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ORIGINAL SCIENTIFIC PAPER

Effects of a Combined 8-Week Group Exercise Program on the Anthropometric Characteristics of Female University Students

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Abstract

The aim of this study was to analyse effects of a combined 8-week group exercise program on the anthropometric characteristics of female university students. Fifty two first year female students from the Faculty of Sports and Physical Education in Novi Sad were divided into two groups: experimental (N=27, 20.43±1.12years, 21.75±3.32 kg/m2) and control group (N= 25, 20.91±1.76years, 20.91±2.93 kg/m2). Experimental group attended 8 weeks of supervised additional exepriemntal program while the control group did not do any aditional physical activity. Over a 8-week period, changes in anthropometric characteristics were carefully monitored through thirteen measures with the Martin antropometer; bioelectrical impedance OMFRON BF 511, Gulick Anthropometric Tape and John Bull calliper. MANOVA and ANOVA were used to determine differences among groups before and after the experimental program. Primary findings of this study indicate that the combined group exercise intervention produced significant improvements in the female students' anthropometric characteristics. Specifically, increases were observed in calf circumference ($p = 0.05$), biceps skinfold thickness ($p = 0.001$), triceps skinfold thickness ($p= 0.001$), forearm skinfold thickness ($p = 0.001$), subscapular skinfold thickness ($p = 0.03$), and abdominal skinfold thickness ($p = 0.001$) These results highlight the positive contribution and significance of the group fitness program in transforming anthropometric characteristics among female students.

Keywords: *anthropometry, group, exercise program, female students*

Introduction

Anthropometric characteristics (AC) play a significant role in numerous medical disciplines, particularly in identifying risk factors that influence the onset and development of various diseases, as well as in the context of studying the processes of growth and development of the human body (Bjorntorp, 1990). Although body dimensions and composition are largely influenced by genetic factors, there is a potential for modification through adequate nutrition and physical activity (PA) (Lightfoot, De Geus, Booth, Bray, Den Hoed et al., 2018). The results of numerous studies indicate that physically active individuals show statistically significant differences in somatic characteristics compared to those leading a sedentary lifestyle (Sivapathy, Chang, Chai, Ang, & Yim, 2013; Zombra, 2018). The quantification of anthropometric measurements and body composition represents an essential element within the physiological profile, and in the athlete population, it plays a particularly important role as it allows for the monitoring of sports performance and training regimes (Chengliang & Li, 2011). This is especially relevant in strength sports (judo, wrestling, weightlifting), gravitational sports (ski jumping, cycling), and aesthetic sports (rhythmic gymnastics, artistic gymnastics), where body composition significantly impacts athletic performance and rankings (Ortansa & Ileana, 2006; Ackland, Lohman, Sundgot-Borgen,

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Maughan, Meyer, Stewart, & Müller, 2012). Equally specific and important is the population of students at faculties of sport and physical education, who are selected in a specific way for studies, precisely because they are required to have above-average somatic characteristics and motor abilities.

PA plays a decisive role in energy expenditure, leading to an energy deficit that aids in weight reduction (DeLany, Kelley, Hames, Jakičić, & Goodpaster, 2014). One of the important factors is determining the appropriate load, as it is closely linked to the outcomes of exercise, such as weight loss and changes in AC (Jakičić, Marcus, & Gallegher, 2003; Slentz et al., 2004). Group fitness programs are a type of structured physical exercise designed with the aim of enhancing health and aesthetic appearance (Bjelica, 2020). These programs serve as an effective tool for controlling and reducing body weight (BW), leading to positive changes in body composition (Stasiulis, Mockiene, Vizbaraite, & Mockus, 2010). The implementation of specific group fitness programs leads to notable changes in body composition, as certain movement patterns act as a significant anabolic stimulus for the body (Eliakim & Beyth, 2003). Group exercise programs can also be combinations, so they can consist of different types of PA, such as aerobics and resistance training. Furthermore, there are studies that have demonstrated that both aerobic (Špirtović et al., 2024) and resistance training (Ndemba et al., 2020) contribute to a significant improvement of AC in women. Aerobics is a form of physical exercise that involves sustained, rhythmic activity to improve cardiovascular fitness and endurance and improve body image, i.e. enhance AC (McArdle, Katch, & Katch, 2014), while the resistance training involves exercises designed to improve muscular strength and endurance by working against a force (Baechle, & Earle, 2008).

Previous research has shown that exercise that combines both aerobic and resistance exercise can lead to desirable changes in both anthropometric and physiologic parameters of adults (Pollock, Franklin, Balady, Chaitman, & Fleg, 2000; Pescatello, Franklin, Fagard, Farquhar, Kelley et al., 2004). Also, when referring specifically to the female population, numerous studies have demonstrated the significant effects of the mentioned combined exercise program in younger women (Špirtović et al., 2024; Bjelica, 2020; Lim, Hwang, Eum, Kim, Cheung et al., 2024), in middle-aged women (Adebero, 2019), and in women with diabetes (Gilyana, Batrakoulis, Goulis, Symeonidou, Al-Mhanna et al., 2024). Similar effects have also been observed in individuals from the academic community (Pugliese, Tuccella, Maisto, D'Angelo, Delle Monache et al., 2025), who were in fact young women, just like the participants in this study. Investigating the effects of combined group exercise programs on AC of female university students is important because this population often experiences lifestyle changes that can negatively impact body composition, such as increased sedentary behavior and irregular eating habits. Understanding how structured PA interventions can mitigate these risks can contribute to the development of effective health promotion strategies tailored for young women in academic settings. Therefore, the aim of this study was to examine the effects of a combined group exercise program on AC of female university students.

Methods

Participants

For the purpose of this research, a sample of participants was drown from the population of female students of the Faculty of Sport and Physical Education in Novi Sad who had been physically inactive up to that point, and who are actively engaged in the exercise program. The study included 52 physical education female students (N=52), aged 20.71±1.51 years. Furtheremore, the participants were divided into experimental (EG) group (N=27, 20.43±1.12years, 21.75±3.32 kg/m2) and control (CG) group (N= 25, 20.91±1.76years, 20.91±2.93 kg/m2). All participants voluntarily took part in the study, and informed consent for participation in the study and data processing was obtained from each of them. Eligible participants were required to attend regular classes in the faculty and have no chronic illnesses or medical restrictions that might impact their fitness or daily activity levels. Respondents were excluded if they had conditions limiting PA, had been advised by a physician to restrict such activity, or were engaged in external structured exercise programs that could influence outcomes. The procedure was conducted within the ethical standards of the Helsinki Declaration of 1964 and according to Resolution 466/12 of the Ministry of Health. The assessment of anthropometric parameters was carried out in the laboratories of the Faculty of Sport and Physical Education in Novi Sad.

Measured variables

AC were assessed using following equipment: Martin antropometer; bioelectrical impedance OMFRON BF 511, Gulick Anthropometric Tape and John Bull calliper.

Body height (BH) was measured using an anthropometer according to Martin (Martin metal anthropometer - GPM Swiss Made). During the measurement, the examinee stands barefoot on a flat and firm surface. Her head is in a position that meets the requirement of the Frankfurt horizontal (the Frankfurt horizontal is a line connecting the lower edge of the left orbit and the upper edge of the left external auditory opening). The examiner stands on the left side of the subject and controls whether the anthropometer is placed vertically and directly on the longitudinal side of the body. The measurement result is read with an accuracy of 0.1 cm (Đurašković 2001).

BW was measured using the bioelectrical impedance OMFRON BF 511 (Kyoto, Japan). During the measurement, the examinee stands barefoot on a flat and firm surface. The examiner stands on the left side of the subject and reads automatically generated result (Beleigoli et al., 2019).

Anthropometric circumferences were measured using a non-elastic medical tape (to the nearest 0.1 cm): Upper arm circumference (UAC) was measured at the midpoint between the acromion process and the olecranon tip of the right arm, with the subject's arm relaxed at the side. Forearm circumference (FRC) was taken at the point of greatest girth of the right forearm, with the palm facing upward and the muscles relaxed. Thigh circumference (TC) was measured midway between the inguinal crease and the proximal border of the patella on the right leg, with the subject standing and weight evenly distributed. Calf circumference (CC) was recorded at the maximal medial calf girth of the right leg, with the subject standing and the foot flat on the floor (Lohman, Roche, & Martorell, 1988).

Skinfold thicknesses were specified using a John Bull calliper with a constant pressure of 10 g/cm² and expressed in mm (Rebato, Salcez, Martin & Rosique, 1998). The biceps skinfold thickness (BSF) was measured over the belly of the biceps brachii muscle on the anterior surface of the right upper arm, midway between the acromion and the antecubital fossa. The triceps skinfold thickness (TSF) was taken on the posterior midline of the upper arm, directly opposite the biceps site, also midway between the acromion and the olecranon process. The forearm skinfold thickness (FSF) was measured on the posterior aspect of the right forearm, at the level of the largest circumference of the forearm. The thigh skinfold thickness (ThSF) was taken on the anterior aspect of the right thigh, midway between the inguinal crease and the proximal border of the patella. The calf skinfold thickness (CaSF) was measured on the medial side of

the right calf at the level of the point of maximal circumference. The subscapular skinfold thickness (SSF) was measured just below the inferior angle of the right scapula, at a 45-degree angle following the natural fold of the skin. The abdominal skinfold thickness (AbSF) was taken vertically approximately 2 cm to the right of the umbilicus.

All measurements were carried out in the morning by the same examiner in a quiet, properly illuminated, and thermally neutral environment. The participantswere wearing light indoor clothing. All meantioned variables were measured according to a standardized International Biological Programme protocol (Weiner & Lourie 1996).

Procedures

Before conducting the study tests, all participants were notified of the study's purpose through an informational letter. All of the aforementioned variables were measured on two occasions: the first (initial measurement) to establish the participants' baseline status, and the second (final measurement) upon completion of the experimental program. Testing was done in the morning hours.

Experimental program

The experimental program lasted 8 weeks and included three supervised exercise sessions per week, consisting of two resistance-training sessions and one aerobic session, as previously implemented by Garber, Blissmer, Deschenes, Franklin, Lamonte, et al. (2011). Each session lasted 60 minutes with incorporated structured warm-up and cool-down. The resistance-training sessions targeted all major muscle groups using a combination of free weights, machines, and bodyweight exercises. Participants performed 2–4 sets of 8–12 repetitions at moderate to vigorous intensity (~60–80% of one-repetition maximum), with progressive overload applied as strength improved. Aerobic sessions consisted of ~50 minutes of continuous steady-state exercise (treadmill, cycling, or elliptical) performed at 40–59% heart rate reserve, corresponding to moderate intensity. The CG did not participate in any additional organized PA program. All sessions were conducted under supervision to ensure adherence and correct technique. The program was designed in accordance with established guidelines indicating that combined resistance and aerobic exercise interventions improve both muscular strength and cardiometabolic health in young adults (Garber et al., 2011).

Statistical analysis

All collected data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc., Chicago, USA). Descriptive statistics, including the mean and standard deviation, were calculated for each variable (Table 1, 2). The normality of the data distribution was examined with the Kolmogorov-Smirnov test. To determine differences between the initial and final testing, multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA) were used. The level of statistical significance for all analyses was set at 0.05.

Results

Tables 1 and 2 present the arithmetic means (Mean) and standard deviations (SD) for each study group, together with the results of the MANOVA and ANOVA analyses.

Table 1. Univariate and multivariate analysis of variance of the experimentaln (EG) and control (CG) groups at the initial measurement.

	Initial testing		Differences between groups	
	EG (N=27) Mean ± SD	CG (N=25) Mean ± SD	F value	P value
BW (kg)	57.7 ± 7.9	62.5 ± 9.3	1.4	0.25
BH (cm)	166.1 ± 5.1	169.5 ± 5.6	0.2	0.51
UAC (cm)	25.1 ± 2.2	24.7 ± 2.6	0.9	0.24
FRC (cm)	21.7 ± 1.3	21.9 ± 1.7	0.2	0.62
TC (cm)	50.0 ± 4.3	51.1 ± 5.3	0.6	0.43
CC (cm)	36.2 ± 1.8	36.2 ± 2.6	0.6	0.51
BFS (mm)	7.0 ± 2.3	7.9 ± 3.0	0.9	0.34
TFS (mm)	9.5 ± 2.1	10.3 ± 3.9	0.7	0.37
FSF (mm)	5.7 ± 1.31	6.2 ± 1.8	0.9	0.34
ThSF (mm)	11.3 ± 2.9	12.7 ± 4.7	1.7	0.19
CaSF (mm)	5.7 ± 2.0	6.5 ± 2.6	1.2	0.21
SSF (mm)	13.6 ± 4.7	12.0 ± 6.4	0.1	0.73
AbSF (mm)	12.1 ± 4.03	12.9 ± 6.4	0.3	0.55

Legend: EG – experimental group; CG – control group; N – number of participants; F value – F test of multivariate analysis of variance (Manova); P value – value of analysis of variance (Anova); * - level of statistical significance <0.05; ** - level of statistical significance <0.01; Mean – mean values; SD – standard deviation; BW – body weight; BH – body height; UAC - Upper arm circumference; FRC – forearm circumference; TC – thigh circumference; CC – calf circumference; BFS - The biceps skinfold thickness; TFS - The triceps skinfold thickness; FSF - The forearm skinfold thickness; ThSF - The thigh skinfold thickness; CaSF - The calf skinfold thickness; SSF - The subscapular skinfold thickness; AbSF - The abdominal skinfold thickness.

From Table 1, it is evident that there are no statistically significant differences in the overall set of variables at baseline in the female students, as indicated by the MANOVA results ($F = 1.16$, $p = 0.43$) and by the univariate ANOVA outcomes shown in the final column. These findings confirm that the EG and CG did not differ significantly on the observed variables at the initial measurement.

After completing the 8-week experimental program, the primary findings of this study indicate that the combined group exercise intervention produced significant improvements in the female students' AC. Specifically, increases were observed in calf circumference ($p = 0.05$), BSF ($p = 0.001$), TSF ($p= 0.001$), FSF ($p = 0.001$), SSF ($p = 0.03$), and AbSF ($p = 0.001$) (Table 2).

Table 2. Univariate and multivariate analysis of variance of the experimentaln (EG) and control (CG) groups at the final measurement.

	Initial testing		Differences between groups	
	EG (N=27) Mean ± SD	CG (N=25) Mean ± SD	F value	P value
BW (kg)	61.0 ± 7.3	61.7 ± 10.8	2.1	0.12
BH (cm)	166.1 ± 5.2	159.5 ± 5.6	0.1	0.62
UAC (cm)	25.4 ± 2.1	25.8 ± 2.7	2.8	0.10
FRC (cm)	21.8 ± 1.3	21.9 ± 1.7	0.5	0.44
TC (cm)	50.3 ± 3.4	51.1 ± 5.3	0.1	0.71
CC (cm)	41.8 ± 1.6	35.3 ± 2.6	3.9	0.05*
BFS (mm)	6.4 ± 2.1	7.8 ± 3.0	12.7	0.001**
TFS (mm)	7.0 ± 1.5	10.3 ± 3.9	27.1	0.000**
FSF (mm)	5.0 ± 1.0	6.2 ± 1.8	15.8	0.001**
ThSF (mm)	10.9 ± 2.1	11.7 ± 4.7	1.5	0.21
CaSF (mm)	5.4 ± 1.6	6.4 ± 2.2	0.6	0.43
SSF (mm)	12.5 ± 3.9	14.4 ± 6.0	5.5	0.03*
AbSF (mm)	10.8 ± 3.8	12.9 ± 6.4	10.1	0.001**

Legend: EG – experimental group; CG – control group; N – number of participants; F value - test of multivariate analysis of variance (Manova); P value – value of analysis of variance (Anova); * - level of statistical significance <0.05; ** - level of statistical significance <0.01; Mean – mean values; SD – standard deviation; BW – body weight; BH – body height; UAC - Upper arm circumference; FRC – forearm circumference; TC – thigh circumference; CC – calf circumference; BFS - The biceps skinfold thickness; TFS - The triceps skinfold thickness; FSF - The forearm skinfold thickness; ThSF - The thigh skinfold thickness; CaSF - The calf skinfold thickness; SSF - The subscapular skinfold thickness; AbSF - The abdominal skinfold thickness.

Discussion

The purpose of this study was to assess how a combined group exercise program influences the AC of female university students. Upon completion of the 8-week intervention, the main findings showed that the combined group exercise program resulted in significant improvements in participants' anthropometric measures, including increased calf circumference and decreased skinfold thickness at the biceps, triceps, forearm, subscapular, and abdominal sites.

Anthropometric characteristic, such as body circumferences, are noninvasive indices of body size and composition (Casadei & Kiel, 2022). In female university students, these measures are especially relevant because they reflect physical fitness and fat distribution, which in turn predict metabolic and cardiovascular risk (Casadei & Kiel, 2022). For example, larger limb circumferences often indicate greater muscle mass (fitness), while central measures like waist circumference track adiposity and metabolic syndrome risk (Shen, Punyanitya, Chen, Gallagher, Albu et al., 2006). In the present study, participants that have went through the combined group exercise program showed a statistically significant increase in mean calf circumference post-intervention, suggesting enhanced lower-leg muscle development. This finding is consistent with other research in young adults: for instance, an 8-week combined HIIT and resistance training program significantly increased lean muscle mass in overweight young women, and so the cirfumferences in lower limbs (Wang, Yang, Deng, Wang, Yang et al., 2024), and structured strength training has been shown to raise calf circumference in college students (Wang, Zheng, Wang, & XuanxiI, 2023; and Gentil, Rodrigo, & Soares, 2013) who reported ~5% increases in arm circumference after an 8-week resistance program in young men. Likewise, Beak et al. (2022) found that low-intensity aerobic exercise with blood-flow restriction significantly increased calf circumference over 8 weeks (Beak, Park, Yang, & Kim, 2022). Relevant for the participants of our study, Liu et al. reported that a 6-week aerobics plus resistance program in female undergraduates substantially increased calf circumference and strength of female university students (Zhou & Hazel, 2024). Physiologically, this response is expected: repeated resistance loading of the calf muscles stimulates muscle protein synthesis and fiber hypertrophy (Smeuninx & McKendry, 2016), which leads to an increase in muscle cross-sectional area and thus larger calf circumference.

Skinfold thickness measurements quantify the thickness of subcutaneous fat at specific body sites (e.g. triceps, subscapular) using calipers, providing an estimate of total body fat (Reilly, Wilson, & Durnin, 1995). These measurements are important in young women because they reflect fat distribution; higher skinfold values, especially in central locations, are associated with increased adiposity and cardiometabolic risk (Duggleby, Jackson, Godfrey, & Robinson, Inskip, 2009). In our study, the 8-week combined aerobic plus resistance program produced significant reductions in most of the measured skinfolds (biceps, triceps, forearm, subscapular, and abdominal). This aligns with many interventional studies showing that exercise lowers subcutaneous fat: for example, O'Connor and Lamb (2003) reported that a 12-week high-repetition resistance program in active women reduced the sum of five skinfolds by about 17 mm (O'Connor & Lamb, 2003). Likewise, a 12-week mixed aerobics protocol in healthy women yielded large relative declines (≈14–21%) in abdominal, thigh, and arm skinfold thickness (Špirtović et al., 2024) These results mirror our findings of broad skinfold thinning, indicating effective fat loss from combined training. In female college populations, Ha and So (2012) similarly observed that 12 weeks of combined exercise significantly reduced waist circumference in obese students (Ha & So, 2012), consistent with decreased central adiposity. Collectively, these studies suggest that young women engaging in combined aerobic-resistance programs tend to lose subcutaneous fat across multiple sites. The physiological mechanism is that such training markedly increases total energy expenditure and fat oxidation: the aerobic component burns calories and mobilizes fat, while added muscle mass from resistance training raises resting metabolism (Melanson, MacLean, & Hill, 2009).

The main limitations of this study relate to the relatively small sample size (N = 52) and the brief duration of the intervention (only eight weeks), which may restrict the generalizability of the findings and the evaluation of the long-term effects of combined aerobic–resistance training. Additionally, the study did not control participants' dietary habits or monitor PA outside the prescribed program, potentially introducing extra variability into the results. To enhance the robustness and breadth of future conclusions, it is recommended that subsequent investigations employ larger samples, longer intervention periods, and rigorous control of nutrition and daily activity levels. Future research should investigate the dose–response relationship between combined aerobic–resistance training volume and anthropometric outcomes by employing varied training intensities and frequencies. Moreover, longitudinal studies incorporating nutritional interventions and objective PA monitoring are warranted to elucidate the mechanistic pathways underlying body composition changes in female university populations.

Conclusion

Based on the findings of this study, an 8-week combined aerobic resistance exercise program induced a significant improvements in female university students' body composition, as demonstrated by increased calf circumference and reduced skinfold thickness at the biceps, triceps, forearm, subscapular, and abdominal sites.

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ORIGINAL SCIENTIFIC PAPER

The Impact of Acute Hydration on Body Composition Assessment Using the Bioelectrical Impedance Method in Female Pilates Novices

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Abstract

The aim of this study was to examine the impact of acute hydration on body composition assessment using the bioelectrical impedance (BIA) method. Given the sensitivity of BIA measurements to changes in hydration status, it was examined how the intake of 0.5 l of water affects body mass and body fat percentage and how quickly the values stabilize after hydration. The study was conducted on 28 female subjects who are recreationally involved in Pilates, and measurements were performed in the morning on an empty stomach, using a multi-purpose BIA device. Body mass and fat percentage were assessed four times: twice before hydration and five and fifteen minutes after hydration. The results showed a statistically significant increase in body mass immediately after water intake ($p < 0.001$), while body fat percentage also increased, contrary to expectations. The values stabilized within 15 minutes after hydration. These changes can be explained by the redistribution of fluid in the body and the algorithms that BIA devices use to assess body composition. It is concluded that fluid intake immediately before BIA analysis may temporarily affect the results, which may lead to misinterpretations of body composition. It is recommended to standardize the measurement conditions and conduct testing under the same hydration conditions to ensure greater reliability of body composition assessment.

Keywords: *body composition analysis, body composition, hydration status, body weight, body fat, measurement reliability*

Introduction

Body composition assessment is one of the key elements in the analysis of an individual's health and fitness. This is particularly important in the context of preventing and monitoring various health conditions, including obesity, diabetes, cardiovascular disease and osteoporosis. In clinical and sports settings, accurate determination of the ratio of fat to lean tissue allows for informed decisions about nutrition, training and health interventions.

One of the most used methods for assessing body composition is bioelectrical impedance analysis (BIA). It is a non-invasive method based on measuring the resistance to electrical current as it passes through the body. Lean body mass, rich in water and electrolytes, conducts electricity well, while adipose tissue, with a lower water content, provides greater resistance. In this way, BIA allows for the assessment of body fat percentage and other body composition parameters (Ling et al., 2011). However, the results obtained with the BIA method can be influenced by various factors, among which hydration of the organism is of particular importance.

The degree of hydration can significantly affect the measurement, since changes in body water change the electrical resistance. For example, dehydration reduces total body water, increasing drag and potentially overestimating body fat percentage (Algül & Özçelik, 2022). On the other hand, hyperhydration can lead to an underestimation of body fat percentage. A study by Dixon et al. (2009) showed that fluid intake can affect body composition estimates using BIA, especially the estimation of visceral fat and total body water. In addition to hydration, other factors such as physical activity prior to measurement, food and beverage intake, skin temperature, and individual characteristics such as gender, age, and

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fitness level can also affect BIA measurement results. For example, physical activity immediately prior to measurement can change the distribution of body water, which can affect the results (Ekingen et al., 2022). Also, food and beverage intake can increase the water content of the digestive tract, which can lead to an underestimation of body fat percentage. Therefore, it is advisable to conduct measurements under standardized conditions, such as measurements in the morning after waking up, before food and fluid intake, and after bladder emptying, in order to minimize the influence of these variables on the results (Mišigoj-Duraković, 2008).

Previous research suggests that different BIA models and frequencies may exhibit different sensitivity to changes in hydration status. Anusitviwat et al. (2023) found that dual-frequency bioelectrical impedance (DF-BIA) can provide more accurate estimates of muscle mass compared to single-frequency models but is still sensitive to fluctuations in hydration. Furthermore, Jeong et al. (2023) found that acute hydration can affect estimates of body mass, body fat percentage, and total body water, with multi-frequency BIA devices showing greater stability compared to single-frequency ones.

In addition, recommendations from manufacturers of BIA scales also emphasize the importance of standardizing measurement conditions to reduce variations caused by changes in hydration. TANITA and other leading BIA manufacturers recommend performing measurements in the morning on an empty stomach, after emptying the bladder, and before fluid intake, as even small changes in hydration status can affect the accuracy of the results. Vasold et al. (2019) further point out that cheaper BIA models may exhibit greater variability and less reliability than more expensive, professional models.

Multifrequency bioelectrical impedance (MF-BIA) provides an estimate of total body water. However, it is not known whether MF-BIA detects increases in body water due to acute hydration, thereby affecting the validity of MF-BIA body composition measurements. Single-frequency bioelectrical impedance (SF-BIA), looking at the results of studies conducted only in women, reveals significant increases in fat percentage, fat-free mass, and fat mass, while total body water significantly decreased with acute hydration (Jeong et al., 2023).

The issue investigated in this paper relates to the impact of acute hydration on the results obtained by the bioelectrical impedance method. Although BIA is widely used in research and clinical settings, there is a need to better understand its sensitivity to fluctuations in hydration. Different levels of hydration can lead to underestimation or overestimation of body fat percentage, which can lead to misinterpretations of body composition.

Therefore, the main aim of this study is to examine how acute hydration affects the assessment of body composition using the bioelectrical impedance method. Specifically, changes in body mass and body fat percentage will be investigated before and after the consumption of 0.5 l of water, and to determine how quickly the results stabilize after fluid intake.

It is predicted that the intake of 0.5 l of water will result in a statistically significant increase in body mass immediately after hydration. Furthermore, it is expected that increased hydration will affect the assessment of body fat percentage, whereby a decrease in electrical resistance could temporarily lead to its lower value. It is assumed that body mass and body fat percentage parameters will stabilize within 15 minutes after fluid intake.

Methods

Subjects

A priori power analysis was performed using the G*Power program (version 3.1.9.7, Germany, Düsseldorf), based on a univariate analysis of variance for repeated measures. The following assumptions were used in the calculation: a minimum practically significant standardized effect size of 0.20, a significance level of 0.05, a statistical power of 0.80, and a correlation between repeated measures of 0.7. The results of the analysis showed that the minimum required sample size was 26 subjects.

Accordingly, 28 women who practice Pilates recreationally were included in the study. The mean age of the subjects was 42.6 ± 9.9 years, height 169.5 ± 5.6 cm, body weight 66.5 ± 11.3 kg, body mass index (BMI) 23.1 ± 3.7, and body fat percentage 28.3 ± 7.7%.

All subjects were informed in detail about the aim and conditions of the study before participating and provided written informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki, and subjects were assured anonymity and the possibility of withdrawing from the study at any time without consequences. Ethical approval was granted by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb (approval number: 48/2025).

Research design

The study was conducted using a cross-sectional design, as the effect of acute hydration on the subjects' body mass and fat percentage was analysed through short-term measurements within a single session, without the need for long-term monitoring of changes over time. All measurements were performed in a single morning visit to the fitness center, and the measurements were performed by experienced assessors. The subjects were advised to come rested, without jewellery, and were measured in their underwear. In order to ensure the greatest possible control of the initial hydration status, the subjects were recommended to consume enough fluids the day before the test and to avoid diuretics such as caffeine and alcohol. In addition, to minimize the influence of previous food and drink intake, all subjects had to come in a fasting state, with the last meal allowed no later than 10 hours before the test. The subjects were also advised not to participate in intense physical activities that could affect hydration and body fluid balance the day before the study. Before the start of the measurements, they were familiarized with the protocol and methods of using the measuring instruments. All measurements were conducted under controlled conditions at a room temperature of 22°C.

As part of the anthropometric measurements, the subjects' height was measured with an anthropometer, and their body mass and body fat percentage were measured with a diagnostic scale. Body mass and body fat percentage were measured four times: twice before and twice after consuming half a litre of water. The first two measurements were performed consecutively to analyse the reliability of the measuring instrument, while the third measurement was performed five minutes after, and the fourth measurement fifteen minutes after hydration. The first, third, and fourth measurements were included in the further analysis, while the second measurement was used solely for assessing the instrument's reliability. After each measurement, the data were stored in a single database for further analysis.

Measuring tools

A digital scale with body composition analysis (TANITA RD-545HR, InnerScan PRO Body Fat & Segmental Composition Scale) was used to measure body mass, while height was measured using an anthropometer (Gneupel, Prazisionsmechanik, Bachenbulach, Switzerland). Based on the measured values of body mass and height, the body mass index (BMI) was calculated according to the formula: BMI = mass (kg) / height (m)^2.

The reliability of the scale was assessed by internal consistency analysis (ICC) and coefficient of variation (CV), with high reliability values obtained for the measurement of body mass (ICC = 0.999, CV = 0.09%) and body fat percentage (ICC = 0.987, CV = 1.27%).

Statistical analysis

Basic descriptive statistics were calculated for age, height, body mass, body fat percentage, and body mass index. Statistical analysis of data was performed using the Statistica software packages (TIBCO Software Inc. (2020). Data Science Workbench, version 14. http://tibco.com) and Excel 365 (Microsoft® Excel® for Microsoft 365 MSO, version 2412, 64-bit version 16.0.18324.20092).

The statistical significance of differences in body mass and body fat percentage was tested by univariate analysis of variance for repeated measures. In the case of a statistically significant difference between measurement points, a post hoc analysis with Bonferroni correction was performed to identify specific differences between individual measurement time points, while controlling for type I error. The statistical significance level was set at $p < 0.05$.

Effect sizes were calculated as Cohen's d and percentage change between measurement points (1, 2 and 3) for body mass and fat percentage. Cohen's d for paired measurements was calculated using the formula: $d = (M_2 - M_1) / SD_{(shared)}$; and Percentage change (%) between measurements: $\%\Delta = ((M_2 - M_1) / M_1) \times 100$. A Cohen's d value of 0.2 is considered a small effect, 0.5 a moderate effect, and 0.8 a large effect (Faul et al., 2007).

Results

A repeated measures analysis of variance showed a statistically significant difference in body mass between different time points ($F = 179.86$, $p < 0.001$). Post-hoc analysis with Bonferroni correction revealed that body mass increased significantly after water consumption compared to the initial measurement ($p < 0.001$), while there was no significant difference between measurements taken five and fifteen minutes after hydration ($p = 1.000$).

Similarly, analysis of variance for body fat percentage showed a statistically significant difference between time points ($F = 18.76$, $p < 0.001$). Post hoc analysis showed a significant increase in body fat percentage between the first and second measurements ($p < 0.001$), while the difference between the second and third measurements was not statistically significant ($p = 0.261$).

The results indicate that the consumption of half a liter of water leads to an acute increase in body mass and estimated body fat percentage, with values stabilizing after hydration.

Table 1. Results of ANOVA and Post Hoc Analysis for Body Mass and Fat Percentage

Measure	Measurement time	M ± SD	ANOVA F	p	Post hoc (p)
Body weight (kg)	1.	66.46 ± 11.30	179.86	<0.001	1. vs. 2. (<0.001)
	2.	67.01 ± 11.23			2. vs. 3. (1.000)
	3.	67.00 ± 11.27			1. vs. 3. (<0.001)
Fat percentage (%)	1.	28.30 ± 7.68	18.76	<0.001	1. vs. 2. (<0.001)
	2.	29.59 ± 7.58			2. vs. 3. (0.261)
	3.	29.21 ± 7.41			1. vs. 3. (<0.001)

Note. M: mean; SD: standard deviation.

Table 2. Cohen's d and Percentage Change for Body Mass and Body Fat Percentage

Measure	Measurement time	Cohen's d	Percentage change (%)
Body weight (kg)	1 → 2	0.05	0.84
	2 → 3	-0.00	-0.01
	1 → 3	0.05	0.83
Fat percentage (%)	1 → 2	0.17	4.53
	2 → 3	-0.05	-1.27
	1 → 3	0.12	3.21

Cohen's d shows a very small effect size across all body mass measurements, indicating minimal differences between time points. On the other hand, the effects for body fat percentage are somewhat more pronounced, especially between the first and second measurements (d = 0.17). The percentage change also suggests that the largest difference between the first and second measurements was for body fat percentage (4.53%), while there was a slight decrease between the second and third measurements (-1.27%).

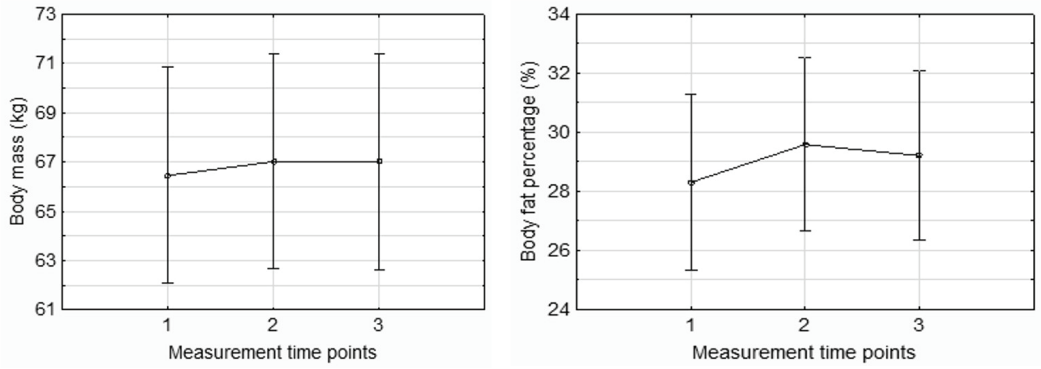

FIGURE 1. Graphs depicting the effects of consuming half a liter of water on body mass and fat percentage at three measurement points: before hydration (point 1) and after hydration (points 2 and 3).

The results suggest that water consumption causes slight but statistically significant changes in body mass and fat percentage, which gradually stabilize after 15 minutes (Figure 1).

Discussion

The results of this study showed that drinking 0.5 l of water caused a statistically significant increase in body mass and body fat percentage immediately after hydration. Body fat percentage recorded the largest change between the first and second measurements (4.53%), while body mass and body composition values stabilized after 15 minutes. Cohen's d showed small effects between time points, suggesting that differences are present but not very pronounced. These findings support the hypothesis that acute hydration can temporarily alter the results of body composition measurements. As expected, body mass increased by approximately half a kilogram, which is consistent with the amount of water consumed. However, a surprising finding was the increase in body fat percentage, which is contrary to expectations. This phenomenon can be explained by changes in the electrical conductivity of the body, since bioelectrical impedance uses the resistance of different tissues to estimate body composition (Algűl & Özcelik, 2022). Fat tissue has higher resistance than muscle tissue, and increased hydration usually reduces the total body resistance, which should result in a decrease in the estimated fat percentage (Algűl & Özcelik, 2022). However, it is possible that the temporary fluid redistribution affected the body composition estimation algorithms, causing a temporary increase in the measured body fat percentage.

Our results are in line with previous research that has shown that fluid consumption immediately before measurement can affect bioelectrical impedance (BIA) and other methods of body composition analysis (Barreira et al., 2020). Namely, the BIA method is based on the passage of an electrical current through the body and measuring the resistance, where increased hydration can reduce the overall resistance, resulting in erroneous estimates of body mass and composition. This phenomenon is particularly pronounced in individuals with different degrees of hydration, where even small variations in fluid intake can significantly affect the results.

Studies such as that of Brtkova et al. (2014) have shown differences in body composition depending on the measurement methods, where it was found that anthropometric methods and BIA often provide different estimates of body fat percentage. This suggests the need to standardize measurement conditions to ensure greater reliability of the results. Furthermore, the study by Vasolda et al. (2019) highlighted the low reliability of cheaper BIA devices when it comes to analyzing hydration status, with more expensive, professional devices being more accurate but still subject to variations caused by acute changes in hydration. This research confirms the need for further research to improve the methodology of body composition assessment and reduce the sensitivity of measuring devices to changes in hydration status.

In addition, Dahlmann and Demond (2022) proposed new anthropometric models that more accurately predict body composition, regardless of current hydration. Our findings support the claim that short-term changes in hydration can cause bias in measurements, which is important for understanding variability in body composition analysis.

Hydration plays a key role in the accuracy of body composition analysis, especially in methods such as bioelectrical impedance analysis (BIA), which are sensitive to changes in body fluids. Previous studies (Anusitviwat et al., 2023) have shown that dual-frequency BIA has better accuracy in determining muscle mass, but it remains susceptible to fluctuations in the hydration status of the subjects.

The practical aspect of these findings is not only important for athletes and people monitoring their fat loss progress, but also for the general population who use various inexpensive digital scales at home that can estimate body fat percentage. Many users are not aware of the potential errors in measurement, especially with fat percentage, which is susceptible to fluctuations caused by hydration. Water consumption can cause a relatively large increase in fat percentage, which can lead users to make incorrect conclusions about their progress in controlling body weight and body composition.

To minimize misassessment of body composition, it is important to standardize measurement conditions and ensure that subjects are in the same hydration status during all measurements. It is desirable to avoid fluid intake for at least two hours before the measurement, and it would be optimal to perform measurements in the morning on an empty stomach to reduce the influence of daily fluctuations in hydration. It is also recommended to perform multiple measurements over different days and analyze trends instead of relying on individual values, which can achieve greater accuracy and reliability of results.

Our study showed that drinking water immediately before body composition analysis causes temporary changes in body mass and body fat percentage. These findings highlight the importance of standardizing measurement conditions to ensure accuracy and reliability of results. Furthermore, research on hydration and its impact on body composition analysis should continue to improve methodology and reduce potential errors in assessing health and body composition.

Conclusion

Based on the research conducted, it can be concluded that drinking water immediately before measuring body composition can temporarily affect the results, increasing body mass and fat percentage. These results emphasize the importance of standardizing measurement conditions, especially in the context of using bioelectrical impedance to assess body composition. Individuals who monitor their progress in body composition, whether they are athletes, recreational athletes or the general population using home digital scales, should be aware that fluid intake can temporarily alter the results and lead to misinterpretations.

Limitations and future research

This study has several limitations that should be considered when interpreting the results. The research was conducted using a short-term, cross-sectional design, which limits the ability to draw conclusions about the long-term effects of hydration on body composition assessment. Furthermore, the sample included only female participants with recreational experience in Pilates, which restricts the generalizability of the findings to other populations, such as men, athletes, or individuals with different physical characteristics. Another limitation is the use of a single bioelectrical impedance device model (TANITA RD-545HR), which may not reflect results obtained with other devices that use different measurement technologies or algorithms.

Future studies should consider employing longitudinal designs to explore how hydration status influences body composition assessment over extended periods. It would also be beneficial to include a more diverse sample concerning sex, age, physical activity level, and body composition. In addition, comparing different BIA devices, including those based on single- and multi-frequency technologies, could provide deeper insight into their sensitivity to acute hydration changes and help establish more robust measurement protocols, as well as contribute to the development of standardized guidelines that would allow for more accurate assessment of body composition independent of acute changes in hydration status.

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ORIGINAL SCIENTIFIC PAPER

Validation of a Self-Discipline Questionnaire for Athletes

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Abstract

This study aims to modify and validate a self-discipline questionnaire for application among athletes in Indonesia. The questionnaire was adapted from the self-discipline scale originally developed by Sal (2022) for university students. This study employed a quantitative research design using a factor analysis approach. The population consisted of coaches and athletes from Central Java Province, representing three types of sports: individual, team, and combat sports. The sample included 30 coaches for the validity test and 265 athletes selected through purposive sampling, based on the criteria of being active athletes and having achieved at least a regional championship. These athletes were then subjected to Exploratory Factor Analysis (EFA). The findings identified two self-discipline dimensions for athletes in Indonesia: Training in a Plan (TIP) and Attention (ATTN). The results of the validity test using Aiken's V indicated that each item scored above 0.8. The EFA results showed a KMO-MSA value of 0.691 (>0.50) and a significant Bartlett's Test of Sphericity ($p < 0.001$). Additionally, the anti-image correlation, communalities, and rotated component matrix revealed factor loadings above 0.50 for all 18 indicator items. Therefore, the modified self-discipline questionnaire for Indonesian athletes demonstrates validity and high factor loadings for each indicator. Future studies are encouraged to expand the sample and include athletes from various provinces across Indonesia, as well as to incorporate more complex analytical methods, which could enhance the questionnaire's reliability and credibility.

Keywords: *self-discipline, sports psychology, sports questionnaire, sports evaluation*

Introduction

Improving athlete performance is not only determined by physical and technical conditions but also by supporting psychological factors, one of which is self-discipline (Podlesny, 2023). Self-discipline is a crucial aspect that helps athletes remain consistent in training, follow nutritional plans, and adhere to established competition strategies (Cropley et al., 2020). Therefore, accurately measuring athletes' self-discipline is essential to support the development of their full potential.

Self-discipline is one of the fundamental pillars supporting an athlete's success. It plays a vital role in helping athletes manage their time and sustain the commitment required to train consistently and participate in competitions, while also fulfilling other responsibilities such as education or work (Pujianto et al., 2024). The ability to manage time efficiently and prioritize different aspects of life can determine the quality and effectiveness of the training undertaken (Sembiring et al., 2023).

Previous studies also show that self-discipline helps athletes maintain consistency in their training (Zhao et al., 2023 & Sahabuddin et al., 2023). This consistency is critical for developing skills and enhancing physical strength according to the demands of their sport. Self-discipline also supports athletes in recovery and self-care, such as maintaining a proper diet, getting sufficient rest, and following routines that prevent injury (Edouard et al., 2022, Abdhi et al., 2024 & Sevindik Aktaş, 2024). This component is vital not only for sustaining peak performance but also for ensuring a long, injury-free athletic career.

Beyond the physical aspects, self-discipline also plays a significant role in coping with pressure and setbacks. Competitive sports often place athletes in high-stress situations that can cause mental and emotional strain (Yusup et al., 2024). Athletes with strong self-discipline are better equipped to handle such situations, use failures as learning opportunities, and maintain the motivation and focus needed to achieve long-term goals (Pujianto et al., 2024).

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Previous studies have developed instruments such as the "Development of an Academic Self-Discipline Questionnaire for University Students," which targets student populations (Sal, 2022). However, there is a need to adapt these tools to fit the sports context, considering the significant differences in demands and environments between athletes and students. Therefore, designing such tool based on previously validated self-discipline instruments is crucial to developing a tool that is both valid and reliable for measuring self-discipline in athletes across various sports.

Hence, this research aims to validate a self-discipline questionnaire developed based on previous tools, and adapted to be suitable for athletes in Indonesia. The study is important because its findings are expected to assist coaches and sports psychologists in identifying athletes' levels of self-discipline, which can then inform the development of more targeted and effective psychological interventions (Budnik-Przybylska et al., 2022). Furthermore, the outcomes of this study have the potential to be applied in athlete development programs at both amateur and professional levels. This research may contribute not only to academic literature but also may have significant practical implications in sports.

Method

Research Procedure

This research is quantitative in nature and employs a factor analysis approach. Specifically, Exploratory Factor Analysis (EFA) was used to validate a self-discipline questionnaire that was adapted for athletes based on a questionnaire originally developed for students. The adaptation process involved modification of the questionnaire items to suit the context and needs of athletes, considering their unique daily activities, mental demands, and physical conditions, which differ significantly from non-athlete populations (Banville et al., 2000).

The research process followed several key stages. First, a literature review and analysis were conducted to adapt existing questionnaire items to the context of performance sports, followed by translation into Indonesian. Second, the modified items were tested through a Focus Group Discussion (FGD) to obtain initial feedback on item clarity and relevance. The FGD involved five sports lecturers with expertise in sports psychology. Based on the FGD outcomes, the questionnaire was refined before distribution to a larger sample. Third, the refined questionnaire was validated by coaches representing different types of sports. This stage aimed to evaluate the precision and accuracy of the questionnaire for use with athletes, particularly in assessing self-discipline levels. The results of this validation were re-evaluated before the questionnaire was administered to athletes. Fourth, data were collected from athletes across various sports to be used in EFA.

Research Population and Sample

The population of this study comprised coaches and athletes from Central Java Province in Indonesia, all with experience in various types of sports. The first sample consisted of coaches who served as validators, and the second sample consisted of athletes whose responses were analyzed using EFA. The study included 15 sports categorized into three groups: 1) Team sports: football, basketball, volleyball, handball; 2) Individual sports: badminton, swimming, athletics, tennis, gymnastics, archery; and 3) Combat sports: boxing, karate, taekwondo, judo, pencak silat.

The first sample included 30 coaches, with two coaches representing each sport. The coach characteristics were as follows: age 40–51 years, coaching experience of 23.7 ± 4.2 years, a minimum of a bachelor's degree in sports, and possession of an active national coaching license. The athlete sample for EFA consisted of 265 athletes: 24 from football, 28 from basketball, 26 from volleyball, 22 from handball, 16 from badminton, 18 from swimming, 23 from athletics, 17 from tennis, 14 from gymnastics, 16 from archery, 11 from boxing, 15 from karate, 13 from taekwondo, 10 from judo, and 12 from pencak silat. The athlete characteristics were: age 18–25 years, training experience of 10.7 ± 9.3 years, competitive experience of 9.1 ± 5.7 years, and national-level achievements within the last two years, as evidenced by a competition certificate.

Instrument

The instrument development process was conducted in the first and second stages outlined in the research procedure. In the first stage, the researchers conducted a literature review and chose to adapt the questionnaire developed by Sal (2022), titled "Development of an Academic Self-Discipline Ques-

Table 1. Modified Self-Discipline Questionnaire for Athletes

Training in a plan	I wake up at the same time every day to maintain my workout routine
	I repeat my training techniques after each session and prepare beforehand
	I don't let my training decisions be dictated by emotions
	I follow my own structured workout schedule
	I use my training time effectively to optimize performance
	I train various aspects of fitness and technique in a structured manner
	I stay fully focused during training sessions and avoid distracting thoughts
	I can decline social invitations that conflict with my training schedule
	I resist using social media during training even when I feel tempted
Attention	I am mentally and physically prepared before each training session
	I organize my training space to be free from distractions
	I eliminate all distractions before starting practice
	I know what I need to accomplish before each practice session begins
	I do not use social media during training
	I distance myself from distractions to practice effectively
	I understand the best ways to improve my physical and technical skills
	If I reach a training goal early, I may end the session to prevent burnout
	I maintain focus during training even in the presence of distractions, boredom, or fatigue

tionnaire for University Students". Following this, the questionnaire was translated and modified following procedures outlined by (Putro et al., 2025), who successfully adapted the Talent Development Environment Questionnaire (TDEQ-5) into Indonesian population. The translation process involved two linguists and one sports science lecturer with academic proficiency in English. After translation, the questionnaire was modified to reflect the conditions of athletes in sports training. In the second stage, the modified questionnaire was tested through an FGD to collect revisions and suggestions. The resulting modifications based on FGD feedback are presented in Table 1.

In Table 1, the questionnaire consists of two indicators: Training in a Plan (TIP) and Attention (ATTN). Each indicator includes 9 statement items, totaling 18 items in the questionnaire.

Statistical Analysis

This study utilized two stages of data analysis. The first stage involved a validity test based on the evaluations of 30 coaches. The validation was calculated using Aiken's V formula (Lewis. R. Aiken, 1985), as shown in Figure 1. The second stage applied Exploratory Factor Analysis (EFA) using SPSS version 27 (George & Mallery, 2021). EFA was selected to assess construct validity using multiple fit indices as indicators. An item was considered valid if the following conditions were met: 1) The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) value exceeded 0.50 (i.e., KMO > 0.50); 2) The Bartlett's Test of Sphericity was significant at $p < 0.05$; 3) The Communalities (extraction values) were adequate; 4) The Anti-Image Correlation matrix values were satisfactory; and 5) The Rotated Component Matrix loading values exceeded 0.50 (Watkins, 2018). The questionnaire employed a 4-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly Agree.

$$\text{V Aiken's: } \frac{\sum s}{n\,(c-1)}$$

S : r – lo
Lo : lowest rating score
C : highest rating score
r : the score given by the assessor

FIGURE 1. Aiken's V Formula

Results

The results of this study correspond to the fifth stage of the research procedure. After data collection was completed, the research proceeded through two main stages of analysis: (1) a validity test conducted by coaches and (2) an Exploratory Factor Analysis (EFA) conducted on data from athletes. Accordingly, the results are presented in two subsections: the instrument validity test performed by 30 coaches and the EFA test conducted with responses from 265 athletes.

Instrument Validity Test

The first stage of data analysis aimed to assess the precision and accuracy of the self-discipline instrument before it was administered to athletes. This validation was conducted by 30 expert coaches using Aiken's V formula. The results of this validity test are presented in Table 2.

To understand the Aiken's V value for each indicator in Table 2, the ΣS is obtained from the score given by each assessor (on a scale of 1 to 4), minus the lowest score in the scale (i.e., 1), and then summed across all assessors (in this study, n = 30 coaches). Meanwhile, n(c−1) is calculated by multiplying the number of assessors (n) by the difference between the highest and lowest scale values (4−1), resulting in 30 × 3 = 90. Aiken's V value is then de-

Table 2. Aiken's V Validity Test Results

Indicator	ΣS	n(c-1)	Aiken's V	Description
TIP 1	74	90	0.822	Valid
TIP 2	75		0.833	Valid
TIP 3	77		0.856	Valid
TIP 4	73		0.811	Valid
TIP 5	77		0.856	Valid
TIP 6	76		0.844	Valid
TIP 7	75		0.833	Valid
TIP 8	77		0.856	Valid
TIP 9	74		0.822	Valid
ATTN 1	77		0.856	Valid
ATTN 2	76		0.844	Valid
ATTN 3	73		0.811	Valid
ATTN 4	74		0.822	Valid
ATTN 5	77		0.856	Valid
ATTN 6	78		0.867	Valid
ATTN 7	76		0.844	Valid
ATTN 8	75		0.833	Valid
ATTN 9	73		0.811	Valid

rived using the formula ∑S / n(c−1). Based on the results presented in Table 2, Aiken's V values for all indicators are greater than 0.8. Therefore, all 18 indicators in the self-discipline questionnaire are considered valid (Susiono et al., 2024 & Wedi et al., 2024).

Exploratory Factor Analisis (EFA)

Following validation by coaches, the instrument was then tested using Exploratory Factor Analysis (EFA) with a sample of 265 athletes. The analysis was conducted using SPSS version 27.

Table 3. KMO and Bartlett's Test Results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.691**
Bartlett's Test of Sphericity	Approx. Chi-Square	2414.070
	df	153
	Sig.	<0.001

As shown in Table 3, the KMO value exceeds the minimum threshold of 0.50, indicating sufficient sampling adequacy. Additionally, Bartlett's Test of Sphericity is significant ($p < 0.05$), which confirms that the dataset is suitable for factor analysis. The specific test of MSA (Measure of Sampling Adequacy) in each indicator was explained in anti-image corelation.

Table 4 presents values for Anti-Image Correlation, Communalities, and the Rotated Component Matrix for all 18 items. Anti-image correlation values for all items exceed 0.50, indicating that each item meets the Measure of Sampling Adequacy (MSA) requirements. Communalities (extraction values) are all above 0.50, demonstrating that each item shares a significant proportion of variance with others in the dataset. Rotated Component Matrix values show that the items successfully load onto two distinct components consistent with the conceptual dimensions: Training in a Plan (TIP) and Attention (ATTN). Each factor loading exceeds 0.50, indicating strong relationships between the items and their respective constructs.

Table 4. Exploratory Factor Analysis Test Results

Item	**Anti-image Correlation**	**Communalities**		**Rotated Component Matrix**	
		Initial	**Extraction**	**1**	**2**
TIP 1	0.551	1.000	0.838	0.799	
TIP 2	0.686		0.703	0.750	
TIP 3	0.626		0.795	0.765	
TIP 4	0.506		0.799	0.810	
TIP 5	0.789		0.709	0.798	
TIP 6	0.761		0.684	0.779	
TIP 7	0.533		0.897	0.920	
TIP 8	0.514		0.782	0.765	
TIP 9	0.717		0.785	0.783	
ATTN 1	0.649		0.788		0.747
ATTN 2	0.758		0.802		0.878
ATTN 3	0.749		0.795		0.771
ATTN 4	0.651		0.765		0.806
ATTN 5	0.585		0.804		0.844
ATTN 6	0.639		0.654		0.701
ATTN 7	0.736		0.725		0.773
ATTN 8	0.695		0.767		0.743
ATTN 9	0.687		0.725		0.843

Discussion

The findings of this study demonstrate that the self-discipline instrument, which was adapted and modified for Indonesian athletes, successfully identified two primary indicators: (1) Training in a Plan and (2) Attention. Both indicators yielded high validity and factor loading values for each item, confirming that the instrument is a reliable tool for assessing self-discipline among athletes in Indonesia. These findings align with previous research that reported similarly strong validity measures in psychological instruments used with Indonesian athletes. For example, the Psychological Skills Inventory for Sports (PSIS-R5) also demonstrated a KMO score above 0.50 and a significant Bartlett's Test result (Dimyati et al., 2023). Likewise, the Talent Development Environment Questionnaire for Indonesian basketball athletes was successfully validated using Exploratory Factor Analysis (EFA), incorporating KMO-MSA, Bartlett's Test of Sphericity, Anti-image Correlation, and Communalities (Putro et al., 2025). These studies support the conclusion that the current self-discipline instrument is appropriate for use among Indonesian athletes.

The first dimension, Training in a Plan, reflects an athlete's ability to adhere to a structured and consistent training regimen. The high factor scores for this indicator suggest that disciplined athletes tend to have a well-defined approach to training. Structured planning is essential for optimizing time, enhancing training efficiency, and maximizing performance outcomes (Latief et al., 2024). From a psychological perspective, such planning can

reduce stress and anxiety by providing clarity and a sense of control over the training process (Saniah et al., 2024). Athletes with clear training plans often feel more confident and motivated, as they can track their progress and experience a sense of achievement when reaching their goals (Utami et al., 2024; Djaba et al., 2024 & Prabowo et al., 2025). With a greater sense of control, athletes can manage competition pressure more effectively, improving their mental well-being.

In terms of performance outcomes, structured planning improves the effectiveness of training sessions by aligning them with specific performance goals, thus enhancing skill acquisition and physical conditioning (Mandan et al., 2024). Moreover, well-designed training schedules that include rest and recovery help prevent fatigue and injuries, supporting optimal performance (West et al., 2021). Planning also enables athletes to evaluate and refine their strategies based on prior performance, leading to continuous improvement (González-Ravé et al., 2022). When athletes set goals, follow structured programs, and regularly monitor progress, they can fully realize their potential and achieve better competitive results.

Furthermore, this indicator is indirectly associated with the variable of service quality. Athletes who follow structured training plans are often supported by high-quality services, such as organizational infrastructure, access to professional training, proper facilities, and guidance from experienced coaches (Prayoga et al., 2024 & Salsabila et al, 2024). High-quality services provide essential resources that help athletes implement and sustain their training programs effectively (Nugroho et al., 2023 & Prabowo, 2024). Such services often offer individualized support, ongoing monitoring, and constructive feedback (Juita et al., 2024), all of which enable athletes to fine-tune their plans for maximum efficiency and impact (Mandan et al., 2024). Therefore, service quality creates an environment conducive to effective planning, which in turn supports athletic performance.

The second dimension, Attention, pertains to an athlete's capacity to maintain focus and attend to detail during both training and competition. High factor scores for this indicator affirm that attentional control is a vital element of effective self-discipline. Focused athletes tend to execute techniques more accurately and adapt strategies more effectively during competition (Utami et al., 2024). Attention also enhances an athlete's ability to absorb coaching instructions and apply them correctly (Fitrianto et al., 2024), which in turn accelerates skill development and improves training efficiency. It allows them to carry out training with precision and efficiency, which is essential for skill development and performance improvement. Furthermore, focused attention helps athletes quickly detect and correct errors, reducing the time required for improvement (Rahimi et al, 2022). It also enhances the capacity to adjust strategies in real-time during training or competition, supporting both mental and physical readiness (Park & Jeon, 2023). Thus, consistent focus not only elevates training quality but also equips athletes to perform better in competitive environments.

This indicator is also closely related to achievement motivation. Athletes with strong attention skills often possess high achievement motivation, which drives goal-oriented behavior and sustained commitment to performance outcomes (Abdhi et al., 2024). Motivated athletes exhibit greater training consistency, leading to skill mastery and strategic competence (Wijayanti et al., 2024 & Prabowo et al., 2025). Moreover, motivated athletes tend to increase consistency in training, leading to skill mastery and effective strategies (Wibowo et al., 2024). Additionally, a strong focus helps athletes make quick and accurate decisions during competition, especially in situations that demand rapid reactions (Ghanati et al, 2022). Thus, achievement motivation not only enhances focus during training but also positively impacts athletic performance, creating a positive cycle in which improved performance further motivates them to continue striving for higher levels.

This study has certain limitations, particularly regarding the population involved, which was drawn from a single province in Indonesia. As a result, the researchers acknowledge the possibility of differing questionnaire outcomes in athletes from other provinces. Therefore, future research should consider diverse populations across various regions in Indonesia. Expanding the sample size will enhance the findings' generalizability and improve the analysis's accuracy. Moreover, employing more advanced analytical methods will be essential to develop a valid, reliable, robust, and trustworthy questionnaire for broader applications.

Conclusion

The results of this study, which focused on validating a self-discipline questionnaire for athletes in Indonesia based on a previous questionnaire for students, yielded 18 valid items categorized into two leading indicators: (1) Training in a Plan and (2) Attention. The Training in a Plan indicator reflects an athlete's ability to adhere to a structured and consistent training regimen, while the Attention indicator represents the capacity to maintain focus and attend to detail during both training and competition. Both indicators demonstrated strong validity and high factor loadings, as confirmed by exploratory factor analysis, indicating that the questionnaire is a valid and reliable for measuring self-discipline among Indonesian athletes. Given its psychometric strength, this questionnaire can be used to evaluate self-discipline within athlete development and performance coaching contexts.

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Conflit of Interest

The researchers have no conflicts of interest.

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Journal of Anthropology of Sport and Physical Education

ORIGINAL SCIENTIFIC PAPER

Differences in Physical Fitness, Quality of Life and Level of Physical Activity Among Adolescents Based on BMI: An Observational Study

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Abstract

Adolescence is an important transitional phase in life, central in the development of capabilities related to health and well-being, and where future patterns of adult health are established. Overweight and obese adolescents are at a higher risk of developing many chronic non-communicable diseases. Moreover, overweight and obesity negatively impact physical fitness (PF), quality of life (QoL) and levels of physical activity (PA). In this context, the aim of this study was to examine differences in PF, QoL, and PA level among adolescents based on BMI. The sample consisted of one hundred thirthy-nine (N=139) high school graduates (4th grade, aged 18 years, 43.7% girls). The Eurofit Fitness Test Battery was used to assess PF, whereas QoL questionnaire adolescent form and PA questionnaire (IPAQ-SF) were employed for QoL and PA level, respectively. One-way ANOVA and Tukey post-hoc were conducted for comparisons ($p<0.05$). Main findings of this study indicate that there were significant differences among three groups (underweight, normal weight, overweight) in PF, QoL, and physical activity levels among adolescents ($p<0.05$; 0.03; 0.01, respectively) in favour of normal weight group. In conlusion, adolescents who are normal weight tend to have better PF, QoL and PA level in comparison with adolescents who are underweight and overweight. Those results underline the importance of spreading awareness about the harmfulness of an increased BMI (body mass index), i.e., the trend of increasing obesity in today's society.

Keywords: *fitness level, well-being, physical activity, dietary status, adolescents, obesity*

Introduction

Adolescence is a life phase marked by various biological, psychological, and social transformations (Lizandra & Gregori-Font, 2021). Many scholars categorize adolescence into three stages: early (10 to 13 years), middle (14 to 16 years), and late (18 to 21 years) (Arnett, 2008). Each of these stages is sensitive to the development of habits and routines, where decisions are often shaped by environmental influences, potentially impacting their future and playing a key role in promoting healthy lifestyles during this period (Duno & Acosta, 2019; Mitraković et al., 2016). Thus, it is essential to take into account all factors that support the development of socially responsible and capable individuals, particularly the ones that can affect the individuals' health. However, there is limited attention given to the effects that can have a relationship with the health of adolescents (WHO, 2020), physical fitness (PF), quality of life (QoL), levels of physical activity (PA), and BMI (body mass index). Overweight and obesity are major modern challenges that can adversely affect adolescent health (WHO, 2020). Given that adolescents with overweight and obesity are at a heightened risk of experiencing these issues throughout their lives (WHO, 2020), the need for timely intervention is evident. A scoping review of current clinical practice guidelines, consensus statements, and position papers demonstrates that lifestyle interventions targeting weight maintenance or weight loss, such as are

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recommended as the first-line treatment for pediatric obesity (Alman et al., 2021). The treatment involves a respectful, stigma-free, family-centered approach that integrates various components and focuses on diet, physical activity, sedentary habits, and sleep patterns (Jebeile et al., 2020; Lister et al., 2023). Unfortunately, the current practice shows a different reality, as there are currently 390 million overweight and obese children and adolescents aged 5–19 worldwide (Vasiljević, 2018). In this regard, by understanding the differences in PF, QoL, and PA level in relation to BMI, we can make recommendations that are significant for the holistic psychobiosocial development of adolescents.

Obesity can impact various aspects of children's and adolescents' lives, including their psychological well-being, cardiovascular health, and overall physical health (Horesh et al., 2021). The link between obesity and serious health outcomes underscores its significance as a public health concern for young people (Jebeile et al., 2021). Adolescents who are overweight or obese face an increased risk of developing diabetes, cardiovascular diseases, cancer, hypertension, and various chronic non-communicable diseases (Davis et al., 2011). Moreover, overweight and obesity negatively impact PF (Dewi et al., 2021; Qui et al., 2022), QoL (Mollerup et al., 2017; Van de Pas et al., 2023) and levels of PA (Raustorp et al., 2004; Dewi et al., 2011; Mateo-Orcajada et al., 2022). Additionally, adolescent obesity is a growing global health concern, with rates rising in low- and middle-income countries and remaining high in many high-income nations (Pulgarón, 2013). Obesity in childhood often persists into adulthood, leading to increased risks of cardiometabolic and psychosocial complications, as well as early mortality (Horesh et al., 2021).

Moreover, body mass index (BMI) is a good tool for assessing obesity risk factors in adolescents (Freedman, 2022). BMI is categorised according to the WHO (2017) specialised for the age of 5 to 19 years for adolescents: ≤18.4 (underweight/undernourished); (normal body mass/normal nutritional status) 18.5–24.1; (24.2–28.1) (overweight); and ≥28.2 (obesity) (Weir & Jan, 2024). From these classifications, it is very important to investigate the differences in PF, QoL, and PA level in relation to BMI. More than a quarter of children with excessive body fat go undetected due to BMI's low sensitivity, despite its high specificity in identifying excess adiposity. (Javed, et al., 2015).

There are previous studies that have investigated differences, based on BMI, in PF (Pahkala et al., 2013; Dewi et al., 2021; Qui et al., 2022), QoL (Pahkala et al., 2013; Chen et al., 2014), and PA level (Raustorp et al., 2004; Dewi et al., 2021; Mateo-Orcajada et al., 2022). However, there is no study, to the best of our knowledge, that has combined all the mentioned variables. To be specific, Qin et al. (2022) showed that lower values of BMI lead to increased values of VO2max, strength, and balance in adolescents, which was confirmed by Dewi et al. (2021), and Pahkala et al. (2013) displayed that adolescents who showed normal or lower values of BMI exhibit a higher VO2max. Regarding QoL, Keating et al. (2011) showed that normal BMI range values, as well as lower BMI values (Chen et al., 2014), lead to higher QoL. On the other side, it was shown that high BMI values lead to worse QoL in adolescents (Mollerup et al., 2017; Van de Pas et al., 2023). Furthermore, Mateo-Orcajada et al. (2022), Raustorp et al. (2004) and Dewi et al. (2021) showed that adolescents with normal BMI values also have a higher PA level compared to adolescents who fall into the overweight category, with no conflicting evidence, to the to the best of our knowledge. Although there are studies that investigate the associations and influence of the mentioned variables, there is no study assessing the differences in PF, QoL, and PA level in relation to BMI. Understanding these differences allows us to gain a better understanding of adolescents' overall development, and by presenting differences in a large number of variables, we can develop guidelines that are relevant to adolescents and aim to prevent the risk factor of obesity, in this case BMI. Based on all the above, the aim of this study was to examine differences in PF, QoL, and PA level among adolescents based on BMI. The study hypothesized that there would be significant differences in PF, QoL, PA levels among adolescents with varying BMI in favour of those who are normal weight in comparison with underwirght or overweight adolescents.

Methods

Participants

This study was an observational study using a stratified sampling design. It utilised a two-component cross-sectional design consisting of a cross-sectional survey encompassing three questionnaires and a cross-sectional PF test. In total, one hundred thirthy-nine (N=139) high school graduates (4th grade, aged 18 years, 43.7% girls) were recruited and gave their written consent to participate in this research. G power analysis (ES 0.5, ANOVA, power level 0.80, alpha 0.05) determined that the sufficient number of respondents for this study was 156 (Faul, 2007), which is a slight deviation from the actual number of respondents who participated in this study. The subjects were divided into 3 groups based on BMI classification (Weir & Jan, 2024). Namely, all respondents fell into group I (underweight, N=33, mean BMI=17.67±4.1), group II (normal weight, N=78, mean BMI=21.9±7.2) and group III (overweight, N=28, mean BMI=26.4±3.9). Participants in the study were adolescents who consented to participate (with parental consent where necessary) and had available anthropometric data for categorizing BMI. Eligible participants were required to attend regular physical education classes and have no chronic illnesses or medical restrictions that might impact PF or daily activity levels. Adolescents were excluded if they had conditions limiting PA, had been advised by a physician to restrict such activity, or were engaged in external structured fitness programs that could influence PF outcomes. The reserach procedure was conducted within the ethical standards of the Helsinki Declaration of 1964 and according to Resolution 466/12 of the Ministry of Health. Additionally, this study protocol was carried out in accordance with the ethics committee of the Faculty of Sport and Physical Education, University of Niš, number 04-2035/2. The data were collected and analysed anonymously.

Procedures

Before conducting the study tests and survey, all participants were notified of the study's purpose through an informational letter. The research team gave a thorough explanation of the survey and guided the adolescents on how to complete a three-page electronic questionnaire, which contained questions about their quality of life (QoL) and physical activity (PA) levels. Researchers administered the survey and assisted participants with any questions or difficulties in understanding the content. Testing took place on two occasions, each lasting 90 minutes. In the morning, body composition was measured, while PF was measured later.

Measurements of variables

Body composition

Body composition was measured using a Martin antropometer and the bioelectrical impedance OMFRON BF 511 (Kyoto, Japan) (Đurašković 2001; Beleigoli et al., 2019).

Body height was measured using an anthropometer according to Martin (Martin metal anthropometer - GPM Swiss Made). During the measurement, the examinee stands barefoot on a flat and firm surface. His head is in a position that meets the requirement of the Frankfurt horizontal (the Frankfurt horizontal is a line connecting the lower edge of the left orbit and the upper edge of the left external auditory opening). The examiner stands on the

left side of the subject and controls whether the anthropometer is placed vertically and directly on the longitudinal side of the body. The measurement result is read with an accuracy of 0.1cm (Beleigoli et al., 2019; Omron Healthcare, 2024).

OmronBF511 - Body Weight (BW), Body Mass Index (BMI), Body fat percentage (BF%), muscle mass percentage (MM%) of the subjects were determined using a tetrapolar bioimpedance device - Omron BF511 (Kyoto, Japan), which measures with an accuracy of 0.1kg, 0.1kg/m2 The researcher takes the display unit and enters age, gender and height, after which the minimally dressed and barefoot subject stands on the main unit of the device (body mass is then read). After the body mass of the subject is shown on the display, the meter hands her the display unit, which he/she grabs firmly by the handles arms fully extended in front. The sound signal informs that the measurement of parameters of the subject's body composition has been completed. Subjects did not eat breakfast or drink water in the morning before the body composition test.

BMI is categorised according to the data of the World Health Organisation (WHO, 2017) specialised for the age of 5 to 19 years for adolescents: less than the fifth percentile ≤18.4 (underweight/); from the 5th to the 85th percentile (normal body mass/) 18.5 - 24.1; from the 85th to the 95th percentile 24.2 - 28.1 (overweight) and or above the 95th percentile ≥ 28.2 (obesity).

Physical fitness

PF was assessed using the EUROFIT fitness test battery (Adam et al., 2003) to evaluate cardiorespiratory fitness, muscular strength, balance, speed and coordination of the upper limbs, and flexibility. These assessments were conducted during physical education classes.

Cardiorespiratory fitness was measured by the 20 m shuttle run test, requiring participants to run back and forth between two lines set 20 meters apart. The starting speed was 8.5 km/h, increasing by 0.5 km/h each minute, with the pace indicated by an audio signal. The test concluded when the adolescents either stopped due to fatigue or failed to reach the line by the audio signal. For analysis, the stages completed were recorded, and maximum oxygen consumption (mL/kg/min) was calculated using the equation by Léger et al. (1989) ($Y = 31.025 + 3.238 \times \text{speed} - 3.248 \times \text{age} + 0.1536 \times \text{age} \times \text{speed}$). This test was performed once.

Muscular strength was assessed using two tests: the standing long jump, which evaluates explosive leg strength by asking participants to jump as far as possible from an upright stance using both feet on a jump platform, and handgrip strength, measured with a Jamar hand dynamometer, validated for adolescent populations (Trajković et al., 2024). Two trials were performed with the dynamometer, standing with the elbow flexed at 90°. Participants took 2 trials, both with dominant and non-dominant hand and better value was recorded. Additionally, in sit up test participants aim to complete as many sit-ups as possible in 30 seconds. Participants lie on a mat with bent knees, feet flat and held by a partner, and interlock fingers behind head. On "Go," participants lift chest until their upper body is vertical, then return to the floor. Test lasts 30 seconds, ensuring their back touches the floor each time. In the bent arm hang test, the subject is positioned with their chin level with a horizontal bar, using an overhand grip, hands shoulder-width apart. Timing begins once released, and they must hold this position as long as possible. Timing ends when the chin drops below the bar or the head tilts back to keep the chin level (Adam et al., 2003).

Balance was evaluated using the flamingo balance test. The individual was requested to stand barefoot on the wooden beam (50cm long, 5cm high, 4cm broad) with the tested leg and bend the free leg at the knee. Both hands should be on the iliac crests. Participants were told to hold this position for as long as they could. A stopwatch was used to record each time the person lost balance, whether by falling off the beam, letting go of the foot being held, or removing hands from the body. The test is done three times, and the best time (longest duration balancing in each position on the beam) is recorded (Oja & Tuxworth, 1995).

Speed and coordination of the upper limbs were assessed using the plate tapping test, which is done by measuring the time for the dominant hand to touch two discs 80cm apart 25 times while the other hand is fixed between the two discs. The best time to make 25 back-and-forth movements is recorded (Oja & Tuxworth, 1995).

Flexibility was evaluated using the sit-and-reach test, which specifically measures the flexibility of the lower back and hamstring muscles. Participants were instructed to sit barefoot on the floor with their legs fully extended and feet flat against a box, then reach forward along a measuring line as far as they could. The furthest position reached was recorded in centimeters over two attempts (Castro-Piñero et al., 2009).

Quality of Life

Quality of life (QoL) was measured using the Youth Quality of Life Instrument—Short Form (YQOL-SF) questionnaire (Patrick et al., 2002). This questionnaire included 15 items, with responses rated on a scale from 0 (not at all) to 10 (a great deal or completely). The scores were summed and converted to a 0–100 scale, where a higher score indicates a higher QoL. The final overall QoL score was calculated according to the YQOL-SF guidelines: COMPUTE Item1_tscore = ((Item1_score-0)/10)*100; item #7 (I feel alone in my life) was reverse-scored before summing, ensuring that a higher score reflects a higher QoL.

Physical activity levels

The International Physical Activity Questionnaire (IPAQ short-version), which has been validated for use with adolescents (Lee, 2011) and further adjusted to Serbia (Simonović et al., 2024) was used to gather data on time spent in PA. The IPAQ records all the PA performed in the previous week. The results were converted into units of metabolic equivalent of task (METs) following the IPAQ specifications: Walking MET-minutes/week =3.3* walking minutes per day; no of days per week in which walking was reported; Moderate MET-minutes/week =4.0* moderate intensity minutes per day * no of days per week in which moderate intensity activity was reported; Vigorous MET- minutes per week =8.0* Vigorous intensity minutes per day * no of days per week in which vigorous intensity activity was reported; Total physical activity MET-minutes/week = Walking + Moderate + Vigorous MET minutes/week scores.

Statistical analysis

All collected data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc., Chicago, USA). Descriptive statistics, including the mean and standard deviation, were calculated for each variable (Table 1). The normality of the data distribution was confirmed with the Kolmogorov-Smirnov test. To determine group differences, ANOVA and the Tukey post hoc test were applied (Table 3), with statistical significance set at $p<0.05$.

Results

Descriptive parameters of PF, QoL, PA levels and the normality of the data distribution are shown in Table 1. The average height of participants was 175.8±10.2cm, while the average body weight was 70.7±8.2kg. The average values of body fat percentage were 22.8±7.2%, while the average values of body muscle percentage were 34.5±9.4%. Given that the average BMI was 22.8±7.2, it can be said that most of the participants had normal BMI (Table 1).

Table 1. Descriptive Statistics And Data Normality Of Distribution.

Variables	Mean ± Std. Dev.	K-S (Sig.)
BH (cm)	175.8±10.2	0.980
BW (kg)	70.7±8.2	0.946
BMI (kg/m2)	22.8±7.2	0.948
BF%	23.1±7.2	0.759
Muscle (%)	34.5±9.4	0.779
Flamingo (s)	3.2±2.7	0.852
PTT(s)	15.2±12.2	0.739
S&R (cm)	21.2±12.1	0.101
SLJ (cm)	173.3±29.4	0.846
HsD (kg)	37.7±9.1	0.846
HsND (kg)	34.7±8.7	0.811
Sit-ups (rep)	22.03±4.4	0.911
Pull-ups (s)	8.51±7.1	0.582
V̇O2max (ml/kg/min)	28.8±8.9	0.605
QoL	66.3±19.6	0.742
PA level (METs)	3505.9±2731.3	0.801

Legend: K-S (Sig.) – Kolmogorov Smirnov test; BH (cm) – body height; BW (kg) – body weight; BMI – body mass index (kg/m2); BF% – body fat percentage (%); Muscle (%) – muscle mass percentage; PTT – plate tapping test; S&R – sit and reach test (cm); SLJ – standing long jump (cm); HsD – handgrip strength dominant hand (kg); HsND – handgrip strength non-dominant hand (kg); VO2max – maximal oxygen uptake (mL/(kg·min); QoL – quality of life; PA level – physical activity level; rep – repetitio; METs – metabolic equivalent of task.

Furthermore, Kolmogorov-Smirnov test determined that there are no data that deviate from the normal distribution. Considering that all adolescents have been categorized into 3 groups based on the aforementioned BMI classification, the following table shows the frequencies of participants in different BMI groups (Table 2):

Table 2. Participants Divided By BMI Classification.

BMI	Frequency	BMI (mean ± SD)
Underweight	N=33	17.67±4.1
Normal weight	N=78	21.9±7.2
Overweight	N=28	26.4±3.9

Legend: BMI – body mass index; N – number of participants.

Table 3. Differences Between Groups (ANOVA).

Variables	Group 1 (underweight) mean ± SD	Group 2 (normal weight) mean ± SD	Group 3 (overweight) mean ± SD	ANOVA (p-value)	Tukey post Hoc test (Multiple Comparisons) (p-value)		
					I vs. II	II vs. III	I vs. III
Flamingo (s)	3.3±2.5	3.4±2.6	3.1±2.3	0.050*	0.110	0.049*	0.048*
PTT (s)	15.1±12.1	15.2±12.2	15.0±11.9	0.210	0.220	0.190	0.110
S&R (cm)	22.9±11.8	21.2±12.1	20.0±10.8	0.050*	0.049*	0.049*	0.030*
SLJ (cm)	179.8±29.4	172.9±29.4	159.3±19.5	0.030*	0.049*	0.020*	0.000**
HsD (kg)	35.3±7.1	37.9±6.1	41.2±9.1	0.020*	0.049*	0.040*	0.010**
HsND (kg)	31.7±7.6	34.7±7.7	39.7±7.9	0.049*	0.030*	0.047*	0.020*
Sit-ups (rep)	20.03±4.1	22.03±4.2	26.03±4.5	0.000**	0.480*	0.040*	0.010**
Pull-ups (s)	9.31±7.3	8.51±7.1	2.46±4.1	0.000**	0.060	0.010**	0.001**
$VO2_{max}$(ml/kg/min)	30.7±9.1	28.8±8.9	21.0±10.8	0.001**	0.048*	0.031*	0.001**
QoL	64.9±18.9	66.3±19.6	61.8±18.2	0.041*	0.110	0.032*	0.047*
PA level (METs)	3298.4±2731.3	3641.9±2731.3	2891.9±2543.3	0.010**	0.040*	0.010**	0.000**

Legend: mean-arithmetic mean; SD-standard deviation; *-statistical significance (p<0,05); ** - statistical significance (p≤0.001); PTT – plate tapping test; S&R – sit and reach test (cm); SLJ – standing long jump (cm); HsD – handgrip strength dominant hand (kg); HsND – handgrip strength non-dominant hand (kg); $VO2_{max}$ – maximal oxygen uptake (mL/(kg·min); QoL – quality of life; PA level – physical activity level; rep – repetition; METs – metabolic equivalent of task.

Additionally, ANOVA was used to determine differences between groups, and a Tukey post Hoc test to determine magnitude of difference between groups (Table 3).

Significant differences are shown among the three groups (underweight, normal weight, and overweight) in PF, QoL and PA level of adolescents hinged on BMI, based on ANOVA and post-hoc Tukey tests (Table 3). For the flamingo test of balance group II (3.4±2.6, p=0.05) scored higher than group III (3.1±2.3, p=0.05), while there were no significant difference with group I (3.3±2.5, p=0.11). Furthermore, in the plate tapping test there we no significant differences between groups (p=0.21). Additionally, in sit and reach test, group I (22.9±11.8) scored significantly higher than both group II (21.2±12.1) and group III (20.0±10.8), where all pairwise comparisons were significant (p=0.04). Next, in the standing long jump test, group I (179.8±29.4) scored higher than group II (172.9±29.4) and group III (159.3±19.5). All intergroup comparisons were significant (p=0.01). Likewise, in the handgrip strength test with dominant hand group 3 (41.2±9.1) showed significantly better scores than group II (37.9±6.1) and group I (35.3±7.1), and the Tukey post hoc test confirmed differences in score (p=0.02), making group III (overweight) the best at this test. On the other side, we saw the same trend in handgrip strength with non-dominant hand where group III (39.7±7.9) showed better scores than group II (34.7±7.7) and group I (31.7±7.6), with Tukey post-hoc confirming the pairwise differences (p=0.03). In the sit-ups test, group I (20.03±4.1) showed better results than group II (22.03±4.2) and group III (26.03±4.5) and post-hoc analysis confirmed those intragroup differences (p=0.03). Furthermore, in the pull ups test group I (9.31±7.3) demonstrated higher scores than group II (8.51±7.1) and group III (2.46±4.1), with the post-hoc test confirming the differences between group II and III (p=0.01) and I and III (p=0.00), while there were no differences between group I and II (p=0.06). In the shutle run test (VO2max) group I (30.7±9.1) scored higher than group II (28.8±8.9) and group 3 (21.0±10.8), with ANOVA showing significant differences (p=0.01) and Tukey post-hoc confirming differences in specific groups (p=0.03). Moreover, ANOVA revealed significant differences (p<0.049) in QoL of groups I (64.9±18.9), II (66.3±19.6) and III (61.8±18.2). Additionally, Tukey post-hoc confirmed differences between groups II and III (p=0.03) and I and III (p<0.048), while there were no differences within groups I and II (p=0.11). At last, ANOVA displayed differences (p=0.01) in IPAQ PA level scores (MeTS) in group I (3298.4±2731.3) group II (3641.9±2731.3) and group III (2891.9±2543.3), with post-hoc confirming differences where all pairwise comparisons were significant: group I and II (p=0.04), group II and III (p=0.01) and group I and III (p<0.001).

Discussion

This study aimed to examine differences in PF, QoL, and PA level among adolescents based on BMI. Therefore, the main findings of this study indicate that there were significant differences among three groups (underweight, normal weight, overweight) in PF, QoL, and PA levels among adolescents, that implies adolescents who are normal weight tend to have better PF, QoL and PA level in comparison with adolescents who are underweight and overweight.

Adolescents undergo growth and notable changes in body composition, which affect their responses to exercise and overall physical fitness (PF) (Bélanger et al., 2015). The findings of this study indicated significant differences in PF among the three groups (underweight, normal weight, overweight). Specifically, the results revealed significant variations across all PF variables (flamingo test, sit-and-reach test, standing long jump, handgrip strength for the dominant hand, handgrip strength for the non-dominant hand, sit-ups, pull-ups, and VO2max - maximal oxygen uptake), except for the plate tapping test. Those differences shown in Table 3 were in accordance with previous studies (Pahkala 2013; Dewi et al., 2021; Qui et al., 2022). Namely, Qin et al. (2022) showed that lower values of BMI lead to increased values of VO2max, strength and balance of adolescents, which was confirmed by Dewi et al. (2021). Additionally, Pakhala et al. (2013) showed that adolescents who showed normal or lower values of BMI displayed a higher VO2max, which is in line with the results of this study. Given that BMI is an indicator of a good image of body composition (Wellens et al., 1996), it can be suggested that the results of this study are expected. Namely, by showing a normal or lower BMI value, adolescents tend to perform better in PF tests (in other words, to have an overall better PF) due to the lower distribution of body fat associated with a lower BMI value, as well as lower body weight. While underweight adolescents may show advantages in aerobic activities due to lower body mass, this does not imply an ideal health status, as being underweight can pose risks to overall health, particularly when it results from inadequate nutrition or other health issues that compromise strength and physical resilience.

Adolescence is a crucial transitional stage in life, vital for developing skills related to health and well-being, and it is during this period that future patterns of adult health are formed (Sawyer et al., 2012). There has been a growing emphasis on understanding, enhancing, and assessing adolescents' quality of life (QoL) (Langeland et al., 2019), as QoL is shaped by both individual and environmental factors (Ferrans et al., 2005). The findings of this study exibited a significant differences (p=0.05) in QoL of group I, II and III. Furthermore, post-hoc confirmed differences between II and III and I and III, while there were no differences within groups I and II, indicating that group II (normal weight) displayed the highest QoL scores, following group I (underweight) and group III showing lowest QoL scores overall. These results are consistent with previous literature, which shows that a normal (Keating et al., 2011) as well as a lower level of BMI (Chen, 2014) lead to a better QoL, while a high BMI (Keating et al., 2011; Van de Pas et al., 2023) is an indicator of a worse QoL in adolescents. The results of our and previous studies are expected, given that it has already been shown that adolescents who have predispositions to obesity have impaired QoL (Van de Pas et al., 2023). Namely, increased BMI is associated with the occurrence of chronic diseases (Mandoh et al., 2023), so we can assume that one of the mechanisms that leads to better QoL in adolescents could hypothetically be the lower frequency of diseases and problems related to them. Therefore, adolescents who have a normal or lower BMI level show a better QoL overall.

Engaging in PA during adolescence is essential for preventing and treating various chronic diseases, particularly obesity, hypertension, diabetes, and metabolic syndrome (Anderson & Durstine, 2019). Despite its importance, the rate of PA decreases annually by 3.4% in boys and 5.3% in girls from the age of nine until the end of adolescence (Farooq, 2022). The results of this study revealed differences (p=0.01) in IPAQ PA level scores (MeTS) in all groups, where all pairwise comparisons were significant: group I and II, group II and III, and group I and III. Namely, the results prove that adolescents who have a normal BMI (group 1) have the highest level of PA, while, to a slightly lesser extent, adolescents from group 1 (underweight) have a lower level of PA compared to group 1, while adolescents who are classified as overweight have the lowest level of PF activities. Our results are in line with the results of previous studies that show that adolescents with normal BMI values also have a higher PA level compared to adolescents who fall into the overweight category (Raustorp et al., 2004; Dewi et al., 2011; Mateo-Orcajada et al., 2022). The results obtained in

this study were consistent with the results of other studies when we talk about BMI and PA levels. Namely, it has already been proven that a higher PA level affects the improvement of body composition, i.e. BMI (Jaremków et al., 2023), so it is expected to observe that adolescents who have a normal BMI level have a better PA level than their peers who fall into the category of underweight or overweight.

The significant differences we found in our study regarding PF, QoL, and PA levels have practical implications. By understanding these differences, we can gain a clearer picture of adolescents' overall development. Presenting variations across numerous variables can help establish meaningful guidelines aimed at preventing obesity-related risk factors, such as elevated BMI. Firstly, these results show that people who tend to be overweight score worse in the largest number of variables included in this research and thus underline the importance of spreading awareness about the harmfulness of an increased body mass index, i.e., the trend of increasing obesity today. This study highlights the strong association between BMI and PA, PF, and QoL among adolescents, with those in the normal BMI range showing the highest PA levels. Lower activity in overweight adolescents may stem from physical or psychological barriers, suggesting the need for supportive interventions. Future research should use objective measures, larger diverse samples, and explore psychological influences to better understand and address these associations over time.

This study reveals several limitations that must be acknowledged. The small sample size of 139 adolescents restricts the generalizability of the findings to a broader population, particularly those from diverse geographic regions, given that the sample consisted only of adolescents in one country. Another limitation is that no follow-up was done after this cross-sectional study. By doing the follow-up, we would have a better understanding of the changes in the given variables as well as the differences between them. Additionally, the study does not consider the psychological factors that might influence PF and QoL, such as motivation, stress, or fatigue, which can also play a significant role in performance or pre-mentioned QoL. Furthermore, major limitation of the study is the reliance on a IPAQ-SF questionnaire, a subjective measure, rather than an accelerometer, which provides a more objective assessment of PA levels. Furtheremore, another limitation is that QoL form is not validated in Serbian population, but we used translation to Serbian language of valid version. Finally, the difference in the number of respondents by BMI category, could have affected the results given that the sample is small and the differences in the number of respondents per group are large.

Conclusion

In conclusion, the results of this study showed significant differences in the variables of PF, QoL, and PA levels of adolescents from Serbia depending on their BMI, which implies that adolescents who are normal weight tend to have better PF, QoL and PA level in comparison with adolescents who are underweight and overweight. Those results underline the importance of spreading awareness about the harmfulness of an increased BMI, i.e., the trend of increasing obesity in today's society.

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Author Contributions

Conceptualization, S.S., T.I. and T.P-I.; methodology, all authors.; software, S.S., S.M., and A.L.; validation, D.R., I.I., G.P. and T.I.; formal analysis, S.S., A.L. and T.P-I.; investigation, S.S., D.R., S.M. and I.I; data curation, S.S., G.P., T.P-I. and I.I.; writing—original draft preparation, S.S. and T.I.; writing—review and editing, all authors; visualization, D.R., A.L. and T.I.; supervision, S.S., T.P-I., G.P. and I.I.; project administration, S.S., S.M. and I.I. The authors of this article have equal contribution and equal rights over it.

Staments and declarations

Ethical Consideration

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Research Ethics Committee of the Faculty of Sport and Physical Education Nis (protocol code 04-2035/2).

Concent to participate

Informed consent was obtained from all subjects involved in the study.

Concent for publication

All authors have read and agreed to the published version of the manuscript

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article**.**

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Data Availability

Full data coded of the included studies can be shared upon reasonable request from the corresponding author.

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ORIGINAL SCIENTIFIC PAPER

Comparative Analysis on the Impact of Ergogenic Aids and Skill Practice to Athletic Performance Among Paid Athletes in Edo State Sports Commission

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Abstract

In the pursuit of athletic excellence, optimizing performance is a paramount concern for athletes, coaches, and sports organizations. This study compares the impact of skill practice and ergogenic aids on athletic performance among 100 paid athletes in Edo State Sports Commission. Six research questions guided the study, and four hypotheses were tested at 0.05 alpha level. A correlational survey research design was used, with a validated questionnaire (EAASP) having a Cronbach's alpha reliability of 0.70, administered through a combination of online and offline modes to ensure maximum participation and response rate. To select the respondents, stratified random sampling technique was utilized to ensure athletes are selected randomly to reflect the diversity of the entire population. The data collected from the study was analysed using frequencies, percentages, and t-test Analysis of variance while inferential statistics of regression was used to test four hypotheses at 0.05 alpha levels. The findings indicate that skill practice is prioritized over ergogenic aids for achieving long-term athletic success (M = 2.27, SD = 1.00). Athletes also acknowledged general health risks (M = 2.15, SD = 0.97) and concerns about dependence or addiction (M = 2.20, SD = 1.03) associated with ergogenic aid use. The study recommends the need for personalized training strategies and structured education on ergogenic aids to prevent misconceptions and potential health risks by prioritizing skill practice; promoting informed decision-making to optimize performance while minimizing risks.

Keywords: *Ergogenic aids, Skill practice, Athletic performance, Athlete Development, Performance Optimization*

Introduction

The pursuit of athletic excellence has led to the widespread adoption of ergogenic aids among athletes. These aids, ranging from carbohydrate-electrolyte drinks to caffeine and deep ocean minerals, aim to enhance physical performance, improve training adaptations, and facilitate recovery. Research conducted by López-Torres et al; (2023) highlights the efficacy of certain ergogenic aids like caffeine, creatine, and beta-alanine in boosting athletic performance. Caffeine, for instance, has been shown to improve jumping performance, isometric strength, and sprint performance, while beta-alanine enhances aerobic capacity (Murphy, et al; 2022). Understanding the effects of these ergogenic aids is crucial for athletes, coaches, and sports organizations seeking to optimize performance. Athletic performance is influenced by a combination of factors, including physical training, skill practice, and the use of ergogenic aids. Ergogenic aids encompass a broad spectrum of substances and techniques utilized by athletes to boost performance, endurance, and recovery processes. Ergogenic aids can be categorized into Nutritional Ergogenic Aids, Pharmacological Ergogenic Aids, Mechanical Ergogenic Aids, and Psychological Ergogenic Aids. Nutritional Ergogenic Aids according to Maughan & Burke, (2015), are dietary supplements designed

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to provide essential nutrients such as carbohydrates, protein powders, and creatine. Protein is essential for muscle repair, and studies show that protein supplementation can significantly enhance recovery and muscle protein synthesis following exercise (Phillips & Van Loon, 2011). Pharmacological Ergogenic Aids include substances like anabolic steroids, stimulants, and growth hormones, which can lead to significant performance improvements but raise serious ethical and health concerns (Calfee & Fadale, 2006).

Research indicates that carbohydrate loading can significantly enhance endurance by maximizing glycogen stores and creatine supplementation has been demonstrated to improve strength and power output during high-intensity workouts (Kreider et al., 2017). The use of anabolic steroids was however countered by Peterson & Brown, (2018) due to the resultant effect on the physiological and psychological well-being of individuals, including mood alterations and cardiovascular complications. The World Anti-Doping Agency (WADA) actively prohibits these substances to ensure fair competition (WADA, 2015).. Jeukendrup, (2017) opined that nutritional aids enhance the availability of energy substrates, crucial for sustaining high-intensity exercise by improving endurance and maintaining blood glucose levels. In same vein, Phillips & Van Loon, (2011) aver that protein and certain amino acids facilitate muscle repair and growth, leading to enhanced recovery after exercise. Creatine supplementation boosts phosphocreatine stores, facilitating the regeneration of ATP during high-intensity activities. However, the prevalence of some Pharmacological Ergogenic Aids in sports raises concerns about ethics, health risks, and fairness. Specifically, performance-enhancing drugs which poses serious health risks and compromise the integrity of competitive sports, highlighting the need to evaluate their impact on athlete well-being and fair play. Skill practice is a fundamental and sustainable approach to enhancing athletic performance. It is the cornerstone of athletic training, built on the repetitive execution of specific movements designed to enhance proficiency and performance. This process of skill acquisition is well-explained by established learning theories, notably Fitts and Posner's Stages of Learning model (Fitts & Posner, 1967) which explains the process of skill acquisition providing a framework that outlines the cognitive, associative, and autonomous stages athletes go through to master skills. This is about deliberate practice, characterized by focused and structured training, and it is crucial for developing expertise in sports (Ericsson & Smith, 1991).

Ericsson & Charness, (1994) emphasized that in Nigeria, the integration of skill practice with conditioning has been shown to significantly boost athletic performance across various disciplines and research consistently shows that athletes who adopt this intentional training method exhibit more significant skill gains than those engaging in less focused activities. Effective skill practice involves technique refinement, tactical understanding, and physical conditioning. Regular practice fine-tunes movements, improving performance in sports like gymnastics and swimming (Adebayo & Ogunleye, 2022). It also develops tactical understanding, enabling swift decision-making and strategy adaptation in team sports (Wang et al., 2019). Vealey, (2016), emphasized that methods such as visualization, relaxation techniques, and cognitive-behavioral strategies have been shown to enhance athletes' focus and alleviate anxiety, thereby improving performance outcomes with mental conditioning increasingly recognized as a critical aspect of athletic training.

In Nigeria, challenges persist with limited access to quality facilities and resources and this hinders effective practice (Okafor & Okwor, 2020). The quality of coaching and training programs will significantly impacts skill acquisition, with well-structured programs yielding better results (Ogunleye & Bakare, 2020). Athletic performance of paid athletes in Edo State Sports Commission will significantly be enhanced by a combination of tailored strength and endurance training, mental toughness, proper nutrition, and consideration of environmental conditions. Optimizing athletic performance involves periodized training for strength and power, mental resilience strategies for focus, and tailored nutrition for recovery (Jones et al., 2020). Environmental factors like altitude and temperature also play a critical role with high-altitude training potentially increasing aerobic capacity (Smith, 2019). The Edo State Sports Commission can play a pivotal role in promoting athlete development by providing access to quality facilities, resources, and well-structured training programs. Integrating these factors, athletes and coaches can develop comprehensive strategies "ultimately enhancing athletic performance among paid athletes in the state" (Edo State Sports Commission, 2022).

Statement of the Problem

The use of ergogenic aids among paid athletes in Edo State Sports Commission has raised concerns about their safety, ethical implications, and potential impact on athletic performance. Despite the widespread use of ergogenic aids and skill practice among paid athletes in Edo State Sports Commission, there is a lack of scientific evidence on the comparative impact of these two factors on athletic performance. Furthermore, the use of ergogenic aids is often shrouded in controversy, with concerns about their potential negative effects on athletes' health and well-being. The problem is compounded by the fact that many athletes in Edo State Sports Commission lack access to qualified coaches, trainers, and sports scientists who can provide evidence-based guidance on the use of ergogenic aids and skill practice. As a result, many athletes are forced to rely on trial and error, or seek advice from unqualified sources, which can lead to ineffective training practices and increased risk of injury or illness.

Moreover, most studies have focused on the effects of ergogenic aids or skill practice in isolation, without considering the potential interactions between these two factors. And the lack of research on the comparative impact of ergogenic aids and skill practice on athletic performance among paid athletes in Edo State Sports Commission makes it difficult for sports administrators, coaches, and trainers to develop effective training programs that optimize athletic performance while minimizing the risks associated with ergogenic aid use. Therefore, this study investigated the comparative impact of ergogenic aids and skill practice on athletic performance among paid athletes in Edo State Sports Commission, with a view to providing evidence-based recommendations for optimizing athletic performance while minimizing the risks associated with ergogenic aid use.

Purpose of the Study

The study investigated the comparative impact of ergogenic aids and skill practice on athletic performance among paid athletes in Edo State Sports Commission.

Research Questions

1. What is the impact of ergogenic aids on athletic performance among paid athletes in Edo State Sports Commission?

2. What is the impact of skill practice on athletic performance among paid athletes in Edo State Sports Commission?

3. Which ergogenic aids are most commonly used among paid athletes in Edo State Sports Commission, and what are their perceived effects on athletic performance?

4.. What are the potential risks and side effects associated with the use of ergogenic aids among paid athletes in Edo State Sports Commission?

5. Is there a significant difference in the impact of ergogenic aids and skill practice on athletic performance among paid athletes in Edo State Sports Commission?

6. How do paid athletes in Edo State Sports Commission perceive the importance of skill practice compared to ergogenic aids in enhancing athletic performance?

Hypotheses

1. There is no significant difference in the impact of ergogenic aids on athletic performance among paid athletes in Edo State Sports Commission.

2. There is no significant difference in the impact of skill practice on athletic performance among paid athletes in Edo State Sports Commission.

3. There is no significant difference in the impact of ergogenic aids and skill practice on athletic performance among paid athletes in Edo State Sports Commission.

4. Paid athletes in Edo State Sports Commission perceive no significant difference in the importance of skill practice and ergogenic aids in enhancing athletic performance.

Methodology

This study employed a correlational survey research design to investigate the relationships between ergogenic aids, skill practice, and athletic performance among paid athletes registered with the Edo State Sports Commission. A stratified random sampling technique was implemented to ensure a representative sample, categorizing the population into distinct strata based on specific sports and randomly selecting athletes from each stratum. This approach ensured representation across different sports and performance levels, enhancing the generalizability of the findings. Statistical power analysis determined the optimal sample size, aiming for a minimum of 100 athletes to guarantee adequate statistical power for meaningful comparisons. Data collected from respondents were analyzed using descriptive statistics, including mean and standard deviation to identify trends and patterns, frequencies, and percentages. Inferential statistics, such as correlation analysis and regression, were used to test four hypotheses at 0.05 alpha levels, examining the relationships between ergogenic aids, skill practice, and athletic performance.

A self-developed questionnaire, tagged EAASP, was the primary instrument used in the study. The questionnaire featured a four-point Likert scale with options for Strongly Agree, Agree, Disagree, and Strongly Disagree. It consisted of two sections: Section A, which comprised five items focused on demographic information such as gender, age, educational level, type of sport, and years of participation, and Section B, which included multiple-choice questions aimed at eliciting responses related to ergogenic aids and skill practice. The questionnaire was administered using a combination of online and offline modes. To ensure the reliability of the instrument, a pilot study was conducted using Cronbach's alpha reliability coefficient, which yielded a reliability score of 0.7. The error probability was set at $p = 0.05$ to maintain statistical relevance.

Results

Tables were utilized to illustrate the descriptive analysis, and suitable interpretations were also employed to show and present the inferential analysis as the research's final result. The demographic characteristics of study participants are presented in the Supplementary File (Supplementary Tables S1, S2, S3, S4, S5, S6 and S7).

Analysis of Research Questions

Research Question 1

What is the impact of ergogenic aids on athletic performance among paid athletes in Edo State Sports Commission?

Supplementary Table S8 presents the descriptive statistics for research question 1. The descriptive statistics in Supplementary Table S8 show moderate agreement among athletes regarding the importance of ergogenic aids in their athletic performance. The mean scores range from 2.10 to 2.33, indicating a slightly positive perception. The standard deviations (0.82-0.87) suggest relatively consistent responses.

Table 1: ANOVA results for research question 1

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F-value	p-value	Decision
Between groups	3,13	3	1.04	1.07	0.363	Fail to reject Ho
Within groups	307.75	396	0.78	-	-	-
Total	310.88	399	-	-	-	-

From the data in table 1, the results of the ANOVA analysis indicate that there's no statistically significant difference in the responses across the four survey items ($F=1.07$, $p=0.363$, $df=399$). Since the p-value (0.363) is greater than 0.05, we fail to reject the null hypothesis. This means there is no statistically significant difference in responses across the four survey items. In other words, respondents' opinions about ergogenic aids are relatively consistent across the different statements.

Research Question 2

What is the impact of skill practice on athletic performance among paid athletes in Edo State Sports Commission?

Supplementary Table S9 presents the descriptive statistics for research question 2. The descriptive statistics in Supplementary Table S9 indicate that athletes generally perceive skill practice as beneficial, with mean scores ranging from 2.14 to 2.43. The standard deviations (0.85-1.03) suggest moderate variability in responses, indicating some consistency in opinions about the impact of skill practice on technical skills, confidence, and muscle memory.

From the data in table 2, the results of the ANOVA analysis indicate that there's no statistically significant difference in the responses across the four survey items ($F=1.64$,, $p=0.179$, $df=399$). Since the p-value (0.179) is greater than 0.05, we fail to reject the null hypothesis. This means that skill practice is generally perceived similarly across different aspects of athletic performance, with no strong statistical variation among the responses.

Table 2: ANOVA results for research question 2

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F-value	p-value	Decision
Between groups	4.55	3	1.52	1.64	0.179	Fail to reject Ho
Within groups	365.65	396	0.92	-	-	-
Total	370.20	399	-	-	-	-

Research Question 3

Which ergogenic aids are most commonly used among paid athletes in Edo State Sports Commission, and what are their perceived effects on athletic performance?

Supplementary Table S10 presents the descriptive statistics for research question 3. The descriptive statistics in Supplementary Table S10 show varying levels of agreement among athletes regarding the use and effectiveness of different ergogenic aids. The mean scores range from 1.83 to 2.53, indicating differing perceptions. Notably, creatine is perceived as effective (mean=1.83), while opinions on safety and effectiveness of ergogenic aids are more divided (mean=2.53).

Table 3: ANOVA results for research question 3

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F-value	p-value	Decision
Between groups	33.93	3	11.31	11.24	433×10^{-7}	Reject Ho
Within groups	398.57	396	1.01	-	-	-
Total	432.50	399	-	-	-	-

From the data in table 3, the results of the ANOVA analysis indicate that there's a highly statistically significant difference in how athletes perceive and use different ergogenic aids. The responses across the four survey items (F=11.24,, p= 4.33×10^{-7}, df=399). Since the p-value (4.33×10^{-7}) is lesser than 0.05, we reject the null hypothesis. This means that athletes perceive and use different ergogenic aids in significantly different ways.

Research Question 4

What are the potential risks and side effects associated with the use of ergogenic aids among paid athletes in Edo State Sports Commission?

Supplementary Table S11 presents the descriptive statistics for research question 4. The descriptive statistics in Supplementary Table S11 show that respondents generally agree that ergogenic aids are associated with potential health risks and side effects. Mean scores range from 2.15 to 2.39, indicating varying levels of concern. Respondents are particularly concerned about health risks (mean=2.15), while cardiovascular problems received the highest mean score (2.39), suggesting relatively lower concern level compared to other items.

Table 4: ANOVA results for research question 4

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F-value	p-value	Decision
Between groups	3.25	3	1.08	1.08	0.36	Fail to reject Ho
Within groups	398.25	396	1.01	-	-	-
Total	401.50	399	-	-	-	-

From the data in table 4, the results of the ANOVA analysis indicate that there's no statistically significant difference in the perceived risks and side effects of ergogenic aids among athletes (F=1.08, p= 0.36, df=399). Since the p-value (0.36) is greater than 0.05, we fail to reject the null hypothesis.

Research Question 5

Is there a significant difference in the impact of ergogenic aids and skill practice on athletic performance among paid athletes in Edo State Sports Commission?

Supplementary Table S12 presents the descriptive statistics for research question 5. The descriptive statistics in Supplementary Table S12 show varying opinions on the importance of ergogenic aids versus skill practice. Respondents tend to agree that skill practice is important (mean=2.10), while opinions on the comparative impact of ergogenic aids and skill practice are more neutral (means range from 2.20 to 2.38). There's also moderate agreement that the impact of ergogenic aids depends on individual needs (mean=2.20).

Table 5: ANOVA results for research question 5

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F-value	p-value	Decision
Between groups	4.05	3	1.35	1.39	0.25	Fail to reject Ho
Within groups	385.15	396	0.97	-	-	-
Total	389.20	399	-	-	-	-

From the data in table 5, the results of the ANOVA analysis indicate that there's no statistically significant difference in the perceived impact of ergogenic aids and skill practice on athletic performance (F=1.39, p= 0.25, df=399). Since the p-value (0.25) is greater than 0.05, we fail to reject the null hypothesis. There is no strong consensus that one factor (ergogenic aids or skill practice) is significantly more impactful than the other.

Research Question 6

How do paid athletes in Edo State Sports Commission perceive the importance of skill practice compared to ergogenic aids in enhancing athletic performance?

Supplementary Table S13 presents the descriptive statistics for research question 6. The descriptive statistics in Supplementary Table S13 show that respondents prioritize skill practice over ergogenic aids (mean=2.27 and 2.16), indicating a stronger emphasis on skill development. Opinions are more neutral regarding the equal importance of both (mean=2.45). Respondents tend to disagree that ergogenic aids are a shortcut to success (mean=2.67), suggesting a preference for skill practice over shortcuts.

Table 6: ANOVA results for research question 6

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F-value	p-value	Decision
Between groups	14.93	3	4.98	4.88	0.0024	Reject Ho
Within groups	404.01	396	1.02	-	-	-
Total	418.94	399	-		-	-

From the data in table 6, the results of the ANOVA analysis indicate that there is a statistically significant difference in how athletes perceive skill practice versus ergogenic aids in enhancing performance (F=4.88, p= 0.0024, df=399). Since the p-value (0.0024) is lesser than 0.05, we reject the null hypothesis. Athletes do not have a uniform perception, some place more emphasis on skill practice, while others may prioritize ergogenic aids differently.

Discussion

The Impact of Ergogenic Aids on Athletic Performance

The findings of this study suggested that paid athletes in Edo State Sports Commission have relatively consistent perceptions regarding the impact of ergogenic aids on athletic performance. Most respondents agreed that ergogenic aids play a role in their athletic preparation and performance, with mean scores ranging from 2.10 to 2.33 and standard deviations between 0.82 and 0.87 (Supplementary Table S8 presents the descriptive statistics for research question 1). This suggests a moderate level of agreement among respondents regarding the role of ergogenic aids in enhancing athletic performance. This finding aligns with previous research by Petróczi & Naughton, (2008) that athletes generally perceive ergogenic aids as beneficial for performance enhancement. However, the ANOVA test results (F = 1.07, p = 0.363) indicate no statistically significant difference in responses across the four survey items (Table 1), suggesting that athletes' perceptions of ergogenic aids are consistent across different aspects of performance. These findings align with previous research, which suggests that ergogenic aids are widely used among athletes to enhance performance, yet perceptions of their effectiveness vary based on personal experience, sport type, and individual physiological responses (Maughan, Burke, & Dvorak, 2018). While some athletes believe that ergogenic aids are essential for achieving peak performance, others may see them as supplementary rather than fundamental to success (Peeling et al., 2019). The lack of significant variation in responses could be attributed to a generally shared understanding of ergogenic aids among paid athletes, possibly influenced by standardized training regimens and knowledge disseminated by sports commissions and coaching staff. Research by Kreider et al. (2017) highlights that education on sports nutrition and supplementation significantly influences athletes' perceptions and usage of ergogenic aids. The relatively low standard deviation in the responses suggests that most athletes hold similar beliefs regarding the importance of these aids. Despite the perceived benefits of ergogenic aids, some literature raises concerns about their long-term effects and ethical considerations in competitive sports (Bahrke & Yesalis, 2019). While this study did not find significant differences in athletes' perceptions, future research could explore variations in perception based on sport type, level of experience, and individual performance outcomes.

The Impact of Skill Practice in Enhancing Athletic Performance

The findings from this study also indicated that paid athletes in Edo State Sports Commission generally perceive skill practice as an important factor in enhancing their athletic performance. The descriptive analysis reveals that respondents largely agreed with statements regarding the impact of skill practice on technical skills, confidence, muscle memory, and reaction time, with mean scores ranging from 2.14 to 2.43 and standard deviations between 0.85 and 1.03 (Supplementary Table S9 presents the descriptive statistics for research question 2). This suggests that skill practice is widely recognized as a key component of athletic development, though individual variations in perception exist. This finding supports the notion that deliberate practice is essential for skill acquisition and performance improvement (Baker & Young, 2014). Similarly, studies by Côté et al. (2012) highlight that athletes who engage in frequent, high-quality practice sessions demonstrate superior technical skills and decision-making abilities compared to those who rely more on talent alone. The ANOVA test results (F = 1.64, p = 0.179) however indicate that there is no statistically significant difference in responses across the four survey items (Table 2). The fact that respondents generally agreed on the importance of skill practice in these areas supports the idea that repetitive training helps refine motor patterns and enhance automaticity in movement execution (Davids, Button, & Bennett, 2008). This reinforces the idea that skill practice serves as a fundamental component in optimizing performance across different sports disciplines. Despite the strong agreement among respondents, the lack of significant differences in responses may be due to standardized training programs within the Edo State Sports Commission. Research by Baker & Young (2014) suggests that access to structured training programs significantly influences an athlete's perception of skill practice, as they are exposed to consistent coaching philosophies and methodologies.

Perceptions and Usage Patterns of Different Ergogenic Aids

Furthermore, the study explored the perceptions of paid athletes regarding different types of ergogenic aids. The descriptive analysis reveals that creatine was perceived as the most effective aid for enhancing muscular strength and endurance, with a mean score of 1.83 (SD = 0.75), indicating a strong level of agreement among respondents (Supplementary Table S10 presents the descriptive statistics for research question 3). This finding is consistent with previous research that creatine supplementation is effective for improving athletic performance (Cronin, 2020). On the other hand, protein powder (M = 2.51, SD = 0.98) and energy drinks (M = 2.12, SD = 1.09) were also commonly used but with more varied opinions on their effectiveness. Additionally, the belief in the safety and efficacy of ergogenic aids showed a wide range of responses (M = 2.53, SD = 1.15), suggesting some level of skepticism or concern among athletes. The ANOVA test results (F = 11.24, p = 4.33×10^{-7}) indicate a highly statistically significant difference in how athletes perceive and use different ergogenic aids (Table 3), suggesting that athletes differentiate between various types of ergogenic aids.

This implies that athletes have distinct preferences and attitudes toward different ergogenic aids, likely based on their perceived effectiveness, availability, and potential risks. These findings align with previous research on ergogenic aid consumption among athletes. Studies have shown that creatine supplementation is widely regarded as one of the most effective and research-backed performance enhancers, particularly for strength

and power-based sports (Branch, 2003; Kreider et al., 2017). The high agreement on creatine's effectiveness in this study supports existing evidence that it enhances muscle strength, endurance, and recovery (Cooper et al., 2012). In contrast, protein powders, while commonly used for muscle repair and growth, tend to be viewed as a supplementary rather than a performance-enhancing aid (Phillips & Van Loon, 2011). The mean score of 2.51 suggests that while some athletes find protein powders beneficial, others may prioritize whole-food protein sources or see limited direct performance benefits. Energy drinks, which had a mean score of 2.12, have been frequently debated in sports science. While some studies suggest that caffeine and sugar in energy drinks can improve alertness and short-term performance, others warn of potential negative effects such as dehydration, increased heart rate, and energy crashes (Higgins, Tuttle, & Higgins, 2010). The mixed responses in this study reflect the ongoing debate on their effectiveness and safety for athletic performance. The perception of ergogenic aids as safe and effective showed the highest variability (M = 2.53, SD = 1.15), indicating differences in individual trust and knowledge regarding these substances. This variation may stem from concerns over side effects, long-term health risks, or regulatory issues, which have been discussed in previous research (Maughan, 2013).

Overall, the findings suggest that while ergogenic aids are widely used among athletes, their perceived effectiveness and safety vary significantly depending on the specific substance. Future research could explore sport-specific trends in ergogenic aid usage, as some aids (e.g., creatine) may be more beneficial for strength-based sports, while others (e.g., caffeine) may be more useful for endurance or skill-based sports. Additionally, educational interventions on the safe and effective use of ergogenic aids could help athletes make more informed choices about supplementation.

Potential Risk and Side Effects of Ergogenic Aids

The findings from this study suggested that paid athletes in Edo State Sports Commission generally acknowledge the potential risks and side effects associated with the use of ergogenic aids, but their perceptions do not significantly differ across specific concerns but their perceptions do not significantly differ across specific concerns. The descriptive analysis reveals that most respondents recognize health risks related to ergogenic aids, with mean scores ranging from 2.15 to 2.39 across the four survey items (Supplementary Table S11 presents the descriptive statistics for research question 4). However, the ANOVA results (F = 1.08, p = 0.36) indicate that there is no statistically significant difference in the perception of different risks (Table 4). The high level of agreement regarding general health risks (M = 2.15, SD = 0.97) aligns with previous studies that highlight concerns about both the short-term and long-term effects of performance-enhancing substances (Maughan, 2013). Similarly, the perception that ergogenic aids can lead to serious side effects such as stomach issues, headaches, or dizziness (M = 2.27, SD = 1.01) is consistent with research showing that substances like creatine, stimulants, and protein supplements can cause gastrointestinal discomfort, dehydration, or other adverse reactions (Cooper et al., 2012; Higgins, Tuttle, and Higgins, 2010). The perception that ergogenic aids increase the risk of cardiovascular problems (M = 2.39, SD = 0.99) is also in line with concerns raised in sports science literature. Stimulant-based supplements, such as caffeine, ephedrine, and anabolic steroids, have been linked to increased heart rate, high blood pressure, and even the risk of heart attacks and strokes (Moran et al., 2018). The slightly higher mean score for this item compared to other risks suggests that some athletes may be more aware of cardiovascular dangers than other side effects.

Additionally, the concern that ergogenic aids can lead to dependence or addiction (M = 2.20, SD = 1.03) reflects the ongoing debate in sports science regarding psychological and physiological dependence on supplements and performance enhancers. Studies have found that some athletes develop reliance on stimulants, painkillers, or anabolic steroids to maintain performance levels, leading to withdrawal symptoms or long-term health complications (Backhouse et al., 2007). The relatively high standard deviation (1.03) for this item suggests that opinions on addiction risks may be more divided than concerns over immediate physical side effects. Despite the high level of agreement on potential risks, the ANOVA results suggest no significant variation in how athletes perceive these risks across different types of side effects. This could indicate that athletes view ergogenic aids as a general health concern rather than distinguishing between specific risks. This uniformity may stem from a lack of detailed knowledge about the specific dangers of different ergogenic aids or from general caution based on publicized cases of doping and supplement misuse. These findings support previous research emphasizing the importance of education and regulation in ergogenic aid use (Maughan, 2013). To ensure athlete safety, sports commissions and regulatory bodies should provide evidence-based guidelines on supplement use, potential risks, and safe alternatives. Given the widespread concern over health risks, targeted awareness campaigns on specific dangers such as cardiovascular risks and dependence could help athletes make more informed decisions.

Differences in the perceptions of skill practice versus ergogenic aids

The findings from this study suggested that paid athletes in Edo State Sports Commission hold statistically significant differences in their perceptions of skill practice versus ergogenic aids in enhancing athletic performance. The descriptive statistics reveal that the statement "I prioritize skill practice over using ergogenic aids to improve my athletic performance" (M = 2.27, SD = 1.00) and "Skill practice is more important than using ergogenic aids for achieving success in my sport" (M = 2.16, SD = 0.97) received relatively high agreement (Supplementary Table S12 presents the descriptive statistics for research question 6). The ANOVA results (F = 4.88, p = 0.0024) indicate that athletes do not have a uniform stance on whether skill practice or ergogenic aids contribute more to performance improvement (Table 6), which highlights the complexity of factors influencing athletic performance. This suggests that some athletes may prioritize consistent training and skill refinement, while others see supplementation as a viable performance enhancer. The descriptive statistics reveal that the statement "I prioritize skill practice over using ergogenic aids to improve my athletic performance" (M = 2.27, SD = 1.00) and "Skill practice is more important than using ergogenic aids for achieving success in my sport" (M = 2.16, SD = 0.97) received relatively high agreement. These findings align with Ericsson et al.'s (1993) theory of deliberate practice, which emphasizes that long-term skill acquisition and training adaptations are the most critical factors in expert performance. Many studies support the notion that consistent, high-quality practice enhances technical skills, motor learning, and competitive success in athletes (Williams and Ford, 2008). On the other hand, some athletes acknowledged the combined importance of both factors, as reflected in the statement "I believe that skill practice and ergogenic aids are equally important for improving athletic performance" (M = 2.45, SD = 1.03). This perspective aligns with research suggesting that ergogenic aids, when used appropriately, can complement training by improving endurance, recovery, and muscle function (Peeling et al., 2018). Legal supplements such as protein powders, creatine, and caffeine have been shown to enhance training outcomes when paired with structured skill practice (Maughan, 2013).

However, a notable divergence in perception is evident in the statement "The use of ergogenic aids is a shortcut to achieving success in my sport, rather than relying on skill practice" (M = 2.67, SD = 1.04). This suggests that some athletes may view ergogenic aids as an alternative to intensive training, possibly due to marketing influence or misconceptions about their effectiveness. Research has shown that athletes sometimes overestimate the benefits of supplements while underestimating the necessity of consistent training (Burke, 2017). This could indicate a need for better education on the limitations and ethical concerns of ergogenic aid use in sports performance.

Comparing the Impact of Ergogenic Aids and Skill Practice

The findings from this study indicated that paid athletes in Edo State Sports Commission do not perceive a significant difference in the impact of ergogenic aids and skill practice on athletic performance. The descriptive statistics reveal a relatively balanced perception, with mean scores ranging from 2.10 to 2.38 across the four survey items (Supplementary Table S13 presents the descriptive statistics for research question 5). The ANOVA results ($F = 1.39$, $p = 0.25$) suggest that there is no statistically significant difference in how athletes rate the importance of ergogenic aids versus skill practice (Table 5), meaning both factors are considered important, but not overwhelmingly superior to one another. The relatively low mean score for the statement that "ergogenic aids have a greater impact than skill practice" (M = 2.38, SD = 0.94) suggests that many athletes do not believe performance-enhancing substances alone can replace skill development. This aligns with previous research emphasizing that skill acquisition, technical training, and practice consistency are key determinants of long-term athletic success (Ericsson, Krampe, & Tesch-Römer, 1993). While ergogenic aids can enhance physiological capacity, they cannot substitute for the neuromuscular adaptations that come from deliberate practice (Baker & Young, 2014). The highest level of agreement in the descriptive results was for the statement "skill practice is more important than using ergogenic aids for achieving success in my sport" (M = 2.10, SD = 0.97). This suggests that athletes generally prioritize training and skill refinement over supplementation. Studies in sports psychology support this perspective, showing that technical mastery, tactical awareness, and psychological resilience developed through practice are more reliable predictors of success than ergogenic aids (Williams & Ford, 2008). Interestingly, the mean score for the statement "both ergogenic aids and skill practice are equally important" (M = 2.21, SD = 1.00) suggests a balanced view among some athletes, recognizing that supplementation may complement training rather than replace it. Some studies have shown that ergogenic aids, when used appropriately, can enhance the benefits of training by improving recovery, increasing endurance, and reducing fatigue (Maughan, 2013).

This supports the idea that a combined approach—proper training supplemented with legal and safe ergogenic aids—may provide the best performance outcomes. The final statement, "the impact of ergogenic aids on athletic performance is dependent on the individual athlete's needs and goals" (M = 2.20, SD = 1.03), highlights the context-dependent nature of supplement use. Some athletes may benefit more from nutritional supplements, creatine, or caffeine, while others may see minimal performance improvements (Peeling et al., 2018). This variability may explain why there was no significant difference in the overall ANOVA results, as different athletes may have unique training needs, physiological responses, and perspectives on ergogenic aids versus skill practice. The lack of statistical significance in the ANOVA results suggests that there is no dominant factor—skill practice and ergogenic aids are perceived as complementary rather than mutually exclusive. This supports previous findings that training adaptations are the primary drivers of performance, but legal supplements may provide additional benefits when used correctly (Burke, 2017).

Conclusion

The study concludes that paid athletes in the Edo State Sports Commission generally recognize the role of both ergogenic aids and skill practice in athletic performance. However, their perceptions remain largely uniform, with no significant differences across various aspects of training and competition. While athletes acknowledge the benefits of ergogenic aids, their views on specific substances vary, with creatine being the most favored and protein powders and energy drinks receiving mixed opinions. Additionally, concerns over health risks exist, but athletes do not significantly differentiate between specific risks such as cardiovascular issues, dependence, or side effects. The findings suggest that while skill practice remains the primary factor in achieving long-term athletic success, some athletes view supplementation as a valuable support tool. However, the statistically significant difference in direct comparisons between skill practice and ergogenic aids indicates that opinions on the best approach to performance enhancement are divided. This highlights the need for personalized training strategies that consider individual athlete preferences, sport-specific demands, and scientific evidence on supplementation efficacy. The study also underscores the importance of structured education on ergogenic aids to prevent misconceptions, over reliance, and potential health risks associated with their misuse.

Supplementary File

The Supplementary File for this article can be found online

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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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Use Times New Roman font, size eleven (11) point.

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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Review papers should provide concise in-depth reviews of both established and new areas, based on a critical examination of the literature, analyzing the various approaches to a specific topic in all aspects of anthropology of sport and physical education from five major fields of anthropology: cultural, global, biological, linguistic and medical.

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- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

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JASPE 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 JASPE. 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 **jaspe@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

JASPE 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:

Analysis of Dietary Intake and Body Composition of Female Athletes over a Competitive Season

Original Scientific Paper

Diet and Body Composition of Female Athletes

Svetlana Nepocatych[1], Gytis Balilionis[1], Eric K. O'Neal[2]

[1]Elon University, Department of Exercise Science1, Elon, NC 27215
[2]University of North Alabama, Department of Health, Physical Education and Recreation, Florence, AL 35632

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2525 CB

Elon, NC 27244

United States

E-mail: snepocatych@elon.edu

Word count: 2,946

Word count: 4259

Abstract word count: 211

Number of Tables: 3

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), and Title, Author's Affiliations, Abstract and Key words must be in English (for both each chosen language of full paper). 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

JASPE 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

JASPE 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. JASPE 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 JASPE.

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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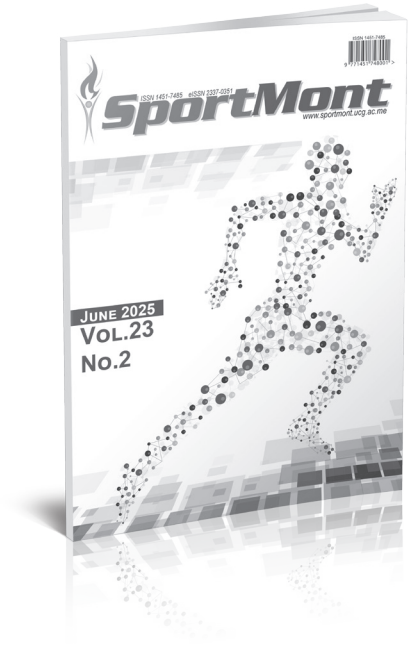

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SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields 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.

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Montenegrin Journal of Sports Science and Medicine

MONTENEGRIN JOURNAL OF SPORTS SCIENCE AND MEDICINE

ISSN 1800-8755

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- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

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Dusko BJELICA, Editor-in Chief – sportmont@t-com.me
Damir SEKULIC, Editor-in Chief – damirsekulic.mjssm@gmail.com

Publication date: Autumn issue – September 2025
Spring issue – March 2026

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 22th Annual Scientific Conference of Montenegrin Sports Academy “Sport, Physical Activity and Health: Contemporary Perspectives” to be held in Dubrovnik, Croatia, from 3 to 6 April, 2025. 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.

USEFUL CONTACTS

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from Montenegrin Sports Academy

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Look Inside!

Sport Mont Journal

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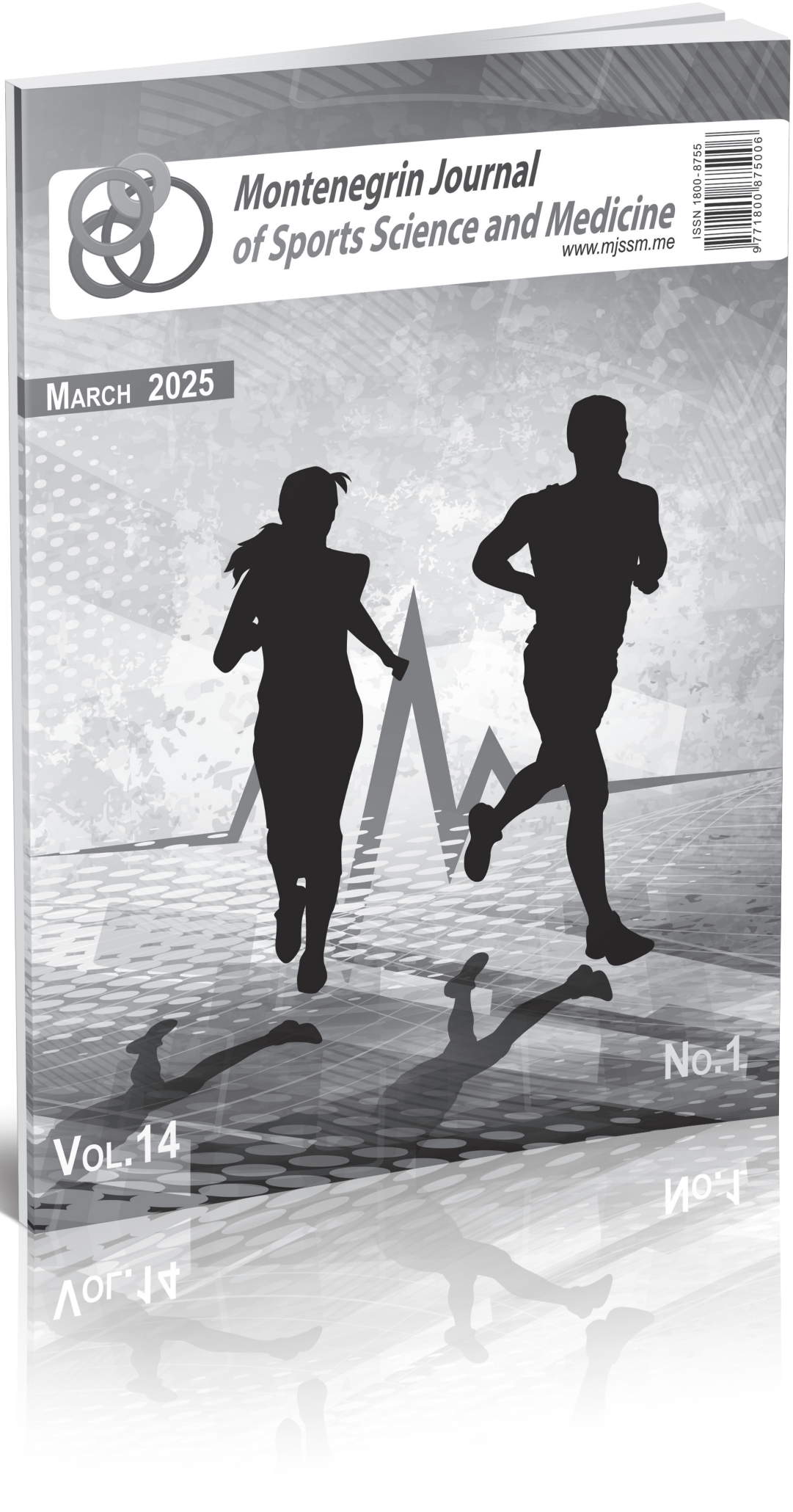
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