscle tightness in lower extremity, particularly calf muscles, resulting in a relative equinus deformity. Numerous study reported the association between equinus deformity and foot pain, partially due to the increased plantar pressure of forefoot. This study was directed to find a relation between running intensity and increased forefoot plantar pressure. Subjects were divided into two groups according to running intensity as classified as runner or non-runner. Forefoot plantar pressures data were obtained using a foot imprinter and analyzed into numerical values. Ankle maximum dorsiflexion was also examined in an extended knee to detect the calf tightness. Mean forefoot plantar pressure value was Grau 2.89 (range 2-4) in runner group, and Grau 2.15 (range 1-4) in non-runner group ($p=0.004$). Ankle maximum dorsiflexion was also limited in runner group (16.05 ± 1.98^0) compared with 19.30 ± 1.38^0 in non-runner group ($p<0.001$). There was an association found between running intensity and plantar pressure elevation. Considering the potential damaging effects to the foot, it is recommended for runners or treating physician to look into this problem as well as to make sure that regular calf stretching is advocated.

Keywords: *equinus, forefoot, plantar pressure, runner*

Introduction

Running became more and more popular recently, and has proven benefits for health. It is easy to perform, relatively inexpensive, and has a social component (Ooms, Veenhof, & de Bakker, 2013; Junior, Pillay, Mechelen, & Verhagen, 2015). In the face of these benefits, running-related musculoskeletal problems are common among runners (Lopes, Junior, Yeung, & Costa, 2012; Kakouris, Yener, & Fong, 2021). Although acute injuries are common, a majority of running injuries can be classified as cumulative micro-trauma injuries and several identifiable factors may predict who is at risk (Ferber, Hreljac, & Kendall, 2009).

Wang et al had concluded that long distance runners appear to have posterior muscle tightness in the lower extremity (Wang, Whitney, Burdett, & Janosky, 1993). Compared with regular walking activity, the average values of gastrocnemius heads were higher during running or jogging in treadmill test (Tsuji, Ishida, Oba, Ueki, & Fujihashi, 2015). It is also known that force exerted on the Achilles tendon during running may exceeds 12-fold the weight of the runner (Hreljac, 1995). Various pathophysiology has been associated to the increased calf muscle tightness in people doing exercise regularly. Equinus deformity, in which the ankle joint dorsiflexion is decreased, one at a time has been thought to be one of the source of excessive strain throughout the foot, thus causing pain (Maskill, Bohay, & Anderson, 2010).

Metatarsalgia is one of the common causes of plantar foot pain that related to gastrocnemius muscle contracture that overload the foot (Cortina, Morris, & Vopat, 2018). Numerous study had reported the association between equinus deformity and foot pain, or between running activity and lower limb musculoskeletal alterations (Van Gils & Roeder, 2002; Amis, 2016; van Oeveren, de Ruiter, Beek, & van Dieen, 2021).

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However, there were prior studies focused on forefoot plantar pressure analysis related to running intensity. This study was directed to find a relation between running activity and increased forefoot plantar pressure as a compensatory result to give additional insight for diagnosis and treatment algorithm.

Material and methods

This was a cross sectional study comprised of thirty-nine subjects aged between eighteen years old to forty-five years old, aiming to compare the plantar pressure distribution between two groups with different running intensity.

Participants

Group 1 consisted of nineteen subjects who had running habit minimum three times a week, not less than three kilometers on each occasion, continuously for at least one year prior to the data collection. This criteria was based on a definition of runner introduced by Clement et al (Clement, Taunton, Smart, & McNicol, 1981). Group 2 consisted of twenty healthy active subjects with no regular running habit, or maximum frequency one occasion per week. Mean age of Group 1 was 26.52±5.12 years old and Group 2 was 29.65±6.08 years old. Sex was not equally distributed (thirteen male and six female subjects in Group 1; fourteen male and six female subjects in Group 2) as seen in Table 1.

Exclusion criteria were as follows: (1) any fixed foot deformity such as pes planovalgus or cavovarus, (2) history of having any significant scar wound or surgical wound on ankle and foot region, (3) known comorbidity that affected musculotendineous contractility such as diabetes or inflammatory arthritis. This study was approved and registered by Universitas Padjadjaran Institutional Review Board No. 650/UN6.KEP/EC/2022 before commenced.

Measurements

Plantar pressure data were obtained at the subjects' running field or workplace (Fig.1), utilizing a Harris Mat foot imprinter, Podiascan scanner and converter software (Diabetik Foot Care Pvt Ltd, Tamil Nadu, India). Footprint were taken from dominant foot from a stance phase of a pace, on natural stride length and comfortable speed. Pressure load of forefoot areas particularly first and second metatarsal head region was classified according to numerical values based on the study by Silvino, Evanski, and Waugh as shown in figure 2 (Cisneros, Fonseca, & Abreu, 2010; Silvino, Evanski, & Waugh, 1980). The highest values of forefoot area plantar pressure from each subject were collected and agreed by two examiners, as illustrated in figure 3. All subjects were also examined for ankle joint maximum dorsiflexion measured by a goniometer, with and without knee flexed.

FIGURE 1. Footprint taking using Harris Mat.

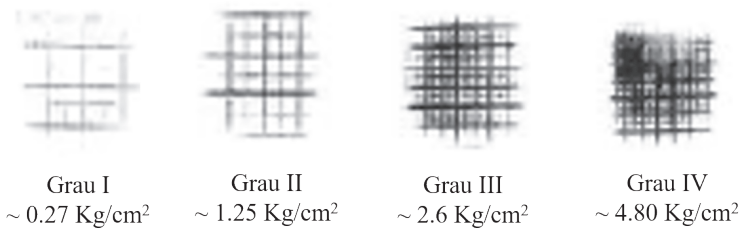

FIGURE 2. Plantar pressure patterns classification based on study by Silvino, Evanski, and Waugh.

Statistics

Data were documented and statistically analyzed to indicate the differences between two independent groups by Mann Whitney U test (Table 1) using IBM SPSS Statistics for Windows, Version 28.0 (Armonk, NY: IBM Corp) software. P<0.005 was considered significant.

Results

Mean forefoot plantar pressure value was Grau 2.89 (range 2-4) in group 1 and 2.15 (range 1-4) in group 2. Mean ankle joint maximum dorsiflexion in group 1 was 16.05±1.98^0 (range 14^0-22^0) in flexed knee and 12.73±1.32^0 (range 10^0-15^0) in extended knee, while in group 2 was 19.30±1.38^0 (range 17^0-

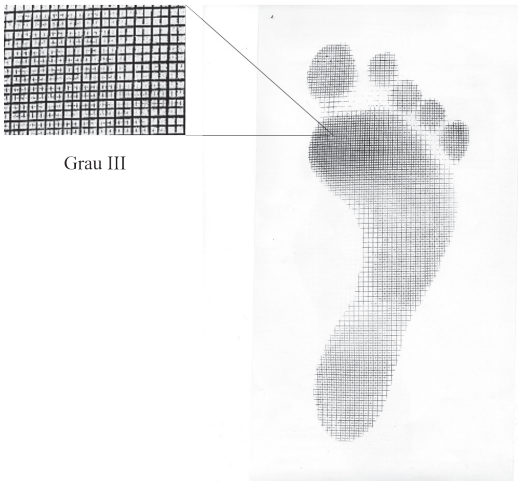

FIGURE 3. Illustration of a footprint depicting Grau 3.

22^0) in flexed knee and 15.8±1.38^0 (range 13^0-18^0) in extended knee. There was significant difference between groups obtained from Mann Whitney U test in terms of forefoot plantar pressure mean (p=0.004) and ankle maximum dorsiflexion mean (p<0.001), while ankle maximum dorsiflexion in flexed knee was not significantly different between two groups (p=0.977).

Table 1. Comparative results between groups.

	Group 1	Group 2	p-value
Age (years)	26.52±5.12	29.65±6.08	
Sex (n)			
Male	13	14	
Female	9	6	
Forefoot plantar pressure mean (Grau)	2.89	2.15	0.004
Ankle maximum dorsiflexion mean (degree)			
With knee flexed	16.05±1.98	19.30±1.38	0.977
With knee extended	12.73±1.32	15.8±1.38	<0.001

Discussion

Foot pain during walking is associated with high plantar pressures generated during gait (Mickle, Munro, Lord, Menz, & Steele, 2010). The results of this study was in concordance with prior studies noticing higher peak plantar pressures in people with equinus foot more than those without the deformity (Lavery, Armstrong, Boulton, & Diabetex Research Group, 2002) as well as the association between running exercise and calf hypertrophy (Ozaki, Loenneke, Thiebaud, Stager, & Abe, 2013; van Oeveren et al., 2021). Equinus deformity was stated if the ankle dorsiflexion was less than 10^0 with the knee flexed that it may occur from bony deformity or from soft tissue contracture, particularly triceps surae muscles or Achilles tendon. Tendon imbalance between bulky posterior muscles and thinner anterior side musculatures in lower leg may result in relative equinus, which in turn will increased stress in forefoot. More than merely pain, ankle equinus contributes to many other foot problems, such as deformities and ulceration. Inadequate ankle dorsiflexion requires compensation within the foot which requires subtalar joint and midtarsal joint to be altered. These abnormal compensatory motion will result in further damage as well (Van Gils & Roeder, 2002).

It is understood that long period of physical exercise such as walking or running can increase leg muscle size even though the investigation of its effect on muscle morphology is still controversial. This study showed that the plantar pressure was significantly higher in runners (Group 1) compared with non regular runners. Particularly, this was attributable to tight calf muscles that decrease the excursion resulted in increased forefoot pressure. Running, walking, and hiking are known as excellent calf-strengthening exercises, especially in inclinations (Ozaki et al., 2013; Chang, Li, Wang, & Zhang, 2020; van Oeveren et al., 2021). Acceleration or agility training in sports that include run, jump, and push off will be beneficial too for toning the calf muscles. Evaluation of maximum ankle joint dorsiflexion between groups presented different comparison regarding whether the knee joint was flexed or extended. Mean of ankle joint range of motion was significantly different with knee extended, but not in flexion. This examination adapted the Silfverskiold test that used to identify isolated gastrocnemius contracture. It was noticeable that the different plantar pressure values between groups was due to gastrocnemius contracture and not Achilles tendon, while bony deformity as a possible cause had been excluded from initial subject selection. This finding confirmed that the limited ankle joint motion was attributable to calf muscle hypertrophy. However, the Achilles tendinopathy as one of the viable sources of contracture was not ruled out at this point.

Non-neuromuscular isolated gastrocnemius contracture deformity among healthy individuals is often subtle or silent. There is a theory namely the split second effect that describing a critical time span during terminal midstance, where damaging forces are produced along the whole tension chain, that explained why a silent equinus contracture can gradually cause

significant harm when left untreated (Amis, 2016). Routine gastrocnemius stretching is advisable for athletes. Prior studies reported a significant higher ankle dorsiflexion flexibility measurements in athletes undergoing routine gastrocnemius stretching compared with control group (Macklin, Healy, & Chockalingam, 2011; Knapik, La Tulip, Salata, Voos, & Liu, 2019). The training regiments included keeping the knee of the stretched leg straight with the heel flat on the ground while bending the front knee and pushing the hips toward a wall. This exercise was held for 10 seconds, repeated 20 times 3 times daily (Knapik et al., 2019). Different result was reported by Searle et al, noticing no meaningful effect of static calf muscle stretching on ankle range of motion, or plantar pressure, in people with diabetes and ankle equinus (Searle, Spink, Oldmeadow, Chiu, & Chuter, 2019).

This study has three main limitations. The most obvious limitation was the design and the sample size. A randomized study involving more cases is necessary to verify the validity of this result. Second limitation is multiple confounding factors that may contribute to the contracture development, such as vascular status, blood glucose level, and smoking habit were not objectively analyzed. Third, the subjects were not categorized according to running types. In fact, calf muscle exercise will be different among sprint, endurance, or recreational running. However, this study may provide framework to define the diagnostic and treatment algorithm regarding foot problems in runners.

Conclusion

There was an association found between running intensity and plantar pressure elevation. This is attributable to the gastrocnemius tightness resulted from long time exercise particularly on calf muscles. Other than metatarsalgia due to increased forefoot pressure, this condition may be harmful to other parts of the foot as well. Isolated gastrocnemius contracture, even though asymptomatic, must be addressed to prevent further damage. It is recommended for runners or treating physician to look into this problem and to make sure that regular calf stretching is advocated.

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Conflict of Interest
The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Russian vs. American Kettlebell Swing – Which One to Choose?

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Abstract

Kettlebell swing exercises have been proposed as a method for developing power, strength, endurance, and aerobic capacity. There are two distinctive techniques or styles of kettlebell swing: Russian (RKBS) and American (AKBS), and the purpose of this study was to quantify the specific differences within each exercise. The aim of this paper was to determine which style offers greater mechanical output in the form of power, velocity and momentum, with consideration of energy expenditure and injury risk, and which represents a safer version of training operator for developing specific dimensions of strength and power along with muscular endurance. The selected population of physically active men (n=15; age: 27.5±4.5 years; height: 185.9±14.1 cm; weight: 96.1±11.1 kg; kettlebell swing experience: 3.6±2.4 years) were recruited to perform kettlebell swings of both styles. They performed eight maximal swings using a 24 kg kettlebell (~25% bodyweight), during which the concentric and eccentric phases and their respective amplitude, duration, peak and mean velocity, momentum and average power were analysed. The results of the paired sample t-test showed a statistically significant difference between styles in cycle duration, momentum, amplitude and velocities, while power generated was similar for both styles. In conclusion, both styles are viable training options, though the RKBS style presents a potentially safer alternative due to its biomechanical properties.

Keywords: *kettlebell training, power, strength, muscle endurance*

Introduction

Kettlebell training has been gaining in popularity among the professional and amateur population and even military and police organisations (Andersen et al., 2015), since it enables the simultaneous development of strength, power and muscular endurance, as well as improving aerobic capacity (Frrar et al., 2010). The kettlebell swing forms the technical base of most other kettlebell exercises, though it is often used on its own in many training programmes (Frrar et al., 2010).

The ballistic nature of this exercise is characterised by potentially great amounts of mechanical work in a short period of time via functional acceleration and deceleration (Brumitt et al., 2010). Its relatively low technical demands and use of relatively light loads makes this exercise effective in power development via quick force production in the lower extremities (Lake & Lauder, 2012). In addition, the power generated during the movement enables greater activation of motor units, which can be beneficial in the development of strength (Maulit et al., 2017).

There are two distinctive techniques of kettlebell swing: Russian (RKBS) and American (AKBS). Both are characterised by specific ballistic flexion, followed by ballistic extension of the hip joint. After initial launch, the kettlebell is brought into the bottom position by the means of active hip flexion, which is determined by hamstring flexibility and the ability to maintain a neutral spine position (McGill & Marshall, 2012). Following this, explosive hip extension is used to bring the kettlebell into the end position where the main difference lies. RKBS ends when the arms are in front of the body, parallel to the floor, whereas AKBS ends with the

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arms overhead and perpendicular to the floor (Kruszewski et al., 2017). The movement is repeated as many times as necessary.

While the RKBS and AKBS styles have similar overall mechanical characteristics, there are specific differences within each exercise (Bullock et al., 2017). Specifically, RKBS exhibits less vertical impulse, vertical displacement, and time (Lake & Lauder, 2012; Falatic et al., 2015) during the propulsion (up) phase and the braking (down) phase than AKBS (McGill & Marshall, 2012; Lake et al., 2014; Bullock et al., 2017). The decreased cycle time in RKBS is associated with a smaller amount of time under tension, which may elicit lower internal joint and tissue loads than AKBS during the swing-braking (down) phase, while simultaneously generating similar peak loads as AKBS (Mohamad, Cronin, & Nosaka, 2012).

Although some kinematic and kinetic similarities and differences are known between the two kettlebell swing styles, it is still not clear which is better or more appropriate for developing strength, power and endurance. Based on the present experiences and those from professional practice, we can assume that both styles have their respective roles in the training process of professional and recreational athletes, so the aim of this study was to determine which style offers greater mechanical power output, velocity and momentum, taking account of energy expenditure and potential risk of injury, to determine which technique represents a safer training operator. To the extent of our knowledge, there are no studies that have conducted kinematic and kinetic analysis based on tracking the kettlebell only.

Methods

Participants

Fifteen healthy, physically active male participants volunteered in the study (age: 27.5±4.5 years; height: 185.9±14.1 cm; weight: 96.1±11.1 kg; kettlebell swing experience: 3.6±2.4 years). There was a mandatory orientation session for a minimum of 72 hours before testing, during which technical corrections were made and for participants to become accustomed to a heavier weight than usual as this could affect their performance, especially during AKBS where the kettlebell ends in the overhead position.

Subjects restrained from performing any exercise for 72 hours before testing. None of the subjects had a recent history of any injury. After verbal introduction about the goal and potential risks of the study, each subject read and voluntarily signed a detailed informed consent form. The Ethics Committee of Faculty of Kinesiology, University of Zagreb approved the study protocol (Decision number: 75/2020, 3 March 2020). The study is in compliance with the Helsinki Declaration.

Variables

The following variables were measured under two conditions (RKBS and AKBS) during the kettlebell swing and recorded: distance (L) during the concentric and eccentric phase of the swing expressed in meters (m), concentric and eccentric phase duration (t_{avg}) expressed in seconds (s), peak (v_{max}) and average velocity (v_{avg}) of concentric and eccentric phase of the swing expressed in meters per second (m/s), peak (p_{max}) and average (p_{avg}) momentum expressed in kilogram-metre per second (kg·m/s), and average kinetic energy (E_{avg}) expressed in Joules (J). The average power generated was calculated based on the average kinetic energy and time during the concentric phase of the swing ($P_{avg} = E_{avg} / t_{avg}$) and expressed in watts (W) (Hamill & Knutzen, 2009).

Procedure

Standardised warm-up preceded testing and consisted of a low intensity running protocol and dynamic stretching, followed by specific warm-up in the form of 10 repetitions of kettlebell swings using ~10% of participant body mass. The testing procedure was performed during a single training session and procedures were done with at least five minutes of rest between conditions.

After assuming the proper starting position, participants performed eight maximal kettlebell swings with a 24 kg kettlebell, which is close to 25% of their body weight. Due to the nature of kettlebell training, there is no established standardised recommendation for weight selection during exercise, nor is it based on a one repetition maximum, so a percentage of the averaged group body mass was used to provide as close an approximation as possible to the same resistance regardless of body mass differences (Levine et al., 2020). The first and last repetition were excluded from the analysis primarily because they were affected by initiation and cessation of the exercise (Levine et al., 2020).

Two Dimensional (2-D) Kinematic Analysis

Video was captured by smartphone video camera (Iphone 12, Apple, CA) filming at 1080p HD at a rate of 60 frames per second. The purpose of kinematic analysis was to determine kinematic variations that can be identified from the sagittal view (Van Gelder et al., 2015). The use of sagittal plane video analysis has been shown to be a valid and reliable measure of movement patterns during a dynamic functional task (Norris & Olson, 2011). The camera was positioned laterally, 3.7 meters away from the position of the subject. A marker (2.5 cm white circle) was placed in the middle of the kettlebell to provide a reference point for consistency in measurements of kettlebell trajectory. Videos were archived onto a laptop for analysis. Tracker, a free video analysis and modeling tool from Open-Source Physics (OSP) v 5.0.6. program was used to analyse the collected video materials.

Statistical analysis

All data collected was processed using STATISTICA, ver. 13.4 for Windows. Basic descriptive statistic parameters were calculated as means and standard deviations and paired samples t-test was used to determine whether there was a statistically significant difference between RKBS and AKBS with regards to distance, peak and mean momentum, peak and mean velocity and mean power. The accepted level of significance in this study was $p<0.05$.

Results

The mean values and standard deviations of amplitude, duration, peak and mean velocity, peak and mean momentum, and peak power for the concentric and eccentric phases of the Russian and American kettlebell swing styles are shown in Table 1. Paired samples t-test showed significant differences ($p<0.05$) in all tested variables, with the exception of mean power ($p=0.681$; Table 1).

Table 1. Differences between Russian and American Kettlebell Swing Style.

	Variables	Russian kettlebell swing	American kettlebell swing	p
Concentric phase	Amplitude (m)	1.92±0.19	2.49±0.22	0.000*
	Duration (s)	0.73±0.05	0.89±0.08	0.000*
	Peak velocity (m/s)	4.71±0.82	5.43±0.70	0.000*
	Mean velocity (m/s)	2.41±0.28	2.56±0.22	0.006*
	Peak momentum (kg·m/s)	116.39±14.97	130.28±16.83	0.000*
	Mean momentum (kg·m/s)	57.32±6.25	61.51±5.21	0.000*
	Mean power (W)	126.96±33.9	125.14±27.34	0.681
Eccentric phase	Duration (s)	0.86±0.06	1.05±0.09	0.000*
	Peak velocity (m/s)	5.02±0.59	5.63±0.73	0.001*
	Mean velocity (m/s)	2.43±0.21	2.53±0.13	0.039*
	Peak momentum (kg·m/s)	120.01±14.18	135.02±17.50	0.001*
	Mean momentum (kg·m/s)	58.16±5.28	60.47±3.17	0.040*

Note. Results are presented as means±standard deviations; *p<0.05.

Discussion

The study showed that the American kettlebell style had greater velocities, duration, and amplitude as well as peak and mean momentums in both the concentric and eccentric phases than the Russian style, though the power output was the same for both styles. Does this suggest that the American style is better than the Russian style? And if so, better for what? This is no single answer to this question, as each of the variables needs to be considered separately and placed in the context of the goal that the exercise seeks to achieve.

First, it should be noted that the higher eccentric phase velocity and momentum makes it a viable prevention tool for hip extensor muscles. Matthews and Cohen (2013) showed that sudden loading during the eccentric phase, followed by rapid contraction of the hamstring muscles, meets the specific requirements for the rehabilitation and prevention of hamstring injury (Comfort et al., 2009). On the other hand, the higher velocity and momentum also makes it a higher risk. It should be emphasised that a person using AKBS must have a higher level of technical proficiency and intramuscular coordination to decelerate and stop the movement of the kettlebell (Lake & Lauder, 2012). Mitchell et al. (2015) analysed the biomechanical requirements during AKBS and reported higher compression forces on the shoulder joint and appurtenant musculature during the end of the concentric phase of the swing. The presence of great compression force indicates that the momentum generated during the swing, unless controlled, can cause high shear forces, greatly increasing the risk of injury, even though the compression is relatively small. According to McGill and Marshall (2012) in terms of the relative risk, compressive loads from AKBS are not problematic, though the large shear to compression load ratio on the lumbar spine suggests that AKBS may be contraindicated for some individuals with spine shear load intolerance (McGill & Marshall, 2012).

Moreover, it is worth noting that if the shoulder mobility is not sufficient during the performance of AKBS, compensation movements are developed, especially lumbar lordosis (Hulsey et al., 2012). This is a mechanism that creates compression during spinal flexion, which is a common cause of disc protrusion (Keilman et al., 2017).

In contrast, RKBS does not include the trajectory part that creates unwanted compression, and it offers constant muscle tension, which can prove beneficial in developing shoulder stabilizer strength. In addition, Jay et al. (2011) suggested that the use of ballistic cyclic training, which generates high peak forces, substantially reduces lower back, neck and shoulder pain.

Other variables to consider are the amplitude and duration of the swing cycle. Results also showed that AKBS has significant 30% higher amplitude and 22% longer cycle duration. Therefore, we can assume that AKBS could ensure better development of muscular endurance than RKBS with equal training volume (i.e., equal number of sets and repetitions). Bullock et al. (2017) compared several kinematic parameters of the Russian and American style as well as the Indian club swing and similarly found a 34% greater cycle duration of the American style and subsequently greater workload compared to other types. Frrar et al. (2010) concluded that kettlebell training is more effective than circuit training using free weights when metabolic demand is considered. Furthermore, Falatic et al. (2015) showed that kettlebell training provided greater benefits than free weight and bodyweight training in oxidative capacity by increasing VO2max levels without losing weight.

The final feature is that both styles ensured equal mechanical power production, which is similar to the results reported by Lake, Hetzler, and Lauder (2014). Since the styles differ significantly in concentric phase duration, amplitude, and velocity, mechanical power output was expected to be similar, but was not. Given the benefits and risks that both styles provide, it seems safer to choose RKBS when the exercise goal is mechanical output in terms of power, as RKBS provides equal power output with less risk.

However, there are some limitations to this study. First, kinematic analysis was performed in two dimensions, meaning that every video was recorded in a single plane, with the possibility that a certain loss of data occurred regarding kettlebell trajectory in other planes. However, considering that the kettlebell swing is performed only in the sagittal plane and that there is less than two degrees of lateral deflection (McGill & Marshall, 2012), we can presume that any loss of data is minimal and negligible. Secondly, the body mass of subjects was highly variable (±11.1 kg), meaning that lighter subjects were in a relatively disadvantaged position during the performance

of the swing. And finally, only one kettlebell weight was analysed, so we can presume that using a different weight would likely alter some of the relations between the mechanical outputs. In addition, Wesley and Kivi (2017) suggested that by changing the load, it is possible to significantly affect training outcomes during kettlebell exercise.

Conclusion

Kettlebell swing has taken its rightful place in the fitness industry among the "arsenal" of strength and conditioning coaches as an exercise that can be considered an important tool in developing strength, power and muscle endurance thanks to its unique ballistic nature. Both styles, American and Russian, offer unique possibilities such as rapid contraction and relaxation cycles that emphasise hamstring and hip extensor strength and power development. In addition, both styles offer considerable stimulus on the trunk stabilizers, which maintain their integrity and the natural curvature of the spine. However, the higher compression to shear ratio put on the lumbar spine during AKBS can be contraindicated for people with low back pain. Therefore, RKBS is recommended as it offers equal power output attained in a much safer manner.

In conclusion, despite their specific nature, both styles offer the same power output, though RKBS attains it in a safer manner and therefore could be used in rehabilitation purposes, while AKBS could potentially offer unique benefits when muscular endurance is the primary goal, all while maintaining the highest levels of technique mastery.

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Conflict of Interest
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

Analysis of Offensive Transitions of Barcelona based on the Initial Penetration after the Ball Recovery

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Abstract

Coaches and analysts alike agree that offensive transitions are very important in modern football. However, only few studies have analyzed offensive transitions in depth. The aim of this study was to analyze the effect of initial penetration on the tactical elements of offensive transitions of Barcelona during the period 2018-19. The sample included 1164 offensive transitions (605 with penetration and 559 without penetration), from 37 matches. The phases were recorded using SportScout analysis software. The parameters of the study were: outcome of attack, match location, quality of opposition, zone of ball recovery, type of ball recovery, initial opponent number, players in possession, type of attack, duration of attack, time frame of attack and match status. The statistical processing of the data was done with the Crosstabs analysis and the Chi-square significance test. The results showed that the tactical characteristics of Barcelona's offensive transitions were significantly influenced by the initial penetration of play, with the exception of zone of ball recovery and quality of opposition parameters. In conclusion, it seems that the profile of Barcelona's offensive transitions is influenced by the initial penetration. Also, the findings on quality of opposition suggest that Barcelona utilizes a similar play-style, regardless of opposition. Finally, the fact that offensive transitions that had penetration were almost equal to those that had no penetration, confirms that Barcelona didn't always try to attack, as soon as they recovered possession, but often chose to complete more passes, aiming to develop its attacking play with more patience and less risk.

Keywords: *soccer, attacking phase, tactics, video-analysis*

Introduction

Football analysts have mainly focused on the characteristics related to the attack, setting aside the processes that express the dynamic of the game (Fernandes, Camerino, Garganta, Hileno, & Barreira, 2020). In addition, in football it seems important to understand the relation between the recovery of ball possession and the impending success or failure of the attack that follows (Barreira, Garganta, Guimaraes, Machado, & Anguera, 2014).

Despite that, little research has been done on the connection between: a) the type of ball recovery in different field zones, b) the level of competition and c) the overall success of the teams (Barreira et al., 2014). Also, the finding of how and where the ball recovery takes place at the top level is crucial for the understanding of the attacking patterns and the time sequence of the actions, while the resulting knowledge can be used for the creation of specific training drills (Barreira, Garganta, Machado, & Anguera, 2014).

According to Cooper & Pulling (2020), the importance of ball recovery has been recognized by research conducted in the past. However, the same authors report that there is still a need to investigate a range of variables, that impact on ball recoveries and the impending possession. Therefore, this specific study is of particular interest for coaches, while, at the same time has the necessary originality, as it examines a field that is of great importance to coaches and hasn't been sufficiently explored in the past.

The field in question is that of offensive transitions, name-

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ly the attacks that happen after recovering ball possession. Offensive transitions are a football element that occupied both the study of Hughes & Lovell (2019) and the study of Turner & Sayers (2010). However, it is a part of the game that hasn't been extensively examined from previous research that had the analysis of offensive tactics in football as their objective.

At the same time, initial penetration is a parameter that has been shown in the past that can play an important role in the outcome of phases. According to González-Rodenas et al. (2019) the initial penetration can really be an important factor in creating goal scoring opportunities. More specifically, the authors state that the initial penetration played an important role in achieving offensive penetration, but also in creating goal scoring opportunities in games of the Spanish league (La Liga).

Concerning Barcelona, it seems that coaches recognize the quality of the team's playstyle, based on the way it manages ball possession, which is difficult to deal with for all teams (Sarmento et al., 2013). The difficulty in dealing with Barcelona when it has ball possession is mainly due to its passing game ability. The man who made a great contribution to the development of Barcelona's passing game was Johan Cruyff, who served the team from two different posts, first as a player and later as a coach (Chassy, 2013).

In addition, LópezBondia, González-Rodenas, Calabuig Moreno, Pérez-Turpin & Aranda Malavés (2017) report that Barcelona does not always try to attack immediately after regaining ball possession, but often chooses to complete more passes, aiming to develop its attacking play with more patience. This claim seems to be confirmed by the sample of this present study, since from the 1164 offensive transitions that Barcelona completed, the 605 had penetration and the 559 had no penetration.

In conclusion, the reason why the games of Barcelona were chosen was because the team is a reference point, for football as a whole, as it has many times defined the football trends in terms of playstyle. This is due to the fact that many teams around the world try to implement attacking elements of Barcelona's game into their game. This is probably due to the very popular and very effective offensive game it uses and characterizes the team.

The purpose of this study was to analyze the effect of initial penetration on the tactical elements of offensive transitions of Barcelona during the season2018-19. The research of Barcelona's match behavior is of particular interest since according to Chassy (2013),the famous passing game that Barcelona widely uses to this day, has led to win significant titles, both Barcelona andt he Spanish national team (also utilized the same play style).

Method

Sample

The sample of the study included the offensive transitions that Barcelona completed (1164 offensive transitions in total) in 37 out of the 38 matches that the team played in one of the top European Championships, that of Spain. Specifically, all the offensive transitions that Barcelona made in its games in the Spanish La Liga of the 2018-2019 season were recorded and evaluated in terms of their tactical characteristics.

The selection criteria of the championship was that, apart from Barcelona, top clubs of the European continent compete in it, such as Atletico Madrid, Real Madrid, Valencia, Sevilla and Athletic Bilbao. The high level of the championship studied is evidenced by the fact that the aforementioned teams have won many European titles and most of their participations in European competitions are remarkable. Regarding the selection of Barcelona, it relied on its dominance in the last decade and especially in the 2017-18 and 2018-19 seasons, when it won two championships with differences of more than 10 points from the second team in the standings and at the same time played in 2 Spanish Cup finals, winning the trophy one of the two times.

Data collection and measuring instruments

The observation protocol was created to observe the matches of this study concerned the offensive transitions. At this point, it should be noted that an attack is considered an offensive transition when at least two completed passes are made between teammates, when a player carries the ball forward for at least 15 m (Turner & Sayers, 2010) and when a ball recovery is followed by a goal scoring opportunity. Offensive transitions are completed when a goal attempt is made, when a goal is scored, when a defender intervenes on the ball, but the attacking team retains ball possession, when ball possession in lost and when the game is interrupted for any reason. Excluding offensive transitions are the phases where the attacker passes the ball back to the goalkeeper, those that despite the intervention of the defenders the ball remains in the possession of the attacking team and those that begin after the application of the fair-play rule.

Thus, the analysis scheme (observation protocol) contained the following parameters:1) initial penetration, 2) outcome of attack, 3) match location, 4)quality of opposition, 5) zone of ball recovery, 6)type of ball recovery, 7) initial opponent number, 8) players in possession, 9) type of attack, 10) duration of attack, 11) time frame of attack and 12) match status (Table 1).

Table 1. The Categories of Analysis and their Respective Parameters

Categories	Parameters	Operational definitions of the parameters
Initial penetration	Penetration	Passes or dribbles towards the opponent´s goal past opponent player(s) performed in the first 3sec of the ball possession (González-Rodenas et al., 2015).
	No penetration	Any technical action towards any direction that does not past opponent player(s) performed in the first 3sec of the ball possession (González-Rodenas et al., 2015).
Outcome of attack	Goal	The team scored a goal.
	Scoring opportunity	The team made a shot or a header on/off target without scoring a goal.
	No scoring opportunity	The team had no chance to score a goal.
Match location	Home Away	

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Table 1. The Categories of Analysis and their Respective Parameters

Categories	Parameters	Operational definitions of the parameters
Quality of opposition	2nd-7th	The teams that finished 2nd-7th in the league standings.
	8th-14th	The teams that finished 8th-14th in the league standings.
	15th-20th	The teams that finished 15th-20th in the league standings.
Zone of ball recovery (Figure 1)	RDZ	Right defensive zone.
	CDZ	Central defensive zone.
	LDZ	Left defensive zone.
	RCDZ	Right centre-defensive zone.
	CCDZ	Central centre-defensive zone.
	LCDZ	Left centre-defensive zone.
	RCOZ	Right centre-offensive zone.
	CCOZ	Central centre-offensive zone.
	LCOZ	Left centre-offensive zone.
	ROZ	Right offensive zone.
	COZ	Central offensive zone.
	LOZ	Left offensive zone.
Type of ball recovery	BR1	Ball possession recovered by any means other than from a player of the same team with the ball in play after a pass or a wrong control of the ball (Aranda et al., 2019).
	BR2	During restart, the tactical situation of the opposite team is not prepared to try to shot at goal or to cross the ball in penalty box in 1-2 passes and that's why tries to pass the ball forward in order to attack (Aranda et al., 2019).
	BR3	During the set-play (corner, foul or penalty), the tactical situation of the opposite team is not prepared to try to shot at goal or to cross the ball in penalty box in 1-2 passes (Aranda et al., 2019).
	BR4	All ball recoveries that came after actions of attackers (wrong control of the ball, wrong dribbling, wrong pass, wrong dribble etc) and led to the ball being recovered by the analyzed team (Gómez et al., 2012).
Initial opponent number	1-3 players	
	4-5 players	
	6 players	
	7+ players	
Players in possession	0-3 players	
	4-5 players	
	6+ players	
Type of attack	Combinative attack	In combinative attack the number of passes were ≥4 (Papadopoulos et al., 2021) and usually >7. The team aims to maintain the ball possession, until the right opportunity to attack is found and its duration depends on the number of players participating in it. (≥11sec and usually >20sec). Combinative attack ends with a shot or a header, when a goal is scored, when ball possession is lost and when for any reason the game is interrupted.
	Direct attack	Team tries to pass the ball fast towards the opponent´s goal with a long pass. Through long pass, the ball move forward ≥20m, while usually ≤40m (Fernández-Navarro et al., 2018). Direct attack ends with a shot, with a goal, when ball possession is lost and when for any reason the game is interrupted.
	Fast attack	In fast attack the circulation of the ball is performed in width and depth with short and quick passes (maximum of 7) with a maximum duration of 18sec and the players with a direct participation in attack are 6 in maximum (Sarmento et al., 2018). A fast attack ends with a shot, with a goal, when ball possession is lost and when for any reason the game is interrupted.
	Counter-attack	Counter-attack starts by winning the ball in play and progresses by either utilizing or attempting to utilize a degree of imbalance from start to the end of the attack. During the ball possession could be used passes in depth (and long passes), while the circulation of the ball takes place more in depth than in width. Moreover, number of passes is small (≤5) and a quick offensive transition (usually with duration ≤12sec) from the zone where the ball is recovered to the finishing zone. The number of players intervening directly on the ball were usually ≤4 (Sarmento et al., 2018). A counter-attack ends with a shot, with a goal, when ball possession is lost and when for any reason the game is interrupted.
	Very short attack	The attack that the ball possession starts by winning the ball in play or restarting the game and the duration of the team possession is too short to allow the observer to categorize it in the other types of attack (Aranda et al., 2019). Very short attacks have duration ≤10sec and end with a shot, with a goal, when ball possession is lost and when for any reason the game is interrupted.

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Table 1. The Categories of Analysis and their Respective Parameters

Categories	Parameters	Operational definitions of the parameters
Duration of attack	Very short	Attacks that lasted 0-4sec.
	Short	Attacks that lasted 5-10sec.
	Long	Attacks that lasted 11-20sec.
	Very long	Attacks that lasted 21+sec.
Time frame of attack	0:01-15:00	
	15:01-30:00	
	30:01-45:00	
	First half added time	
	45:01-60:00	
	60:01-75:00	
	75:01-90:00	
	Second half added time	
Match status	Winning	Barcelona was winning.
	Drawing	Barcelona was drawing.
	Losing	Barcelona was losing.

The observation of the matches and the collection of the data was done using the SportScout analysis software. The recording of the phases started when Barcelona regained possession of the ball and ended when a goal was scored or when the game was stopped for any reason (e.g., offside).

The observation protocol was created with the assistance of a professional high level football coach. The validity and reliability of the data were checked using the intra-observation agreement, with which both the coach and the observer recorded (separately) 60 random offensive transitions, in accordance with the observation protocol already formatted for the needs of the present study. From Cohen's Kappa value, it appeared that the parameters were recorded correctly by the observer (k=1.000 for all indicators). Then, to check the stability regarding the correct recording of the phases, another 60 phases were observed, but this time only by the observer. After a week, the same observation was repeated where Cohen's Kappa value was high (k=1.000), which confirmed that the observer was consistent in recorded the phases (Papadopoulos et al., 2021).

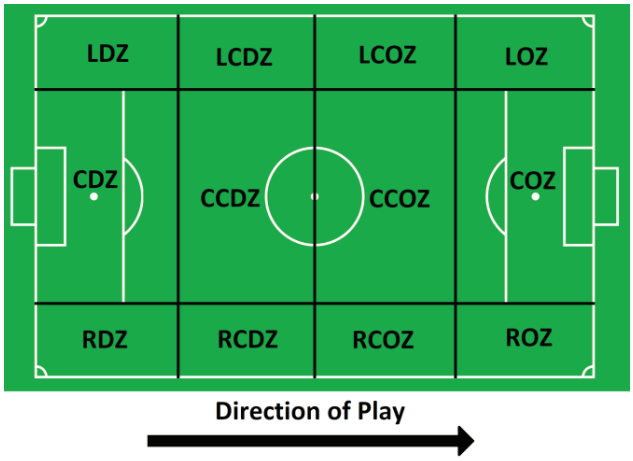

FIGURE 1. Field zone and the zones of ball recovery.
Legend: LDZ – Left Defensive Zone, CDZ – Central Defensive Zone, RDZ – Right Defensive Zone, LCDZ – Left Centre-Defensive Zone, CCDZ – Central Centre-Defensive Zone, RCDZ – Right Centre-Defensive Zone, LCOZ – Left Centre-Offensive Zone, CCOZ – Central Centre-Offensive Zone, RCOZ – Right Centre-Offensive Zone, LOZ – Left Offensive Zone, COZ – Central Offensive Zone, ROZ – Right Offensive Zone.

Data analysis

The data were analyzed using the SPSS statistical analysis software. The type of analysis used was the Crosstabs analysis and the criterion of the Chi-square test significance value $p<0.05$. In case even one expected price was <5 (cases where the conditions of statistical analysis were not met), then Fisher's exact test value was used. The purpose of the above analysis was to check whether the frequency of occurrence of the parameters observed for the offensive transitions depended on the initial penetration.

Results

According to the results (Table 2), a significant effect of the initial penetration was observed in all parameters, except the zone of ball recovery (Fisher=17.900, $p>0.05$) and the quality of opposition (Chi-square(2)=4.724, $p>0.05$). In addition, the findings show that the offensive transitions that ended in a goal and there was penetration, were almost four times those that did not have penetration (4.5% against 1.2%).

Also, Table 2 shows that regardless of match location,

Table 2. The Percentages of Offensive Transitions based on Initial Penetration.

Categories	Parameters	Penetration	No penetration
Outcome of attack (p<0.001)	Goal	4.5%	1.2%
	Scoring opportunity	19.5%	8.8%
	No scoring opportunity	76%	90%
Match location (p<0.05)	Home	58%	52.1%
	Away	42%	47.9%
Quality of opposition (p>0.05)	2nd-7th	33.8%	28.4%
	8th-14th	33.6%	38.5%
	15th-20th	32.6%	33.1%
Zone of ball-recovery (p>0.05)	RDZ	3.3%	5.7%
	CDZ	33.2%	32%
	LDZ	4.8%	5.4%
	RCDZ	5.6%	5.4%
	CCDZ	21.8%	23.4%
	LCDZ	5.5%	6.8%
	RCOZ	4.5%	4.7%
	CCOZ	13.4%	11.8%
	LCOZ	3.3%	2.9%
	ROZ	1.2%	0.2%
	COZ	2.8%	0.7%
	LOZ	0.6%	1%
Type of ball recovery (p<0.05)	BR1	53.7%	50.8%
	BR2	4.8%	7.3%
	BR3	4%	1.8%
	BR4	37.5%	40.1%
Initial opponent number (p<0.001)	0-3 players	7.8%	0%
	4-5 players	25%	3.6%
	6 players	14.6%	11.2%
	7+ players	52.6%	85.2%
Players in possession (p<0.001)	1-3 players	55.5%	17.9%
	4-5 players	29%	33.3%
	6+ players	15.5%	48.8%
Type of attack (p<0.001)	Combinative attack	15.7%	60.8%
	Direct attack	8.8%	6.6%
	Fast attack	22%	11.1%
	Counter-attack	21.5%	0%
	Very short attack	32%	21.5%
Duration of attack (p<0.001)	Very short	13.4%	2.3%
	Short	45.1%	22.9%
	Long	28.4%	31%
	Very long	13.1%	43.8%
Time frame of attack (p<0.01)	0:01-15:00	13.4%	17.9%
	15:01-30:00	16.9%	19%
	30:01-45:00	13.9%	14.7%
	First half added time	1.3%	1%
	45:01-60:00	18.2%	16.6%
	60:01-75:00	12.6%	14.8%
	75:01-90:00	17.7%	14%
	Second half added time	6%	2%
Match status (p<0.001)	Winning	48.1%	36.1%
	Drawing	42.5%	52.5%
	Losing	9.4%	11.4%

Barcelona achieved penetration more often, but this phenomenon was more intense at home matches (58% against 52.1%). Respectively, the most common type of ball recovery was the BR1, whether there was penetration (53.7%), or not (50.8%).

Furthermore, it turns out that in most offensive transitions where there was penetration, the players in possession were 1-3 players (55.5%),while in those with no penetration players in possession were 6+ (48.8%). Respectively in both cases, the most frequent initial opponent number that appeared was 7+players (penetration: 52.6% &no penetration: 85.2%), but there were significantly more phases with penetration that the number was 4-5 (25% against 3.6%) or 1-3 (7.8% against 0%).

Regarding the type of attack, it was found that when there was penetration, the very short attacks appeared more often (32%), while when there was no penetration, the combinative attacks occurred (60.8%). Additionally, the duration of attack

was usually short (5-10sec) when the offensive transitions had penetration (45.1%) and very long (21+sec) when they had no penetration (43.8%).

According to Table 2, it is clear that Barcelona achieved penetration more often in the second half (54.5% against 45.5%) and more specifically in the time frame of 45:01-60:00 (18.2%). At the same time, it seems that Barcelona had more offensive transitions with no penetration in the first half (52.6% against 47.4%) and specifically in 15:01-30:00 (19%).

Finally, showed the most offensive transitions with penetration when it was winning (48.1%) and the most with no penetration when it was drawing (52.5%), while similar were the percentages of offensive transitions that took place while Barcelona was behind in score (penetration: 9.4% and no penetration: 11.4%).

Discussion

In recent years there has been an increase in researches, which are dealing with defensive (Vogelbein, Nopp, & Hökelmann, 2014; Freitas, Volossovitch, & Almeida, 2020) and offensive transitions (Malta & Travassos, 2014; Lago-Peñas, Gómez-Ruano, & Yang, 2017). At the same time, Hewitt, Greenham, & Norton (2016) consider transitions to be key moments of play, while according to Fernandez-Navarro, Ruiz-Ruiz, Zubillaga, & Fradua (2020) the attacking tactical parameters have been widely studied in football.

However, offensive transitions haven't been extensively investigated in terms of their attacking tactical characteristics. Therefore, the present study is of particular interest, since as it was mentioned before, its purpose was to analyze the effect of initial penetration on the tactical elements of Barcelona's offensive transitions during the season 2018-19.

Regarding the quality of opposition, in this research was found that the largest percentage of offensive transitions took place against medium (8th-14th) and high (2nd-7th) quality teams. In particular, when there was penetration, the highest percentages of transitions occurred against high and medium quality teams, while when there was no penetration, towards medium quality teams. Respectively, González-Rodenas et al. (2020) observed that more than half of the attacks of the sample occurred versus medium quality teams.

The same authors (González-Rodenas et al., 2020) also noted that most of their sample attacks took place in home games. Respectively, in the present study it was found that regardless of whether there was penetration or not, the largest percentage of offensive transitions took place in home matches, with the differences observed, however, being statistically significant.

In the research of Maneiro et al. (2019), it was observed that the majority of offensive transitions made by Europe's top national teams took place in the first half hour of the games (2008: 33.4% and 2016: 34.3%). Similar percentages were found for Barcelona when offensive transitions had no penetration. On the contrary, when Barcelona's offensive transitions had penetration, the highest percentages were observed in the second half and specifically in the intervals of 45:01-60:00 and 75:01-90:00.

In the present study, the 605 offensive transitions had penetration and the rest559 had no penetration. The findings of López Bondia et al. (2017) are similar to those of the present article, which report that in 51% of Barcelona's phases that were observed, there was penetration and in 49% there was not.

In addition, the same research states that 57.3% of Barcelona's phases took place after the ball was recovered with the ball in play (BR1). Respectively, in the present study similar results were found when there was penetration (53.7%) and when there was no penetration (50.8%).

According to Cooper & Pulling (2020) the Spanish teams included in their sample more often regained the ball possession in the defensive and in the centre-defensive zone. A similar behavior was shown by Barcelona, which more often started its offensive transitions from the defensive and centre-defensive zone, whether its transitions had penetration, or hadn o penetration.

The data show that in the most offensive transitions the number of defenders was 7+ players. However, the percentage discrepancy between the transitions in which there was penetration and those that there wasn't penetration was large, while the differences observed were statistically significant. Respectively, in the study of Gonzalez-Rodenas, Lopez-Bondia, Calabuig, James, & Aranda (2015) it was found that in 76.6% of the offensive transitions of the Spanish national team the number of defenders was 7+. In addition, the findings of Gonzalez-Rodenas et al. (2015) can help to understand Barcelona's attacking game better, since according to Chassy (2013) the national team of Spain has widely used the Barcelona's famous passing game.

In the study of Lago-Ballesteros, Lago-Peñas & Rey (2012) 908 ball possessions from 12 La Liga matches were analyzed and it was observed that in most phases 1-3 players participated. At the same time, in the same research it was noted that in 31% of the phases in which 1-3 players participated, the ball reached he penalty box area of the opponents. Respectively, in the present study it was found that when there was penetration, the largest percentage of offensive transitions was that of1-3 players participated, while when there was no penetration, then the largest percentage was that of6+ players participated.

Regarding the parameter duration of attack, the findings show that when there was penetration then the majority of Barcelona's offensive transitions were of short duration. Similar was the percentage of offensive transitions of short duration of the Spanish national team in the study of Gonzalez-Rodenas et al. (2015).

According to the Table 2Barcelona had almost three times as many goals and more than twice as many goal scoring opportunities when the offensive transitions had penetration. In the research of González-Rodenas et al., (2019) a similar variation was found in terms of percentages. More specifically, it was found that 7% of the attacks of the Spanish teams ended up to a goal or a scoring opportunity when there was no penetration, while this percentage more than doubled when there was penetration (14.6%).

In the same research it was observed that the most common type of attack was the combinative attack (35.5%) and the fast attack (34.4%). However, in the present study, large differences were identified in the type of attack based on the initial penetration. More specifically, in most of the offensive transitions that had no penetration, the type of attack used was the combinative attack while when there was penetration, then the very short attack appeared more often.

Although Barcelona is one of the best teams in Europe, analyzing only their own matches could be a limitation of the present study. But as mentioned it is considered as a team, popular for effective play and can be an example for teams of the same or lower level. Future research could analyze Barcelona's

matches of the last three years, for the reason that they are not the first team in the final ranking of the Spanish league. In this way, it will be studied whether the change in the final ranking (from first to second and third place) is due to the different coaching philosophy of the team or to the departure of important players from this team.

Conclusion

In conclusion, the findings of this research show that the tactical parameter of initial penetration significantly influenced the tactical characteristics of Barcelona's offensive transitions. Additionally, in the past it has been observed that this specific parameter and the type of attack play an important role, concerning the creation of goal scoring opportunities (González-Rodenaset al., 2019). Therefore, these parameters should be taken into account by coaches and analysts when analyzing football matches.

Finally, the results of the present study are particularly important, as there are many teams around the world that try to apply several elements of Barcelona's playstyle to their game. This phenomenon is probably due to the fact that this is a team that determines the tactics around football, something that is likely to happen due to the very popular and very effective attacking play that it uses most of the time. The attacking game in question was assimilated by Barcelona, during the period when Pep Guardiola was the team's manager (head coach in period 2008-2012) and is still widely used to this day (Bekkers & Dabadghao, 2019).

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Conflict of Interest
The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

Preparation, Exercising, and Motivation in Sports Practice during COVID-19 Pandemic among Young Football Players in Bosnia and Herzegovina

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Abstract

The Covid-19 outbreak has also led to significant changes in football, such as the suspension of leagues, isolation, and the fact that football players are forced to train on their own. Therefore, the purpose of this study was to determine if there were differences in the level of preparation, practices, and motivation for athletic training among young professional football players during the Covid-19 pandemic, depending on the level of competition. The sample of respondents consisted of 82 young football players from Bosnia and Herzegovina, divided into the first league group (n=47, 18.30±0.62 age) and the second league group (n=35, 17.66±0.73 age). The questionnaire for sports preparation and training (SPEQ) was used, which consists of 11 items and was created according to the existing questionnaire for self-assessment of the level of preparation and type of training of athletes during the training process in the Covid-19 pandemic. Also, a questionnaire on sports motivation during the Covid-19 pandemic was used, consisting of 18 items related to motivation to participate in sports, modified according to the Participation Motivation Questionnaire (PMQ). A five-point Likert scale was used for the questionnaire. The questionnaire was available in electronic form and was sent to the football players through a Google form. The difference was found only in the frequency of the type of exercise in two variables, while there were no differences between the groups of young football players in the other variables of training frequency, level of preparation, and motivation in sports training. It was also established that despite the Covid-19 situation, the motivation for sports training among young football players was at a very high level.

Keywords: *soccer, football training, fitness preparation, motivation for training, Covid-19 lockdown*

Introduction

Football is characterized by numerous and diverse complex cyclic and acyclic movements (Gardasevic, Bjelica, & Corluka, 2018). Nowadays, football has evolved with great strides, it is played stronger, faster and more explosive. For this reason, football players must have a high level of physical, technical, tactical and psychological preparation (Aleksić & Janković, 2006; Koprivica, 2013).

In modern football, physical fitness is of great importance for the performance of football players (Castagna, Chamari, Stolen, & Wisloff, 2005). Technical and tactical skills can only be brought to bear if the football player has a high level of physical preparation (Bangsbo 1994; Hoff, Wisløff, & Engen, 2002). Endurance, speed, and strength dominate the physical preparation of football players. This corresponds to the hierarchical structure indicated by Milanović (1996): endurance 30%, speed 25%, strength 20%, coordination 15%, and flexibility 10%. These are precisely the skills that have been most

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frequently assessed in scientific papers dealing with football in recent years (Katanić, Ugrinić, & Ilić, 2019). This suggests that these skills should be developed primarily for the physical preparation of football players.

The Covid-19 pandemic has changed the lives of athletes and led to uncertainties related to maintaining training and postponing sporting events (Mon-López, de la Rubia, Hontoria, & Refoyo, 2020; Parm, Aluoja, Tomingas, & Tamm, 2021). The Covid-19 outbreak also led to significant changes in football, such as suspension of leagues, isolation of players, individual training, etc. (Brooks et al., 2020).

During the Covid-19 pandemic, motivation to play sports may play a greater role due to changes in athletes' routines, such as reduced training and increased uncertainty in goal setting (Tingaz, 2021). Motivation is considered a fundamental factor that promotes athletes' participation in sport activities (Roychovdhury, 2018) and influences success in sport (Bollok, Takacs, Kalmar, & Dobay, 2011). For this reason, many authors are increasingly addressing this issue (Ruffault, Bernier, Fournier, & Hauw, 2020; Leyton-Román, de la Vega, & Jiménez-Castuera, 2021; Katanic, Bjelica, Corluka, Preljevic, & Osmani, 2022).

During the Covid-19 lockout, many teams created home training plans for their players that included physical, technical, and tactical preparation (Peña et al., 2021). Although coaches made efforts to create training plans and programs, athletes usually trained alone at home without supervision (Sarto et al. 2020), which made it difficult to conduct training. It is noticeable that training at home faces more challenges, such as inadequate training conditions, poorly organized training, movement restrictions, and lack of communication with coaches (Jukic et al. 2020), which may negatively affect football players' motivation to perform sports activities.

As far as we know, there are only a limited number of studies investigating the possibilities of training young football players during the Covid-19 pandemic (Washif, Mujika, et al., 2022), and this is certainly the first study of its kind in Bosnia and Herzegovina. Accordingly, the study aimed to determine if there is a difference in the level of preparation, exercise, and motivation for sports training during the Covid-19 pandemic among young professional football players depending on their level of competition.

Methods

Participants

The sample of respondents consisted of 82 young football players from Bosnia and Herzegovina, divided according to the competitive level of the first and second leagues. Table 1 shows the descriptive parameters of the first league group (n=47, 18.30±0.62 age) and the second league group (n=35, 17.66±0.73 age). All participating football players were healthy, had no serious injuries, and had been training for more than 5 years. Ethical review and approval according to local legislation and institutional requirements are required for the study in human participants. Experimental procedures were explained to all participants before participation. The research was conducted in accordance with the Declaration of Helsinki.

Table 1. Sample description of elite and sub-elite young football players.

	Football Players (n 83)	
Competitive Rang	First League	Second League
Number of Participants	47	35
Age (Mean±SD)	18.30±0.62	17.66±0.73

Legend: Mean - Arithmetic mean; SD - Standard deviation; n – number.

Measurements

Two 27-items questionnaires were used to self-assess preparation level, type and frequency of practice, and motivation to participate in athletic training during the Covid-19 pandemic.

Sports Preparation and Exercise Questionnaire (SPEQ)

The SPEQ questionnaire consists of 11 items and was designed following the existing questionnaire on exercise during the Covid-19 pandemic (Washif et al., 2022). The questionnaire contains 4 items related to self-assessment of athletes' level of preparation (Bompa, 1999; Koprivica, 2013), and a five-point scale was used (poor -1, moderate - 2, good - 3, very good - 4, excellent - 5). The remaining 7 items refer to the type of exercise during the training process during the Covid-19 pandemic (Washif et al., 2022), and a three-point scale was used (I did not apply - 1, I applied occasionally - 2, I applied often - 3).

Participant Motivation Questionnaire (PMQ)

A Participant Motivation to Participate in Sports (PMQ) and Maintenance of Sports Participation Questionnaire was used during the Covid-19 pandemic, which consisted of 16 items related to motivation to participate in sports, modified according to the PMQ (Gill, Gross, & Huddleston, 1983; Zahariadis & Biddle, 2000). In previous research (Katanic et al., 2022), the internal structure of the questionnaire was examined using factor analysis, and variables were grouped into factors based on their calculated factor weights. Factor analysis identified dimensions such as "Sports Success," 'Social Status," 'Friendship," 'Physical Health," and 'Sports Activities," which were used in this study. A five-point Likert scale was used in the questionnaire, and responses were labelled as 'very important," 'important," 'somewhat important," "not important," and 'not important at all" (Joshi, Kale, Chandel, & Pal, 2015). The questionnaires were available in electronic form and were sent to the football players via Google form.

Statistics

Data analysis was conducted using the SPSS statistical analysis program (IBM SPSS Statistics for Windows, version 26.0. Armonk, NY: IBM Corp.). Descriptive analysis was used to distribute the data based on the number of participants, means, and standard deviation. An independent-sample T-test was used to determine differences in the level of competition between first and second-division football players in terms of preparation, training, and motivation in sports practice. Statistical significance was assumed at $p>0.05$.

Results

Table 2 shows the level of sports preparation. It was found that there was no difference between groups of football players in any type of preparation (physical, technical, tactical, psychological).

Regarding the frequency of the types of training, a significant difference was found in explosive strength (.024) and ball skills exercises (.027), while there was no difference in the presentation of the other types of training (aerobic, agility/coordination, flexibility, isometric strength, repetitive strength).

Table 2. Level of sports preparation and frequency of exercising between the groups.

			First league (Mean±SD)	Second league (Mean±SD)	t	p
Sports Preparation and Exercising Questionnaire (SPEQ)	Sports Preparation	Physical Preparation	3.64±0.92	3.94±0.76	-1.635	.106
		Technical Preparation	3.96±0.98	4.09±0.82	-.629	.531
		Tactical Preparation	3.94±0.87	3.91±0.98	.107	.915
		Psychological Preparation	4.21±1.04	4.54±0.70	-1.714	.090
	Exercise Frequency	Aerobic Exercise	2.28±0.68	2.23±0.69	.314	.754
		Agility/Coordination Exercise	2.26±0.67	2.40±0.55	-1.035	.304
		Flexibility Exercise	2.26±0.67	2.40±0.55	-1.035	.304
		Explosive Power Exercise	2.23±0.67	2.54±0.51	-2.293	.024*
		Isometric Strength Exercise	1.98±0.64	2.17±0.71	-1.288	.202
		Repetitive Strength Exercise	2.64±0.53	2.60±0.60	.305	.761
		Ball Skills Exercise	1.70±0.72	2.06±0.68	-2.257	.027*

Legend: Mean - Arithmetic mean; SD - Standard deviation; t - t test value; p - Statistical significance; * - Significant difference.

Participants' motivation to exercise was assessed by 16 items divided into 5 factors (sports success, social status, friendship, physical health, sports activity). In Table 3, it was found that there was no significant difference in any of the variables between the groups of young football players.

Table 3. Motivation for sports training in young professional football players.

			First league (Mean±SD)	Second league (Mean±SD)	t	p
Participant Motivation Questionnaire (PMQ)	Sport success	Like to compete	4.89±0.48	4.83±0.45	.624	.534
		Want to play at a higher level	4.96±0.20	4.94±0.24	.300	.765
		Like the rewards	4.83±0.67	4.89±0.40	-.438	.663
		Like the sport challenge	4.94±0.25	4.86±0.43	.974	.335
	Social status	Want to be popular	3.96±1.10	4.11±0.83	-.705	.483
		Want to gain status	4.81±0.68	4.71±0.67	.625	.533
	Friendship	Like to meet new friends	4.43±0.90	4.51±0.61	-.502	.617
		Like the teamwork	4.74±0.53	4.89±0.32	-1.490	.140
		Like being on a team	4.91±0.35	4.83±0.51	.904	.369
		Like the excitement	4.77±0.43	4.83±0.45	-.639	.524
	Physical health	Want to be healthy	4.98±0.15	4.91±0.28	1.227	.226
		Want to stay in shape	5.00±0.00	4.91±0.28	1.785	.083
		Get rid of excessive energy	4.17±1.09	3.91±1.15	1.028	.307
	Sport activity	Wished of group training	4.77±0.56	4.94±0.24	-1.947	.056
		Wished of friendly games	4.13±1.08	4.09±1.22	.165	.870
		Wished of official games	4.89±0,37	4.97±0.17	-1.261	.212

Legend: Mean - Arithmetic mean; SD - Standard deviation; t - t test value; p - Statistical significance; * - Significant difference.

Discussion

This study examined the difference in the level of preparation, training, and motivation for athletic training during the Covid-19 pandemic in young professional soccer players as a function of competition level. There is no difference between the groups of soccer players in terms of the type of preparation (physical, technical, tactical, psychological). There are also no differences between the groups in the motivation variables. Only two of the seven variables on the frequency of training showed differences. Second-division players reported a significantly higher frequency of explosive strength (.024) and ball skills training (.027) than first-division players, while there was no difference in the presentation of other types of training (aerobic, agility/coordination, flexibility, isometric

strength, repetitive strength).

In modern soccer, there is a need for quantification of data, especially in the morphological, motor (Gardašević, Bjelica, & Vasiljević, 2016; Katanić, Nikolić, Ilić, Stanković, & Vitasović, 2021; Versic, Modric, Katanic, Jelicic, & Sekulic, 2022), and psychological domains (Bjelica, 2008), as well as in the technical and tactical parts (Adambekov, 2014; Katanić, Stanković, & Prvulović, 2019; Stanković et al., 2020). In this context, the authors emphasize the general sports preparation of soccer players, which includes physical, technical, tactical, and psychological preparation (Bompa, 1999; Koprivica, 2013). In this work, there was no difference in the level of self-assessed sports preparation between groups, but these data cannot be considered consistent because sports preparation was assessed based on self-assessments. Although there is a difference between elite and lower-ranked soccer players in physical preparation (Gissis et al., 2006; Trecroci et al., 2018; Trecroci, Longo, Perri, Iaia, & Alberti, 2019), technical (Janković, Leontijević, Sofronijević, 2015), tactical (Janković et al., 2015; Janković, Leontijević, & Tomić, 2016), and psychological preparation (Ward & Williams, 2003; Lilić, Aleksić, & Radivojević, 2013).

In terms of physical preparation, young elite soccer players showed better performance in vertical jumps, changes of direction with 90° turns, i.e., tests of explosive strength and agility, than sub-elite players (Gissis et al., 2006; Trecroci et al., 2018; Trecroci, Longo, Perri, Iaia, & Alberti, 2019; Katanić, Ilić, Stojmenović, & Vitasović, 2021). The results of the Gissis et al. (2006) study suggest that young elite soccer players differ from sub-elite and young soccer players in terms of strength and speed characteristics such as maximal isometric strength, force-time curve characteristics, cadence, vertical jump, and sprint performance.

In terms of technical and tactical preparation of soccer players, it was found that there are significant variations and differences in the performance of teams and individual players in terms of technique and tactics (Janković, Leontijević, & Sofronijević, 2015; Janković, Leontijević, & Tomić, 2016). Significant differences are shown in the extent of application of technical-tactical elements by higher-ranked teams compared to lower-ranked teams (Janković, Leontijević, & Sofronijević, 2015).

It was also found that elite football players (of different age groups) differed significantly from players of a lower level of competition in psychological characteristics, especially in their perceptual and cognitive abilities, which enabled them to receive, process, and integrate contextual information more efficiently and that this was one of the main factors for their greater success (Ward & Williams, 2003; Lilić, Aleksić, & Radivojević, 2013).

Although it has been confirmed that there is a difference in the level of sports preparation between young elite and sub-elite football players, this difference was not present in our study. The main reason for this is that our study was a self-assessment in which players of different levels assessed their level of physical, technical, tactical, and psychological preparation in approximately the same way.

When looking at the representation of specific types of training, it was found that lower-ranked football players had higher scores in the representation of explosive strength (.024) and ball skills exercises (.027) during Covid-19 pandemic, while no difference was found in other exercises (aerobic, agility/coordination, flexibility, explosive strength, isometric and repetitive exercises, and ball skills exercises). It is well known that explosive power is one of the most important motor characteristics in athletes (Prvulović, Martinović, Kostić, & Katanić), and ball drills lead to increased performance in various technical skills (Waldron & Worsfold, 2010; Katanić, Ilić, Stojmenović, Stanković, & Vitasović, 2020). So this is one of the reasons why sub-elite football players develop these skills. However, because no study has examined the differences between young football players according to competition level during the pandemic, it is not easy to verify our results. Since this is not a true evaluation but a self-assessment subject to subjective feelings, we must take these results with caution.

The motivational structures are divided into five factor dimensions: 'Sporting Success', 'Social Status', 'Friendship', 'Physical Health', and 'Sporting Activities', and is in line with previous studies that mostly found a 5- to 8-factor basic structure (Fabrigar, Wegener, MacCallum, & Strahan, 1999; Katanic et al., 2022).

It should be noted that there was no difference in any of the dimensions ("Sporting Success," 'Social Status," 'Friendship," 'Physical Health," and "Sporting Activities") in terms of training motivation. Thus, this work showed that there was no difference in training motivation between elite and sub-elite young football players during the Covid-19 pandemic. On a Likert scale of 1to 5, the mean scores for both groups and each dimension were above 4, except for the elite players' social status, which was 3.96 (almost 4). This means that the motivation for training among the young football players of the elite and the sub-elite was very high under the given conditions. It was found that young football players from these areas (Serbia and Montenegro) are significantly more motivated by an intrinsic desire to achieve their sports competencies than their Russian peers (Mladenovic & Marjanovic, 2011). Also in Malcic's (2012) research, the results showed that intrinsic motivation is the main driver for sports participation. As for the structure of motives, health is the most important, followed by love for sport, then success, friendship, popularity and good looks. Bačanac, Lazarević and Arunović (1994), on the other hand, state that the most important thing is: "to get to a higher level', 'competitions', then "to be in good physical condition', "to practice", "to do something to learn'. Motivation in sports manifests itself through perseverance and persistence. Perseverance in sport is influenced by biological, psychological, sensory, and situational factors (Abernethy, Hanrahan, Kippers, Mackinnon, & Pandy, 2012). It is also important to set goals and strive to achieve them because each goal achieved increases motivation and vice versa.

Limitations

Although this study has several limitations, the most important one is that the level of sports preparation and the presentation of the different types of training were assessed using a questionnaire, and since it is a self-assessment, the results may be based on a subjective feeling and not on a realistic assessment. In this regard, the proposal for further research should investigate these parameters with optimal measurement tools. Another limitation arises from the fact that the athletes answered the questionnaires electronically, i.e. someone could have influenced their answers.

Conclusion

The difference between elite and sub-elite young football players was found only in the frequency of the type of exercise in two variables, while there were no differences between the groups in the other variables of training frequency, level

of preparation, and motivation in sports training. It was also established that despite the Covid-19 situation, the motivation for sports training among young football players was at a high level. In addition to the mentioned limitations, the strength of this study refers to the fact that this is the first study that assessed the possibilities for sports training during the Covid-19 pandemic among young football players in Bosnia and Herzegovina.

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Conflict of interest
The authors declare that there is no conflict of interest

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SportMont

ORIGINAL SCIENTIFIC PAPER

Differences in Motor, Functional, and Sport-Specific Skills in Gifted Wrestlers with Different Acceleration of Biological Development

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Abstract

It is assumed that the selection of gifted children aged 13-14 years old is dominated by those with accelerated biological development. A better understanding of this problem can greatly improve the selection process for gifted children. The paper aimed to determine the differences in motor, functional, and sport-specific skills between children with different levels of biological acceleration. The study was conducted on a sample of 26 wrestlers aged 13.8±0.74 years old selected from the city of Zagreb. The participants were divided into three groups according to the acceleration of biological development (early maturers, n=9; normal, n=10; late maturers, n=7) and tested with a battery of 10 tests (6 motor, 1 functional, and 3 sport-specific). As was expected, even though there were no differences in experience and placement, the groups differed in all physical characteristics (Kruskal–Wallis ANOVA: age p=0.01; body mass, p<0.01; body height, p<0.01; sitting body height, p<0.01; body mass index, p=0.02). The groups differed significantly in two sport-specific tests and one motor test (Kruskal–Wallis ANOVA: wrestling bridge flexibility p=0.02; flipover p=0.04; medicine ball throw p<0.01). Although these were selected wrestlers, not all of them were classified as early maturers; rather, they were evenly distributed in different groups. We can assume that late maturers had technical–tactical advantages that compensated for the early maturers' advantage in explosive power. Early maturers were better in terms of explosive power, but the late maturers were better at sport-specific flexibility, as expected.

Keywords: *wrestling, biological age, talented athletes*

Introduction

Wrestling is an Olympic combat sport based on grappling and one of the few sports that was represented at the Ancient Olympic Games (Horswill, 1992). The optimal age to begin wrestling training is age 10, whereas peak performance is reached at the age of 25 (Karninčić, Baić, & Sprem, 2017). In this article we were interested in a particularly sensitive period of accelerated growth and development, i.e., older boys from 13 to 15 years old (according to international wrestling rules). This period is also called puberty and is marked by rapid changes in body size, shape, and composition (Rogol, Clark, & Roemmich, 2000). Puberty onset may occur earlier or later than expected, and in this regard, children are divided into three groups (Ostojic, 2017). Early maturers are children whose phase of accelerated growth and development began earlier, whereas late maturers are children whose biological development is delayed. The third group includes children with normal biological development that follows chronological age. The peak height velocity is an indicator of biological maturity and represents the maximum rate of natural growth during adolescence. Male adolescents generally reach it by the age of 14 (Brown, Patel, & Darmawan, 2017). The most common noninvasive method of determining a child's biological development is using a regression equation that predicts how

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far the child is from the age of peak height velocity considering the following variables: gender, date of birth, date of measurement, body height, sitting body height, and body mass (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Children who mature earlier have an advantage in strength over those who mature later (Faigenbaum & Westcott, 2000). Children who mature later train and compete with those who mature earlier. By training and competing with bigger and stronger children, late maturers will be less successful and will give up on sports.

There are no studies of the acceleration of biological development in wrestling and its relationship with the selection of wrestlers. Most of the studies dealing with this problem in combat sports refer to the relative age effect (RAE) (Albuquerque et al., 2015; de Almeida-Neto et al.) RAE does not refer to accelerated or slowed biological development. Instead, RAE refers to athletes who are older within their age group, for example, because they were born at the beginning of the year. In a sample of judokas of different age groups, Franchini and colleagues found that hand grip strength is related more to body mass than to age (Franchini, Schwartz, & Takito, 2020). Based on hormonal status, Piskin and colleagues found that young wrestlers do not have different pubertal development from the rest of the population (Piskin, Gumus, Bayraktaroglu, Akalin, and Yamaner, 2018). Constant reductions in body mass in adolescent wrestlers did not slow down growth and development (Roemmich and Sinning, 1997).

The focus of this study is not the RAE; the focus is on the acceleration of biological development. Early maturers predominate in youth sports (Ostojic, 2017), and this phenomenon has not been investigated in a sample of wrestlers. Parents and coaches should know the implications of delayed adolescent development, and they should develop their expectations accordingly (Manna, 2014). The impact of biological development on skills, selection, or athletic performance has mainly been investigated in team sports, especially football (Burgess and Naughton, 2010; Ostojic et al., 2014). If we composed a sample from selected children who are the most successful in wrestling at that age, most of them would probably be children with accelerated biological development. This study aimed to determine the differences in biological acceleration in the most successful wrestlers from the city of Zagreb (city selection) and to determine the differences in motor, functional, and sport-specific skills between gifted wrestlers of different levels of biological acceleration.

Methods

Sample

The sample of participants included 26 male wrestlers aged 13.8±0.74 years who train in wrestling and compete at national championships in the age category of younger or older schoolboys. The sample is a selection of the best wrestlers from 12 clubs in the Croatian capital, Zagreb. A detailed description of the sample is presented in Table 1. For the age of peak height velocity (PHV) prediction, an online calculator was used (Prediction of Age of Peak Height Velocity—College of Kinesiology | University of Saskatchewan). The calculator uses the Mirwald et al. method from 2002, and the required variables are gender, age, body height, body mass, and sitting height. The age from PHV estimates how many years the subject is from his age at PHV (Milić, 2014; Rađa, Erceg, & Milić, 2016; Baxter-Jones et al., 2020). The variable individual deviation from the average value (APHV) was obtained, and the respondents were divided into three groups: early maturers (APHV <-0.51); normal maturers (n = 10) (APHV range -0.50 to 0.50); and late maturers (n = 7) (APHV >0.51).

The study protocol followed the guidelines stated in the Declaration of Helsinki. The study is part of the Fitness Profiles of Wrestlers and Construction and Validation of Sport-Specific Tests project and was approved by the Ethics committee of the Faculty of Kinesiology of the University of Split (no 2181-205-02-05-22-0012).

Variables

The variable sample included anthropometric variables: age, body mass, body height, sitting body height, and body mass index; variables assessing motor skills: sit-and-reach, medicine ball throw, flexed arm hang test, sit-up test, push-ups, and bench press 1RM; a variable assessing functional skills: running 1500 m; and variables assessing sport-specific motor skills: wrestling bridge flexibility, flipover, and dummy throwing, with the addition of the variable placement at the national championship.

All variables for the assessment of motor abilities, functional characteristics, and sport-specific tests are part of the standard battery for the selection of the best wrestlers in the city of Zagreb. Since the boys had significantly different physical characteristics, a relative result was calculated for the following three variables: medicine ball throw, flexed arm hang test, and bench press 1 RM. All sport-specific tests have already been used in the wrestling literature: wrestling bridge flexibility: In this test, the distance between the forehead and heels is measured when the wrestler is in the position of the wrestling bridge (Kuleš & Marić, 2001; Said Abdel-Hakim, 2015); wrestling bridge turnover or flipover: the wrestler must switch over his head as many times as possible in one minute from the position of the back bridge to the front bridge and back (Kuleš & Marić, 2001); SWFT: the wrestler throws two opponents alternately (shoulder throw) for three periods of 30 seconds, maximally fast—heart frequency is measured immediately after throwing and after 1 minute of rest. The SJFT index is calculated according to the formula HR1+HR2/maximum number of throws (Emerson et al., 1998; Işik, Doğan, Cİcİoğlu, & Yildirim, 2017; Marković et al., 2021).

Data-processing methods

The data were analyzed using Statistics 13 (Statsoft, USA, 2013). The normality of distribution was tested by the Shapiro–Wilk test due to the small number of participants in the subsamples. Due to significant deviations from the normal distribution (Shapiro–Wilk test), differences between the groups were examined using a nonparametric Kruskal–Wallis ANOVA test. Even though the results indicated the need for nonparametric statistics rather than descriptive statistics for better results readability, the following parameters were calculated: arithmetic mean, standard deviation, and the minimum and maximum result. The level of significance was set at $p<0.05$.

Results

It can be seen in Table 1 that there is a statistically significant difference between the groups in the following variables: age, body mass, body height, sitting body height, and body

Table 1. Descriptive statistical parameters (arithmetic mean and standard deviation - mean±SD and minimum and maximum result - min/max) for all the variables describing the sample and differences between the groups (Kruskal-Wallis ANOVA).

	All groups (n=26)		Late maturers (n=7)	
	Mean±SD	Min/Max	Mean±SD	Min/Max
Age	13.8±0.74*	12.00/14.00	12.43±0.53*	12.00/13.00
Experience	4.31±1.54	2.00/7.00	4.93±1.97	3.00/7.00
Body mass (kg)	58.30±12.17*	37.70/85.60	46.37±6.35*	37.00/53.00
Body height (cm)	166,25±10 48*	144.00/187.00	152.93±6.44*	144.00/159.50
Siting body height (cm)	85.98±8.00*	56.40/95.80	80.61±3.84*	73.00/83.00
Body mass index (BMI)	20.86±2.45*	17.59/25.79	19.78±2.00*	18.06/23.60
Placement	5.25±4.80	1.00/24.00	8.13±7.96	1.50/24.00
	Early maturers (n=9)		Normal (n=10)	
	Mean±SD	Min/Max	Mean±SD	Min/Max
Age	13.56±0.53*	13.00/14.00	13.10±0.74*	12.00/14.00
Experience	4.61±1.58	2.50/7.00	3.60±0.94	2.00/5.00
Body mass (kg)	70.43±9.96*	56.10/85.60	55.74±4.29*	50.00/67.20
Body height (cm)	175.56±6.91*	161.30/187.00	167.19±3.08*	163.30/171.40
Siting body height (cm)	92.16±2.61*	88.50/95.80	84.18±9.88*	56.40/90.30
Body mass index (BMI)	22.81±2.54*	17.77/25.79	19.94±1.62*	17.59/22.87
Placement	3.31±1.45	1.67/5.50	4.97±3.07	1.00/9.00

*statistically significant difference between groups in variables: Age (H=9.85, p=0.01); Body mass (H=17.80, p<0.01); Body height (H=19.20, p<0.01); Siting body height (H=18.92, p<0.01); Body mass index (H=7.50, p=0.02).

mass index.

It can be seen in Table 2 that the groups differ significantly in the following variables: wrestling bridge flexibility, medical ball throw (relative), and flipover.

Table 2. Descriptive statistical parameters (arithmetic mean and standard deviation - mean±SD and minimum and maximum result - min/max) for all the analyzed variables and differences between the groups (Kruskal-Wallis ANOVA).

	All groups (n=26)		Late maturers (n=7)	
	Mean±SD	Min/Max	Mean±SD	Min/Max
Sit-and-reach (cm)	52.13±9.07	34.00/71.00	54.29±9.95	40.00/67.00
Wrestling bridge flexibility (cm)	32.52±12.07*	13.50/62.00	25.80±5.70*	16.30/32.10
Medicine ball throw (cm)	380.38±105.15	76.00/554.00	298.43±32.05	259.00/334.00
Medicine ball throw (relative)	58.30±12.07*	37.70/85.60	6.51±0.84*	5.07/7.70
Flexed arm hang test (sec)	41.81±19.63	1.00/78.00	40.71±25.49	6.00/78.00
Flexed arm hang test (relative)	0.77±0.44	0.02/1.93	0.92±0.63	0.11/1.93
Sit-up test (1 min)	41.08±6.20	31.00/52.00	40.00±6.63	32.00/49.00
Push-ups	35.27±14.54	14.00/72.00	28.00±9.92	14.00/40.00
Bench press 1RM	49.27±18.20	21.00/90.00	34.29±7.87	30.00/50.00
Bench press 1RM (relative)	0.86±0.23	49.27/12.07	0.75±0.20	0.56/1.20
Running 1500 m	429.76±65.36	362.00/522.00	449.00±58.18	362.00/515.00
Flip-over (1 min)	20.73±7.56*	0.00/31.00	23.71±3.97*	14.00/23.00
Dummy throwing (3×30sec)	19.48±3.75	14.00/27.00	17.29±2.87	14.00/23.00
	Early maturers (n=9)		Normal (n=10)	
	Mean±SD	Min/Max	Mean±SD	Min/Max
Sit-and-reach (cm)	53.17±5.41	45.00/58.50	49.70±11.20	34.00/71.00
Wrestling bridge flexibility (cm)	41.26±13.92*	23.50/62.00	29.36.00±9.38*	13.50/38.20
Medicine ball throw (cm)	455.89±77.85	332.00/554.00	369.80±116.50	76.00/523.00
Medicine ball throw (relative)	6.48±0.70*	5.48/7.51	7.28±0.67*	5.78/8.14
Flexed arm hang test (sec)	43.67±14.36	26.00/68.00	40.90±21.17	1.00/74.00

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Table 2. Descriptive statistical parameters (arithmetic mean and standard deviation - mean±SD and minimum and maximum result - min/max) for all the analyzed variables and differences between the groups (Kruskal-Wallis ANOVA).

	Early maturers (n=9)		Normal (n=10)	
	Mean±SD	Min/Max	Mean±SD	Min/Max
Flexed arm hang test (relative)	0.63±0.27	0.35/1.21	0.79±0.41	0.02/1.30
Sit-up test (1 min)	41.00±6.24	31.00/49.00	41.90±6.42	33.00/52.00
Push-ups	40.67±18.41	20.00/72.00	35.50±12.26	21.00/50.00
Bench press 1RM	63.89±16.35	40.00/90.00	46.60±15.64	21.00/65.00
Bench press 1RM (relative)	0.92±0.24	0.54/1.22	0.90±0.22	0.51/1.23
Running 1500 m	411.50±41.87	362.00/475.00	432.00±70.24	370.00/522.00
Flip-over (1 min)	15.11±9.51*	0.00/25.00	23.70±4.45*	16.00/31.00
Dummy throwing (3×30sec)	20.63±3.50	16.00/25.00	20.10±4.15	15.00/27.00

*statistically significant difference between groups in variables wrestling bridge flexibility (H=07.50 p=0.02, flip-over (H=065, p=0.04), and medicine ball throw (H=17.80, p<0.01).

Discussion

It should be noted that the groups differed significantly by age; therefore, differences between the groups may have occurred due to age differences and not biological acceleration. This requires a revision of the methodology for monitoring biological acceleration and the entire theoretical framework exploring biological acceleration rates. In 2000 and 2010, Malina found that children with accelerated biological development were selected for teams because they were recognized as having talent. In our study, the selected best young wrestlers from Zagreb were classified in all three categories of biological age (Malina et al., 2010; Malina et al., 2000). We assumed that most of these wrestlers would be in the group of accelerated biological development (early maturers). However, most of the wrestlers are in the normal biological acceleration group (ten participants), nine wrestlers are in the early maturers group, and seven wrestlers are in the late maturers group. Similar results were obtained by Piskin and colleagues when they determined that wrestlers do not differ from the rest of the population in terms of growth during puberty (Piskin et al., 2018). It can be assumed that not all of them can be classified as early maturers due to the complex technical and tactical structure of wrestling. The most successful wrestlers in the city who belong to the late maturers group do not dominate in terms of physical abilities but are technically and tactically superior to their opponents. Earlier studies also found that early maturers often rely on physical superiority and not on technique and tactics (Curby, 2013). Soccer players of different biological acceleration rates were compared in the technical aspects of soccer, and the research showed that there were no statistically significant differences in most of the analyzed variables (precision, passing, dribbling) (Thomas, Oliver, Kelly, and Knapman, 2017). Wrestlers who mature faster physically do not mature faster mentally; this means they are not necessarily mentally ready for greater challenges (Mirzaei, 2021). This may be the reason why, among the selected participants, there were also those who matured late. The advantage of early biological acceleration does not have to be reflected in the technical structure, but it should be reflected in motor skills. Another study on soccer players showed that early maturers are significantly better than late maturers in all motor skills (Rađa et al., 2016). In this study, early maturers were significantly better than others only in explosive arm power (medicine ball throw, H = 17.80; p <0.01).

Interestingly, no differences were found in maximum strength, repetitive strength, or strength endurance. Moderate correlations between strength variables and PHV were found in judokas, but the sample was not a selection of the best judokas (Detanico, Kons, Fukuda, and Teixeira, 2020). Early maturers had significantly lower results in specific flexibility (wrestling bridge flexibility, H = 07.50; p = 0.02), which was expected since other studies have confirmed this (Nikolaïdis, 2012). In previous studies on judokas, sport specific tests were associated with PHV (Detanico et al., 2020). There was also a significant difference in the sport-specific flipover test (H = 065; p = 0.04). This test is heavily influenced by flexibility (Starosta, Fostiak, and Zurek, 2017), and specific flexibility has proven to be significant in the wrestling bridge flexibility test. In the other sport-specific test (dummy throwing), there were no statistically significant differences between the groups. In this sport-specific test, both explosive power and flexibility played an important role. Since early maturers have superior explosive power and inferior flexibility, it is logical that there are no significant differences in this test.

Limitations

Very few studies have dealt with research on the accelerated biological development of wrestlers. Research on wrestlers using Mirvald's methodology (the assessment of maturity from anthropometric measurement) does not exist. Thus, it is impossible to compare the results of this paper to a similar sample in wrestling. No data were collected on the reduction of body mass in the subjects (which is a common behavior of wrestlers), but the reduction of body mass can affect the acceleration of biological development.

Conclusion

Early maturers did not dominate in the selected group of wrestlers as hypothesized before the test. Accelerated biological development is not related to the technical or tactical aspects of the sport. Wrestlers with slower biological development acceleration can compensate for the lag in motor skills with better technical and tactical preparation. In the sample of the selected group of wrestlers, the early maturers were superior only in explosive power and inferior in flexibil-

ity. The two sport-specific tests did not show an advantage in early maturers because both are more influenced by flexibility, in which late maturers are superior. If a sample includes the most successful wrestlers of this age, children classified as early maturers are not dominant in either motor skills or sport-specific tests. Future research should exclude the influence of age on the results when investigating biological age acceleration.

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Conflict of Interest
The author declares that there is no conflict of interest.

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REVIEW

Aerobic and Anaerobic Effect of CrossFit Training: A Narrative Review

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Abstract

CrossFit is recognized as one of the fastest growing modes of high-intensity functional training. This strength and conditioning program is used to optimize physical competence in ten fitness domains: (1) cardiovascular/respiratory endurance, (2) stamina, (3) strength, (4) flexibility, (5) power, (6) speed, (7) coordination, (8) agility, (9) balance, and (10) accuracy. The aim of this review is to provide an overview related to Crossfit and its implication in aerobic and anaerobic parameters. Specifically, in this work, we will discuss the impact that this type of physical activity can have on a physiological level. Furthermore, the tools will be provided to understand how, by modulating the intensity, one can have benefits at an aerobic and anaerobic level. We will also review studies using CF as a resistance training methodology and finally discuss the findings of the various studies and provide recommendations for future studies.

Keywords: *CrossFit, Functional fitness, aerobic training, anaerobic training, workouts programs*

Introduction

Functional fitness is a type of exercise designed to emulate activities from everyday life. Functional fitness likely grew out of an older concept called general physical preparedness (GPP) that has similarly experienced a recent renaissance (Gamble, 2006). The evidence of the growth and expansion of GPP and functional fitness training can be seen in the emergences of CrossFit (CF) across the world. The CF is one of the new modality of HIFT that have emerged in the last few years. A typical CF training is organized into daily sessions called "workouts of the day" (WOD), including metabolic exercises (running, rowing), gymnastic movements (pull-up, push-ups, air squats, burpees), and weightlifting (snatch, clean, and jerk) and performed at an intensity close to 95% of the maximum heart rate (HRmax) (Maté-Muñoz et al., 2018). WODs are organized as circuits with little or no rest periods, performed "as many repetitions as possible" (AMRAP) during a given time domain (Katz et al., 2016) or as quickly as possible over periods of 10 to 20 min ("CrossFit-based High Intensity Power Training Improves Maximal Aerobic Fitness and Body Composition: Retraction" 2017).

Variety is one of the main appeals for CF program participants as workouts are short, intense, and constantly varied. The intense nature of this form of training is congruent with CF training. The CF is a type training regimen based upon a multidimensional view of fitness (D'alpino et al., 2022). The CF model suggests that fitness is best measured via performance in a variety of tasks in relation to other competitors (Glassman, 2002). This multifaceted description of fitness has been offered before, by two authors (Kilgore & Rippetoe, 2007) and by the American College of Sports Medicine (American College of Sports Medicine, 2014). The CF adds a layer of competition to the attainment of multidimensional fitness, which may explain the recent rise in popularity and number of affiliates nationwide. The CF is a form of high-intensity functional training that combines resistance exercises, gymnastics, and traditional

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aerobic modalities (e.g., cycling, rowing, running) into single workouts that vary by day to elicit general physical preparedness (Glassman, 2016). This training form is enjoyed recreationally by participants of varying levels of fitness, training experience, age, and lifestyles (Thompson, 2017) and also exists as its own sport. The primary CF competition is the Reebok CrossFit Games™ (the Games) which awards individual winners the title of "Fittest on Earth". Historically, this competition has consisted of several stages designed to narrow the initial participant pool down to the top athletes. Although the competition's structure has changed over time, the presence of an initial online qualifying round (e.g., the CrossFit OpenTM) has remained. This round typically involves multiple workout challenges that are completed over the course of several weeks. Competitors who complete all workouts and rank high enough will progress to the next stage of the competition. Regardless of which stage, it is expected that each workout will consist of a set of challenges that will require some combination of strength, power, endurance, and/or sport-specific skill (Glassman, 2016). However, little is known about which physiological characteristics of competitors who progress beyond the opening round of the competition.

The CF Games have matured from an informal athletic meeting to a worldwide sponsored competition with prize money (CrossFit Games, 2016). In concert with this worldwide competition, local CF affiliates routinely host fitness contests. With the rise in popularity of CF and CF competition, an opportunity exists to evaluate the capacities of these athletes from a laboratory perspective. Physical capability, including the aerobic and anaerobic capacity of athletes, is an important element leading to success in athletic endeavors (Moscatelli et al., 2020). Traditional methods of assessing physical capacity are power and aerobic capacity. The ability to optimize muscular power output is considered fundamental to the successful performance of many athletic and sporting activities (Cronin & Sleivert, 2005). Aerobic capacity has also been accepted as a major component of athletic success (Ranković et al., 2010). Although the CF training model incorporates both aerobic and anaerobic capabilities, to date very little research has been conducted to understand the impact of CF training, or the abilities required to be successful (attaining greater ranking in competitions local, regional or national) in CF competitions. Results released from a 2010 study funded by the U.S. Army suggest that CF training can improve the functional capacity of soldiers (Paine & Uptgraft, 2010). This study and one other represents the only existing research that examined actual CF model training schemes and the effects on fitness (Smith et al., 2013). Reviews of research that use similar functional fitness schemes such as sandbag training (Sell et al., 2011; Moscatelli et al., 2021) and functional fitness training for Judo athletes (Henry, 2011) suggest that these functional schemes have been associated with increases in fitness capability. However, to date there is no existing research on the components of fitness associated with the sport aspect of CF, thus the aim of this review was to provided an overview on the CF and its effects on the aerobic and anaerobic parameters.

Physiological aspect of CrossFit

It is important to understand how anaerobic and aerobic metabolism relate to this innovative activity in order to better comprehend CrossFit performance. Authors (Dodd, 2007) ran an experiment to determine the kind of training that would help a sportsperson's lower body power. Results showed that when compared to conventional heavy resistance and high-velocity approaches, complex training, which combines plyometrics and heavy resistance training simultaneously, produced larger increases in lower body speed and power. The idea that anaerobic performance would probably be related to CrossFit performance is backed by the fact that the event frequently consists of both weight training and runs up to 800 meters. A recent investigation (Farrar, 2010) who showed that kettlebell swings posed an aerobic challenge that could impact VO2 max supports the existence of a reasonable link between aerobic fitness. The enormous volume of repetitive weightlifting motion used in CrossFit training, which is comparable to the continuous kettlebell swings in the Farrar, Mayhew, and Koch (2010) study, makes this work extremely pertinent.

Body mass (Butcher et al., 2015), strength and anaerobic power (Moscatelli, 2015; Martínez-Gómez et al., 2019), aerobic capacity (Bellar et al., 2015), sport-specific skill (Barbieri et al., 2020), and experience (Serafini et al., 2018) have all been associated with either CF workout performance or competitive ranking. Collectively, these data imply that athletes must train to be proficient in each to perform well in competition. However, several limitations exist among these studies that prevent making such a conclusion. For instance, Serafini et al. (2018) reported that higher ranking competitors of the 2016 Open were stronger, more powerful, and more proficient at short-duration, sprint-type CF workouts. Among regional competitors, final ranking was positively related to 400-m sprint time and time-to-completion in longer, benchmark workouts (i.e., Filthy-50) (r=0.69–0.77), and negatively related to maximal weight lifted in the Olympic lifts (r=-0.39 to -0.42) (Barbieri et al., 2020). Although these studies involved participants who have successful competitive records, the measures used to distinguish rank were all self-reported. As such, the authenticity and actual data of measurement (self-reported data were obtained from an online resource) cannot be verified. In contrast, others have measured a variety of physical parameters and related them to CF-style workouts performed in a controlled, laboratory setting (Martínez-Gómez et al., 2019). While these studies have also included successful CF athletes, laboratory workouts do not adequately emulate the competitive setting and may influence the physiological response to CF training (Mangine et al., 2019). Thus, questions remain about the distinguishing characteristics of successful CF athletes.

In more traditional sports (e.g., football, baseball, basketball, etc.), identifying the key physiological and athletic characteristics that distinguish performance is common (Mangine et al., 2014). The practice enables strength and conditioning professionals to develop sport-specific training programs that are more effective in translating adaptations to in-game performance. However, CF is unique in that typical training session workouts mirror those that appear in competition. Moreover and consistent with its primary purpose (Feito et al., 2018), chronic participation in CF training has been documented to improve a variety of fitness parameters (Feito et al., 2019). Though it might be assumed that CF training represents an ideal training strategy for developing the physiological characteristics present in successful competitors, such a conclusion would be premature based on the available data.

CrossFit and resistance training

Amongst a variety of training regimens for increasing performance, resistance training (RT) is essential, as it enhances muscular strength and power (Suchomel et al., 2016). Typically,

RT aims at increasing skeletal muscle strength by working against a weight or force. Recently, high-intensity functional training (HIFT) has received growing popularity and is alleged to improve overall physical conditions. The HIFT relies on basic elements of "every day" movements derived from both aerobic and resistance efforts, performed at high intensities. The efficiency of exercise training depends not only to the training load, but also on the athlete's capability to sustain it. One way to gauge exercise-induced internal environmental stress fluctuations is through the evaluation of the hormonal responses, and through the monitoring of biomarkers of inflammation and oxidative stress. Improving overall performance or accounting for residual training effects might rely on reproducible indicators of reactions to training (Rankovic et al., 2011). Along this line, any effort made to quantify the fine balance between training practice and athlete's tolerance may help to optimize training programs (Powers & Jackson, 2008). In fact, the CF is a style of exercise that takes a multifaceted approach to fitness. According to the CF concept, the best way to gauge fitness is by competitors' performance in a variety of tasks (Glassman, 2002). The American College of Sports Medicine (2000) and Kilgore and Kilgore (2007) have both previously provided this comprehensive definition of fitness. The recent increase in popularity and the number of affiliates countrywide may be attributed to the fact that CF adds a level of competitiveness to the pursuit of holistic health.

The undoubted beneficial effects of exercise have been underlined in a number of studies. Nevertheless, exercise is a stress situation that challenges homeostasis (Powers & Jackson, 2008), and the body must find a new dynamic equilibrium, that requires, among others, adaptive responses of the hormonal, metabolic, and immune systems. As concerns the outcomes of HIFT programs, CF has been demonstrated to improve body composition and physical fitness (Ahmad et al., 2018), also eliciting metabolic (Ramires et al., 2016), inflammatory (Heavens et al., 2014), and hormonal responses (Mangine et al., 2018). Furthermore, CF training has been shown to induce an immunosuppressive effect (Jin et al., 2015) and acute oxidative stress responses, affecting the immune system (Kliszczewicz et al., 2015). Particularly, it has been shown that a HIFT with short rest protocol carried out in men and women with no experience in resistance training elicits significant increases in inflammation and induced hyperreactions in metabolic and adrenal (cortisol) functions. Another study showed that two consecutive HIFT sessions increase pro/anti-inflammatory cytokines with no interference on muscle performance in the recovery period (Ramires et al., 2016). On the whole, a recent review (Ramires et al., 2018) analyzed the prevalence and incidence of physiological responses and chronic adaptations to HIFT programs, which resulted in increased acute oxidative, metabolic, cardiovascular, and hormonal stress, depending on the protocol adopted, as for intensity, duration, and training status of the subjects. Interestingly, the authors reported that an insufficient rest between HIFT sessions resulted in unfavorable cytokine responses, with a decrease in anti-inflammatory and increase in proinflammatory cytokines. We can assume that advanced-level technique during maximal timed exercise repetitions, without suitable rest intervals between sets and shifts, as well as an inadequate recovery time between high-volume loads and training sessions (such as CF) may produce premature fatigue and additional oxidative stress level in athletes (Claudino et al., 2018). The immune and endocrine systems are closely intertwined in modulating an appropriate response to physiological and psychological stress factors (Elenkov, 2008; Moscatelli et al., 2022). Moreover, biochemical monitoring is useful in sports contexts to assess and manage workload and fatigue of athletes at all levels (McCall et al., 2015). With regard to exercise, cortisol plays an important regulatory role in metabolic responses to stressor events through the activation of energy proteolysis and lipolysis (Kraemer & Ratamess, 2005; Ruberto et al., 2021). Lastly, the regulation of protein turnover during recovery from physical exercise, involving also contractile myofibrils adaptation to training, is closely linked to appropriate glucocorticoid actions (Viru & Viru, 2004). Studies have shown significant elevations in acute cortisol secretion as no change (Ahtiainen et al., 2003) or reductions (Harizi et al., 2014). Elevations of cortisol levels have been reported during normal strength and power training (Häkkinen & Pakarinen, 1991), while in CF training a greater acute cortisol response (Mangine et al., 2018) and a lower chronic response were obtained compared to strength and power training (Poderoso et al., 2019).

According to Kraemer and Ratamess (Kraemer, 2005), regimens including high volume, high intensity, and little rest tend to result in larger hormonal increases. Mangine et al. (2018) recently documented an increase in testosterone in CrossFit® training participants, which may be the result of temporary increases in muscle force production. Depending on the mix of the many training variables (exercise type and modality, volume, and load) throughout time, it's possible that CrossFit periodization ®'s has an impact. These increases may be caused by training overload and the recruitment of motor units during the various exercises used in Olympic weightlifting and powerlifting. The relationship between cortisol and testosterone levels was inverse. According to França et al. (2006), testosterone and cortisol levels vary depending on the volume and length of exercise. A persistent adaptation to exercise can be a drop in cortisol levels, particularly in men. Recreationally active people, according to Mangine et al. (2018), undergo adaptive organic processes to safeguard the muscles and other tissues susceptible to glucocorticoids and prevent negative effects.

Exercise performance is significantly impacted by persistent cortisol increases in the skeletal muscles. Assessing adrenal function activation is relevant as exacerbated cortisol concentrations may lead to reiterative stress over subsequent training sessions, contributing to a non-functional overreaching or even to overtraining. Yet, it is well established that training can alter host defense, leading to changes in disease susceptibility and severity (Collao et al., 2020). Both aerobic and RT have been explored to understand their inflammatory mediators and the parameters of the reaction to exercise (Monteiro et al., 2017). For instance, as to exercise-induced changes in interleukin-1 (IL-1) circulating levels, long-distance runners showed chronically elevated plasma IL-1 without an acute increase 3 h after an eccentric exercise bout, whereas their untrained controls had lower baseline IL-1 levels along with acute spurs 3 h post-exercise (Evans et al., 1986). In line with this, a two-fold increase in plasma IL-1 beta β (IL-1β) concentrations were found 30 min after 45-min cycling exercise at 70% of VO2max in non-athlete subjects (Vassilakopoulos et al., 2003). In another work, plasma IL-1 levels were undetectable after exercise (Northoff & Berg, 1991).

Exercise regulates a number of bodily processes, and more recently, it has come to light that skeletal muscle is a metabolically active organ, which has heightened the need to research how training regimens affect the generation of myokines (Pedersen, 2012). Myokines are chemicals generated by the contraction of skeletal muscles that serve a variety of purposes inside the body and can act locally or in other tissues (Pedersen. 2008). Typically, endurance training mediates anti-inflammatory actions that lead to fat loss and improvement of aerobic capacity. However, research recently demonstrated that high-intensity intermittent exercise cause anti-inflammatory responses similarly to moderate-intensity continuous exercise (Zwetsloot 2014; Cabral-Santos 2015; Lira 2015).

Finally, the antioxidant defense is activated by exercise, preferably via low molecular weight non-enzymatic antioxidants, i.e., uric acid (Sacheck & Blumberg, 2001). It is known that plasma urate levels increase with exercise, possibly as a physiological coping mechanism to increased oxidative stress. Recently it has been shown that anaerobic trainings (Wiecek et al., 2018), as well as a CF program (Kliszczewicz et al., 2015), induce oxidative stress immediately after the exercise, and also during the early period of recovery. However, the mechanisms controlling training load are not fully known, and stress responses are key determinants to that purpose. Given the complexity of these HIFT programs and the increasingly high number of its participants, studies are required to investigate the effects of these trainings and whether a tailored training optimization could be obtained.

Discussion

A study comparing CF training with a training approach based on ACSM recommendations reported CrossFit training as more strenuous and considered a "very hard" activity by participants (Drum et al., 2017). CrossFit participants also reported greater fatigue, greater muscle pain and swelling, and limb movement difficulties during or within 48 h after the workout (Drum et al., 2017). In an acute study, the WOD "CF triplet" (i.e., three burpees, four push-ups, and five squats) was associated with significant changes in physiological responses (Shaw et al., 2015). Participants achieved approximately 12,000 mmHg for rate pressure product, 6 mmol/L for blood lactate, and 54% of HRmax (Shaw et al., 2015). According to the authors, "CF triplet" was of moderate to high intensity and thus considered a viable interval training option that provides sufficient intensity in a safe manner (Shaw et al., 2015). In the correlation studies, whole-body strength, power, endurance, and experience seemed to be important measures associated with performance in CrossFit (Butcher et al., 2015). Others authors found VO2max and anaerobic power to be significant predictors of performance after one CrossFit training session (Bellar et al., 2015). The authors also divided 32 young healthy men into two groups and found CrossFit experience, or CrossFit training history, was also a predictor of performance during a WOD (Monda et al., 2017a; 2017b). Nonetheless, more research is required as the present literature is inconclusive regarding predictors of CrossFit performance.

Based on the systematic review, in general, WODs present highly varied psycho-physiological demands: heart rate between 54 and 98% of HRmax, blood lactate levels between 6 and 15 mmol/L, %VO2max between 57 and 66%, RPE between 8 and 9 (out of 10), and rate pressure product around 12,000 mmHg. Some WODs (e.g., "Fran," "Cindy," and "15.5") can be identified as high-intensity level whereas others (e.g., "CrossFit triplet") can be considered moderate. Until now, current CrossFit scientific literature has been based on studies that investigated the effects of CrossFit on body composition, psycho-physiological parameters, musculoskeletal injury risk, life and health aspects, and psycho-social behavior. Meta-analysis did not find a significant effect of CrossFit training changes in body mass index, relative body fat, fat mass, lean body mass, and waist circumference. Unfortunately, the number of studies investigating CrossFit with high level of evidence at low risk of bias is sparse. As a result, these findings neither firmly establish the benefits or risks of CrossFit, nor provide definitive practical recommendations concerning CrossFit training. Despite this disparity, there is the existence of initial evidence of higher levels of sense of community, satisfaction, and motivation among CrossFit participants.

Our study, despite dealing with a recent and highly topical topic, has some limitations. Initially, few studies have been conducted on this modality of physical exercise practice, and therefore, it would be necessary to increase the number of subjects undergoing CF to more accurately evaluate the impact of this new discipline. Furthermore, the training loads should be accurately evaluated and how they are modular in the different age groups. Therefore we believe that many studies can be carried out in the future which will be able to provide useful indications for the development of this recent discipline in order to obtain excellent results in terms of efficacy and also reduce the risk of injuries.

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Conflict of Interest
The author declares that there is no conflict of interest.

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Revised September 2019

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Format the manuscript in A4 paper size; margins are 1 inch or 2.5 cm all around.

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Number (Arabic numerals) the pages consecutively (centering at the bottom of each page), beginning with the title page as page 1 and ending with the Figure legend page.

Include line numbers (continuous) for the convenience of the reviewers.

Apart from chapter headings and sub-headings avoid any kind of formatting in the main text of the manuscripts.

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Original scientific papers should be:

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Review papers should provide concise in-depth reviews of both established and new areas, based on a critical examination

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Invited papers and award papers include invited papers from authors with outstanding scientific credentials. Nomination of invited authors is at the discretion of the SM editorial board. SM also publishes award papers selected by the scientific committee of the International Scientific Conference on Transformation Processes in Sport.

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- The author signs a formal statement that the submitted manuscript complies with the directions and guidelines of SM.

The editors-in-chief and associate editors will make a preliminary analysis regarding the appropriateness, quality, originality and written style/grammar of the submitted manuscript. The editors reserve the right to request additional information, corrections, and guideline compliance before they submit the manuscript to the ad-hoc review process.

SM uses ad-hoc reviewers, who volunteer to analyze the merit of the study. Typically, one or two expert reviewers are consulted in a double-blind process. Authors are notified by e-mail when their submission has been accepted (or rejected). Minor changes in the text may be made at the discretion of the editors-in-chief and/or associate editors. Changes can include spelling and grammar in the chosen language, written style, journal citations, and reference guidelines. The author is notified of changes via email. The final version is available to the author for his or her approval before it is published.

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1.6. After Acceptance

After the manuscript has been accepted, authors will receive a PDF version of the manuscripts for authorization, as it should look in printed version of SM. Authors should carefully check for omissions. Reporting errors after this point will not be possible and the Editorial Board will not be eligible for them.

Should there be any errors, authors should report them to the Office e-mail address **sportmont@ucg.ac.me**. If there are not any errors authors should also write a short e-mail stating that they agree with the received version.

1.7. Code of Conduct Ethics Committee of Publications

SM is hosting the Code of Conduct Ethics Committee of Publications of the **COPE** (the Committee on Publication Ethics), which provides a forum for publishers and Editors of scientific journals to discuss issues relating to the integrity of the work submitted to or published in their journals.

2. MANUSCRIPT STRUCTURE

2.1. Title Page

The first page of the manuscripts should be the title page, containing: title, type of publication, running head, authors, affiliations, corresponding author, and manuscript information. *See* example:

Body Composition of Elite Soccer Players from Montenegro

Original Scientific Paper

Elite Soccer Players from Montenegro

Dusko Bjelica[1]

[1]Univeristy of Montenegro, Faculty for Sport an Physical Education, Niksic, Montenegro

Corresponding author:

Dusko Bjelica

University of Montenegro

Faculty for Sport and Physical Education

Narodne omladine bb, 81400 Niksic, Montenegro

E-mail: sportmont@t-com.me

Word count: 2,946

Abstract word count: 236

Number of Tables: 3

Number of Figures: 0

2.1.1. Title

Title should be short and informative and the recommended length is no more than 20 words. The title should be in Title Case, written in uppercase and lowercase letters (initial uppercase for all words except articles, conjunctions, short prepositions no longer than four letters etc.) so that first letters of the words in the title are capitalized. Exceptions are words like: “and”, “or”, “between” etc. The word following a colon (:) or a hyphen (-) in the title is always capitalized.

2.1.2. Type of publication

Authors should suggest the type of their submission.

2.1.3. Running head

Short running title should not exceed 50 characters including spaces.

2.1.4. Authors

The form of an author’s name is first name, middle initial(s), and last name. In one line list all authors with full names separated by a comma (and space). Avoid any abbreviations of academic or professional titles. If authors belong to different institutions, following a family name of the author there should be a number in superscript designating affiliation.

2.1.5. Affiliations

Affiliation consists of the name of an institution, department, city, country/territory (in this order) to which the author(s) belong and to which the presented / submitted work should be attributed. List all affiliations (each in a separate line) in the order corresponding to the list of authors. Affiliations must be written in English, so carefully check the official English translation of the names of institutions and departments.

Only if there is more than one affiliation, should a number be given to each affiliation in order of appearance. This number should be written in superscript at the beginning of the line, separated from corresponding affiliation with a space. This number should also be put after corresponding name of the author, in superscript with no space in between.

If an author belongs to more than one institution, all corresponding superscript digits, separated with a comma with no space in between, should be present behind the family name of this author.

In case all authors belong to the same institution affiliation numbering is not needed.

Whenever possible expand your authors' affiliations with departments, or some other, specific and lower levels of organization.

2.1.6. Corresponding author

Corresponding author's name with full postal address in English and e-mail address should appear, after the affiliations. It is preferred that submitted address is institutional and not private. Corresponding author's name should include only initials of the first and middle names separated by a full stop (and a space) and the last name. Postal address should be written in the following line in sentence case. Parts of the address should be separated by a comma instead of a line break. E-mail (if possible) should be placed in the line following the postal address. Author should clearly state whether or not the e-mail should be published.

2.1.7. Manuscript information

All authors are required to provide word count (excluding title page, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References), the Abstract word count, the number of Tables, and the number of Figures.

2.2. Abstract

The second page of the manuscripts should be the abstract and key words. It should be placed on second page of the manuscripts after the standard title written in upper and lower case letters, bold.

Since abstract is independent part of your paper, all abbreviations used in the abstract should also be explained in it. If an abbreviation is used, the term should always be first written in full with the abbreviation in parentheses immediately after it. Abstract should not have any special headings (e.g., Aim, Results…).

Authors should provide up to six key words that capture the main topics of the article. Terms from the Medical Subject Headings (MeSH) list of Index Medicus are recommended to be used.

Key words should be placed on the second page of the manuscript right below the abstract, written in italic. Separate each key word by a comma (and a space). Do not put a full stop after the last key word. *See* example:

Abstract

Results of the analysis of

Key words: *spatial memory, blind, transfer of learning, feedback*

2.3. Main Chapters

Starting from the third page of the manuscripts, it should be the main chapters. Depending on the type of publication main manuscript chapters may vary. The general outline is: Introduction, Methods, Results, Discussion, Acknowledgements

(optional), Conflict of Interest (optional). However, this scheme may not be suitable for reviews or publications from some areas and authors should then adjust their chapters accordingly but use the general outline as much as possible.

2.3.1. Headings

Main chapter headings: written in bold and in Title Case. *See* example:

- ✓ **Methods**

Sub-headings: written in italic and in normal sentence case. Do not put a full stop or any other sign at the end of the title. Do not create more than one level of sub-heading. *See* example:

- ✓ *Table position of the research football team*

2.3.2 Ethics

When reporting experiments on human subjects, there must be a declaration of Ethics compliance. Inclusion of a statement such as follow in Methods section will be understood by the Editor as authors' affirmation of compliance: "This study was approved in advance by [name of committee and/or its institutional sponsor]. Each participant voluntarily provided written informed consent before participating." Authors that fail to submit an Ethics statement will be asked to resubmit the manuscripts, which may delay publication.

2.3.3 Statistics reporting

SM encourages authors to report precise p-values. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Use normal text (i.e., non-capitalized, non-italic) for statistical term "p".

2.3.4. 'Acknowledgements' and 'Conflict of Interest' (optional)

All contributors who do not meet the criteria for authorship should be listed in the 'Acknowledgements' section. If applicable, in 'Conflict of Interest' section, authors must clearly disclose any grants, financial or material supports, or any sort of technical assistances from an institution, organization, group or an individual that might be perceived as leading to a conflict of interest.

2.4. References

References should be placed on a new page after the standard title written in upper and lower case letters, bold.

All information needed for each type of must be present as specified in guidelines. Authors are solely responsible for accuracy of each reference. Use authoritative source for information such as Web of Science, Medline, or PubMed to check the validity of citations.

2.4.1. References style

SM adheres to the American Psychological Association 6th Edition reference style. Check "American Psychological Association. (2009). Concise rules of APA style. American Psychological Association." to ensure the manuscripts conform to this reference style. Authors using EndNote® to organize the references must convert the citations and bibliography to plain text before submission.

2.4.2. Examples for Reference citations

One work by one author

- ✓ In one study (Reilly, 1997), soccer players
- ✓ In the study by Reilly (1997), soccer players
- ✓ In 1997, Reilly's study of soccer players

Works by two authors

- ✓ Duffield and Marino (2007) studied
- ✓ In one study (Duffield & Marino, 2007), soccer players
- ✓ In 2007, Duffield and Marino's study of soccer players

Works by three to five authors: cite all the author names the first time the reference occurs and then subsequently include only the first author followed by et al.

- ✓ First citation: Bangsbo, Iaia, and Krustrup (2008) stated that
- ✓ Subséquent citation: Bangsbo et al. (2008) stated that

Works by six or more authors: cite only the name of the first author followed by et al. and the year

- ✓ Krustrup et al. (2003) studied
- ✓ In one study (Krustrup et al., 2003), soccer players

Two or more works in the same parenthetical citation: Citation of two or more works in the same parentheses should be listed in the order they appear in the reference list (i.e., alphabetically, then chronologically)

- ✓ Several studies (Bangsbo et al., 2008; Duffield & Marino, 2007; Reilly, 1997) suggest that

2.4.3. Examples for Reference list

Journal article (print):

Nepocatych, S., Balilionis, G., & O'Neal, E. K. (2017). Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 57-65. doi: 10.26773/mjssm.2017.09.008

Duffield, R., & Marino, F. E. (2007). Effects of pre-cooling procedures on intermittent-sprint exercise performance in warm conditions. *European Journal of Applied Physiology, 100*(6), 727-735. doi: 10.1007/s00421-007-0468-x

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. doi: 10.1249/01.MSS.0000058441.94520.32

Journal article (online; electronic version of print source):

Williams, R. (2016). Krishna's Neglected Responsibilities: Religious devotion and social critique in eighteenth-century North India [Electronic version]. *Modern Asian Studies, 50*(5), 1403-1440. doi:10.1017/S0026749X14000444

Journal article (online; electronic only):

Chantavanich, S. (2003, October). Recent research on human trafficking. *Kyoto Review of Southeast Asia, 4*. Retrieved November 15, 2005, from http://kyotoreview.cseas.kyoto-u.ac.jp/issue/issue3/index.html

Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

Encyclopedia entry (print, with author):

Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.

Encyclopedia entry (online, no author):

Ethnology. (2005, July). In *The Columbia encyclopedia* (6th ed.). New York: Columbia University Press. Retrieved November 21, 2005, from http://www.bartleby.com/65/et/ethnolog.html

Thesis and dissertation:

Pyun, D. Y. (2006). *The proposed model of attitude toward advertising through sport.* Unpublished Doctoral Dissertation. Tallahassee, FL: The Florida State University.

Book:

Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human kinetics.

Chapter of a book:

Kellmann, M. (2012). Chapter 31-Overtraining and recovery: Chapter taken from Routledge Handbook of Applied Sport Psychology ISBN: 978-0-203-85104-3 *Routledge Online Studies on the Olympic and Paralympic Games* (Vol. 1, pp. 292-302).

Reference to an internet source:

Agency. (2007). Water for Health: Hydration Best Practice Toolkit for Hospitals and Healthcare. Retrieved 10/29, 2013, from www.rcn.org.uk/newsevents/hydration

2.5. Tables

All tables should be included in the main manuscript file, each on a separate page right after the Reference section.

Tables should be presented as standard MS Word tables.

Number (Arabic) tables consecutively in the order of their first citation in the text.

Tables and table headings should be completely intelligible without reference to the text. Give each column a short or abbreviated heading. Authors should place explanatory matter in footnotes, not in the heading. All abbreviations appearing in a table and not considered standard must be explained in a footnote of that table. Avoid any shading or coloring in your tables and be sure that each table is cited in the text.

If you use data from another published or unpublished source, it is the authors' responsibility to obtain permission and acknowledge them fully.

2.5.1. Table heading

Table heading should be written above the table, in Title Case, and without a full stop at the end of the heading. Do not use suffix letters (e.g., Table 1a, 1b, 1c); instead, combine the related tables. *See* example:

- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

2.5.2. Table sub-heading

All text appearing in tables should be written beginning only with first letter of the first word in all capitals, i.e., all words for variable names, column headings etc. in tables should start with the first letter in all capitals. Avoid any formatting (e.g., bold, italic, underline) in tables.

2.5.3. Table footnotes

Table footnotes should be written below the table.

General notes explain, qualify or provide information about the table as a whole. Put explanations of abbreviations, symbols, etc. here. General notes are designated by the word *Note* (italicized) followed by a period.

- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

Specific notes explain, qualify or provide information about a particular column, row, or individual entry. To indicate specific notes, use superscript lowercase letters (e.g. $^{a, b, c}$), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript ^{a}.

- ✓ ^{a}One participant was diagnosed with heat illness and n = 19.^{b}n =20.

Probability notes provide the reader with the results of the texts for statistical significance. Probability notes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || etc.

- ✓ *P<0.05,†p<0.01.

2.5.4. Table citation

In the text, tables should be cited as full words. *See* example:

- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

2.6. Figures

On the last separate page of the main manuscript file, authors should place the legends of all the figures submitted separately.

All graphic materials should be of sufficient quality for print with a minimum resolution of 600 dpi. SM prefers TIFF, EPS and PNG formats.

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Figures and figure legends should be completely intelligible without reference to the text.

The price of printing in color is 50 EUR per page as printed in an issue of SM.

2.6.1. Figure legends

Figures should not contain footnotes. All information, including explanations of abbreviations must be present in figure legends. Figure legends should be written bellow the figure, in sentence case. *See* example:

- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

2.6.2. Figure citation

All graphic materials should be referred to as Figures in the text. Figures are cited in the text as full words. *See* example:

- ✓ Figure 1
  - × figure 1
  - × Figure 1.
  - ✓ ….exhibit greater variance than the year before (Figure 2). Therefore…
  - ✓ ….as shown in Figures 1 and 3. (citing more figures at once)
  - ✓ ….result has shown (Figures 1-3) that... (citing more figures at once)
  - ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

2.6.3. Sub-figures

If there is a figure divided in several sub-figures, each sub-figure should be marked with a small letter, starting with a, b, c etc. The letter should be marked for each subfigure in a logical and consistent way. *See* example:

- ✓ Figure 1a
- ✓ …in Figures 1a and b we can…
- ✓ …data represent (Figures 1a-d)…

2.7. Scientific Terminology

All units of measures should conform to the International System of Units (SI).

Measurements of length, height, weight, and volume should be reported in metric units (meter, kilogram, or liter) or their decimal multiples.

Decimal places in English language are separated with a full stop and not with a comma. Thousands are separated with a comma.

Percentage	Degrees	All other units of measure	Ratios	Decimal numbers
✓ 10%	✓ 10º	✓ 10 kg	✓ 12:2	✓ 0.056
× 10 %	× 10 º	× 10kg	× 12 : 2	× .056

Signs should be placed immediately preceding the relevant number.		
✓ 45±3.4	✓ p<0.01	✓ males >30 years of age
× 45 ± 3.4	× p < 0.01	× males > 30 years of age

2.8. Latin Names

Latin names of species, families etc. should be written in italics (even in titles). If you mention Latin names in your abstract they should be written in non-italic since the rest of the text in abstract is in italic. The first time the name of a species appears in the text both genus and species must be present; later on in the text it is possible to use genus abbreviations. *See* example:

- ✓ First time appearing: *musculus biceps brachii*

Abbreviated: *m. biceps brachii*

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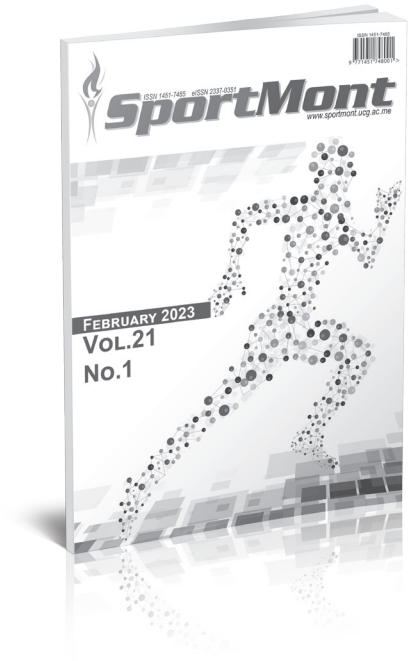

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Sport Mont Journal (SMJ) is a print (ISSN 1451-7485) and electronic scientific journal (eISSN 2337-0351) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:

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- Post-publication tools to indicate quality and impact;
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- Worldwide media coverage.

SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

SMJ covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the SMJ website: http://www.sportmont.ucg.ac.me/?sekcija=page&p=51. Contributors are urged to read SMJ's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to sportmont@ucg.ac.me or contact following Editors:

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Zoran MILOSEVIC, Editor-in Chief – zoranais@eunet.rs
Borko KATANIC, Managing Editor – borkokatanic@gmail.com
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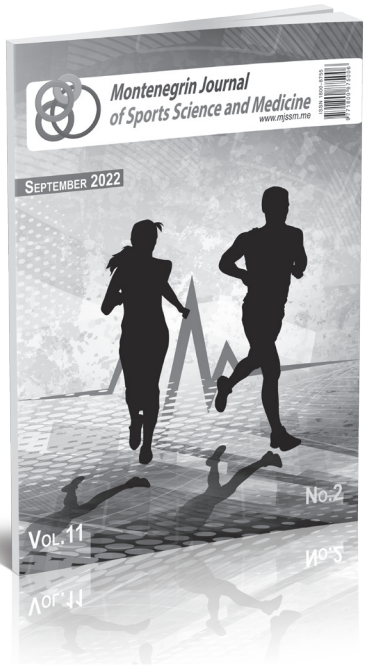
Winter issue – February 2023

Montenegrin Journal of Sports Science and Medicine

MONTENEGRIN **J**OURNAL
OF **S**PORTS **S**CIENCE
AND **M**EDICINE



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- Fast publication time;
- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

MJSSM is published biannually, in September and March of each year. MJSSM publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

MJSSM covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the MJSSM website: http://www.mjssm.me/?sekcija=page&p=51. Contributors are urged to read MJSSM's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to office@mjssm.me or contact following Editors:

Dusko BJELICA, Editor-in Chief – sportmont@t-com.me
Damir SEKULIC, Editor-in Chief – damirsekulic.mjssm@gmail.com

Publication date: Spring issue – March 2023
Autumn issue – September 2023

Montenegrin Sports Academy welcomes you to *Dubrovnik, Croatia*

KEY DATES

- **1st of July 2022, 24:00 CET**
  Abstract submission opening and opening of registration
- **1st of December 2022, 24:00 CET**
  Abstract submission deadline
- **15th of January 2023, 24:00 CET**
  Notification to authors about acceptance
- **1st of February 2023, 24:00 CET**
  Deadline for early-bird registration for presenting authors
- **15th of February 2023, 24:00 CET**
  Deadline for late registration for presenting authors

* CET = Central European Time

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MSA Dubrovnik 2023

20th Annual Scientific Conference of Montenegrin Sports Academy "Sport, Physical Activity and Health: Contemporary Perspectives"

MSA Dubrovnik 2023

20th - 23th April 2023

CONFERENCE VENUE

Hotel Croatia Cavtat, situated across the bay from the historic walls of Dubrovnik, Hotel Croatia Cavtat is a leading five-star resort and conference hotel on the southern part of Adriatic. Hotel Croatia's architecture blends seamlessly with its natural surroundings. Shaded by a pine tree forest, while offering spectacular sea views, all 487 accommodation units feature balconies which overlook the Adriatic Sea or Cavtat Bay. State-of-the-art facilities include numerous gourmet restaurants, a spa centre, and private beaches. Hotel Croatia is ideal for a broader experience of the Dubrovnik Riviera. Suited for business and relaxation alike, Hotel Croatia serves as an excellent base for exploring the city of Dubrovnik and the Dubrovnik Riviera.

WELCOME TO DUBROVNIK

Regardless of whether you are visiting Dubrovnik for the first time or the hundredth, the sense of awe never fails to descend when you set eyes on the beauty of the old town. Indeed it's hard to imagine anyone becoming jaded by the city's white limestone streets, baroque buildings and the endless shimmer of the Adriatic, or failing to be inspired by a walk along the ancient city walls that protected a civilised, sophisticated republic for centuries.

LANGUAGE

The official Conference language is English.

FIRST ANNOUNCEMENT

Dear Friends and Colleagues,

Montenegrin Sports Academy will mark its 20th Anniversary by organising the 20th Annual Scientific Conference during 20.-23. April 2023 in Dubrovnik Croatia. The 20th Anniversary Conference will be held in Hotel Croatia, Cavtat.

Reserve your calendars, let us gather in person after these turbulent times and make our conference even more prestigious. Guarantee for our further prosperity is our international partners and Montenegrin Sports Academy. See you in Dubrovnik next spring!

We look forward to seeing you in spring 2023,

Prof. Duško Bjelica, Conference President

Conference sub-themes include:

Adapted Physical Activity; Anthropology; Architecture and Urbanism; Biochemistry; Biomechanics; Coaching; Economics; Health and Fitness; History; Molecular Biology; Motor Learning; Neuromuscular Physiology; Nutrition; Olympism; Philosophy and Ethics; Physical Education and Pedagogics; Physiology; Physiotherapy; Psychology; Rehabilitation; Sociology; Sport Management and Law; Sport Statistics and Analyses; Sport Technology; Sport Tourism; Sports Medicine and Orthopaedics; Training and Testing; Traumatology; and other Multi- & Interdisciplinary Themes.

Look inside!

Montenegrin Journal of Sports Science and Medicine

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CALL FOR ABSTRACTS

Research scholars and students are invited to present their original work in any of the conference sub-themes. The list of the conference sub-themes is not exhaustive and, therefore, authors should not feel limited by them. Authors can submit their original work in the form of an ABSTRACT, free of charge. An author may submit only one abstract as the first author and two abstracts as the co-author. After undergoing the reviewing process, all authors will be notified about the condition of their submission (accepted or rejected). Presenters (= the first authors) must be registered and have paid registration fees for the conference to secure their oral or poster (not debated) presentation during the conference and the publication in Montenegrin Journal of Sports Science and Medicine that is abstracted/indexed in Emerging Sources Citation Index, SCOPUS and other database, under the condition that the first author has paid registration fee.

CALL FOR PAPERS

Full-length manuscripts may be submitted for publishing in the Sport Mont journal (see at HYPERLINK "http://www.sportmont.ucg.ac.me" www.sportmont.ucg.ac.me), an international peer-reviewed scientific journal, indexed in Scopus, DOAJ, SPORTDiscus, Index Copernicus, ERIH PLUS, et cetera. Full-length paper submission is free of charge but author(s) has to pay additional 50 euros per accepted full-length paper to cover publication costs. Full manuscripts should be submitted for consideration of publication by the 15th of March, 2023 and prepared according to the guidelines for authors.

REGISTRATION FEES

For participants 260 EUR (220 EUR early-bird)
For students 190 EUR (160 EUR early-bird)
For accompanying persons 140 EUR (110 EUR early-bird)

MONTENEGRIN SPORTS ACADEMY

Founded in 2003 in Podgorica (Montenegro), the Montenegrin Sports Academy (MSA) is a sports scientific society dedicated to the collection, generation and dissemination of scientific knowledge at the Montenegrin level and beyond.

The Montenegrin Sports Academy (MSA) is the leading association of sports scientists at the Montenegrin level, which maintains extensive co-operation with the corresponding associations from abroad. The purpose of the MSA is the promotion of science and research, with special attention to sports science across Montenegro and beyond. Its topics include motivation, attitudes, values and responses, adaptation, performance and health aspects of people engaged in physical activity and the relation of physical activity and lifestyle to health, prevention and aging. These topics are investigated on an interdisciplinary basis and they bring together scientists from all areas of sports science, such as adapted physical activity, biochemistry, biomechanics, chronic disease and exercise, coaching and performance, doping, education, engineering and technology, environmental physiology, ethics, exercise and health, exercise, lifestyle and fitness, gender in sports, growth and development, human performance and aging, management and sports law, molecular biology and genetics, motor control and learning, muscle mechanics and neuromuscular control, muscle metabolism and hemodynamics, nutrition and exercise, overtraining, physiology, physiotherapy, rehabilitation, sports history, sports medicine, sports pedagogy, sports philosophy, sports psychology, sports sociology, training and testing.

The MSA is a non-profit organization. It supports Montenegrin institutions, such as the Ministry of Education and Sports, the Ministry of Science and the Montenegrin Olympic Committee, by offering scientific advice and assistance for carrying out coordinated national and European research projects defined by these bodies. In addition, the MSA serves as the most important Montenegrin and regional network of sports scientists from all relevant subdisciplines.

The main scientific event organized by the Montenegrin Sports Academy (MSA) is the annual conference held in the first week of April.

Annual conferences have been organized since the inauguration of the MSA in 2003. Today the MSA conference ranks among the leading sports scientific congresses in the Western Balkans. The conference comprises a range of invited lecturers, oral and poster presentations from multi- and mono-disciplinary areas, as well as various types of workshops. The MSA conference is attended by national, regional and international sports scientists with academic careers. The MSA conference now welcomes up to 200 participants from all over the world.

It is our great pleasure to announce the upcoming 19th Annual Scientific Conference of Montenegrin Sports Academy “Sport, Physical Activity and Health: Contemporary Perspectives” to be held in Dubrovnik, Croatia, from 7 to 10 April, 2022. It is planned to be once again organized by the Montenegrin Sports Academy, in cooperation with the Faculty of Sport and Physical Education, University of Montenegro and other international partner institutions (specified in the partner section).

The conference is focused on very current topics from all areas of sports science and sports medicine including physiology and sports medicine, social sciences and humanities, biomechanics and neuromuscular (see Abstract Submission page for more information).

We do believe that the topics offered to our conference participants will serve as a useful forum for the presentation of the latest research, as well as both for the theoretical and applied insight into the field of sports science and sports medicine disciplines.

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Sports Science and Medicine Journals

from Montenegrin Sports Academy

We have expanded the quality of our journals considerably over the past years and can now claim to be the market leader in terms of breadth of coverage.

As we continue to increase the quality of our publications across the field, we hope that you will continue to regard MSA journals as authoritative and stimulating sources for your research. We would be delighted to receive your comments and suggestions, mostly due to the reason your proposals are always welcome.

Look Inside!

Sport Mont Journal

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Zoran Milosevic**, Serbia
Managing Editor: **Borko Katanic**, Montenegro; **Nedim Covic**, Bosnia and Herzegovina

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Sport Mont Journal is a scientific journal that provides: Open-access and freely accessible online; Fast publication time; Peer review by expert, practicing researchers; Post-publication tools to indicate quality and impact; Community-based dialogue on articles; Worldwide media coverage. SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

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Montenegrin Journal of Sports Science and Medicine

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Damir Sekulic**, Croatia
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www.mjssm.me


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20th Annual Scientific Conference of Montenegrin Sports Academy

"Sport, Physical Activity and Health: Contemporary perspectives"

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MONTENEGRIN SPORTS ACADEMY

20th - 23th April 2023,
Dubrovnik - Croatia