Tematske oblasti/Themes:

- Predškolsko vaspitanje u funkciji razvoja djece
- Savremeno školsko fizičko vaspitanje u funkciji pravilnog rasta i razvoja djece i omladine
- Savremeno fizičko vaspitanje i zdravlje mladih
- Studentski sport kao faktor zdravog življenja
- Sport u funkciji rekreacije građana- stanovništva i zdravlja
- Sportsko- rekreativne aktivnosti kao faktor borbe protiv stresa
- Primjena sportsko-rekreativnih aktivnosti u promjeni načina života ljudi
- Moderne sportsko-rekreativne aktivnosti (fitnes, ekstremni sportovi i dr.) I zdravlje vježbača
- Korektivna gimnastika i kineziterapija u otklanjanju posturalnih poremećaja
- Sport osoba sa posebnim potrebama u funkciji osposobljavanja za život i rad
- Sport invalida kao faktor zdravlja i resocijalizacije
- Vrhunski sport i zdravlje
- Ostale aktuelne teme vezane za sportske nauke i zdravlje

- Preschool education in the function of child development
- Modern school physical education in the function of proper growth and development of children and youth
- Modern physical education and youth health
- University sports as a factor of healthy living
- Sport in the function of recreation and health of citizens
- Sports and recreational activities as anti-stress factor
- Use of sports and recreational activities in the change of people's lifestyle
- Modern sports and recreational activities (fitness, extreme sports, etc.) and health of exercisers
- Corrective exercises and kinetic therapy in the elimination of postural disorders
- Sport for people with special needs as a function of training for life and work
- Disabled sports as a factor of health and social reintegration
- Top sport and health
- Other current topics related to sports science and health

SPORTSKE NAUKE I ZDRAVLJE
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Sadržaj / Contents

Dragi čitaoci,

u našem junskom izdanju Časopisa možete naći velik broj zanimljivih radova, Uredništvo je u ovaj broj uvrstilo 12 radova, autora iz Tajlanda, Indonezije, Belgije, Japana, Ukrajine, Hrvatske i Bosne i Hercegovine.

U ovom broju ćete pročitati članke o treningu i oporavku sprintera, dugoročni uticaj na zgloba brahiali na vježbe sa otporom malog intenziteta, uticaj benč pres treninga na sposobnost bacanja koplja budućih sportista, uticaj indonežanske sportske masaže na znanja i vještine sportskih terapeuta, strukuru fudbala na osnovu indikatora situacione efikasnosti svjetskih prvenstava 2010, 2014, 2018 godine, doprinos statusa uhranjenosti u objašnjenju eksplozivne i repetativne snage kod djece osnovnoškolskog uzrasta, percepcija tumačenja i ranog prepoznavanja i podrške sportskih nadarenih učenika, uticaj složenog rehabilitacionog procesa na kvalitet života bolesnika s multiplom sklerozom, poboljšanje sposobnosti učenika za donošenje odluka i bolju komunikaciju korištenjem hibridnih nelinearnih pedagoških modela, uticaj tjelesne aktivnosti na promjene u mitohondrijskom pulu mišićnih vlakana, kombinaciju terapijske masaže i terapijske vježbe za ubrzanje oporavka poslije sportske povrede, analizu odbojkaškog servisa iz skoka i bez skoka u hrvatskoj muškoj odbojkaškoj superligi, studiju koja istražuje bavljenje sportom, doživljeni stres i njegovu povezanost sa zadovoljstvomizmeđu studenata univerziteta.

Zahvaljujemo svim prije svega autorima, recenzentima i članovima uredništva na uloženom trudu kako bi naš Časopis rastao i bio što kvalitetniji svakim novim brojem. Nadamo se da će i ovaj junski broj ispuniti očekivanja šire čitalačke populacije.

UREDNIŠTVO ČASOPISA

Dear readers,

in our June edition of the Journal you can find a large number of interesting works, the Editorial Board has included 12 works in this issue, by authors from Thailand, Indonesia, Belgium, Japan, Ukraine, Croatia and Bosnia and Herzegovina.

In this issue, you will read articles about the training and recovery of sprinters, the long-term effect on the brachial joints of low-intensity resistance exercises, the effect of bench press training on the javelin throwing ability of future athletes, the effect of Indonesian sports massage on the knowledge and skills of sports therapists, the structure of football based on indicators of the situational efficiency of the world championships 2010, 2014, 2018, the contribution of nutritional status in the explanation of explosive and repetitive strength in children of elementary school age, the perception of interpretation and early recognition and support of gifted sports students, the impact of a complex rehabilitation process on the quality of life of patients with multiple sclerosis, improvement students' ability to make decisions and better communication using hybrid non-linear pedagogical models, the influence of physical activity on changes in the mitochondrial pool of muscle fibers, a combination of therapeutic massage and therapeutic exercises to accelerate recovery after a sports injury, analysis of volleyball serves from a jump and without a jump in Croatian men's volleyball superliga, a study that investigates playing sports, experienced stress and its connection with satisfaction among university students.

First of all, we would like to thank all the authors, reviewers and members of the editorial board for their efforts in order for our Journal to grow and be of better quality with each new issue. We hope that this June issue will also meet the expectations of the wider readership.

EDITORIAL BOARD OF THE JOURNAL

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A CROSS-SECTIONAL STUDY EXPLORING SPORT PARTICIPATION, PERCEIVED STRESS, AND ITS ASSOCIATION WITH LIFE SATISFACTION AMONG UNIVERSITY STUDENTS

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A CROSS-SECTIONAL STUDY EXPLORING SPORT PARTICIPATION, PERCEIVED STRESS, AND ITS ASSOCIATION WITH LIFE SATISFACTION AMONG UNIVERSITY STUDENTS

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Abstract: *Physical activity in type of sport participation is well-known for its enormous benefit for mental health, affecting in better mood and improved quality of life. However, knowledge of how sport participation is associated with psychological status and life satisfaction during adolescence is insufficient. This study aims to explore sport participation in a university-based sample of youths, and to analyze how it correlated with mental health and life satisfaction. A total of 495 university students were recruited. The instruments included demographic characteristics questionnaire and previously validated measures such as Sport Participation (SLIM-18), Perceived Stress Scale (PSS-10), as well as The Satisfaction with Life Scale (SWLS) questionnaires. The research results observed that students' sports participation and perception of stress were fall into the moderate category with percentage of 77.2% and 70.3, respectively. While life satisfaction was fall into neutral category (70.7%). The differences in sports participation and stress were significantly different (p<0.05) between genders, but not with life satisfaction (p>0.05). Sports participation was negatively correlated with perceived stress (p<0.05), but positively related to life satisfaction (p<0.01), while perceived stress was negatively associated with life satisfaction (p<0.01). Sports participation plays a crucial role in reducing mental health problems and improving psychological well-being of students during their university time. It also positively promotes higher life satisfaction and better physical as well as mental health.*

Keywords: *life satisfaction, mental health, physical activity, sport participation, stress, student*

INTRODUCTION

The association between physical and mental health has been observed and studied since thousand years ago, yielding "*men sana in corpore sano*", the Latin phrase which means a healthy mind in a healthy body (Fossati et al., 2021). The scientific researches provide several evidences of concept regarding this hypothesis, with many literatures analysing the role of physical activity on mental health as well as the role of mental health on physical performance (Aparicio et al., 2019; Fossati et al., 2020). The improvement of physical performance requires certain strategies to address the influence of lifestyle on psychological state (Alam & Rufo, 2019), especially for specific population such as adolescents and young adults. The transitional phase from adolescence into early adulthood reflects an important period that might have a distinct impact on the adaptation and adoption of health behaviours, resulting in healthy body and healthy state of mind (Jaworska & MacQueen, 2015; Vankim & Nelson, 2013). Therefore, the one of the efforts to prevent mental disturbances during this critical period is through promoting competitive and recreational sport participation (Fossati et al., 2021).

There is a clear difference between physical activity or exercise and sport participation (Fossati et al., 2021). In some studies assessing mental health in youth population, physical activity (PA) was described as participation in any competitive or recreational exercise/sport (Pfisterer et al., 2022). Meanwhile, sport participation was defined as purposely active in participating in sport-related physical activity during leisure-time (Deelen et al., 2018). The World Health Organization has highlighted the importance of sport participation to the health and development of adolescents (Cairney & Veldhuizen, 2017). Regular participation in sport activity offers many health benefits such as reduces body fat, improves bone health and physical fitness, and increases other favourable cardiovascular profiles (Eime et al., 2013; Ridwan et al., 2022). With that many positive impacts on health, yet previous cross sectional studies showed a large decrease in PA level and sport participation, especially in adolescents, young adults, and above 65 years old (Zimmermann-Sloutskis et al., 2010).

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The decrease level of sport participation in adolescents is special concern as study found that youths are likely to be more physically inactive as their age increase (Guddal et al., 2019). Adolescent is a critical period due to healthy habit and behaviours including engaging in any kind of regular physical activity, exercise, or sport are often developed during this time, paving the way for long-term health in later life (Guddal et al., 2019; Wilson et al., 2021). According to Indonesian Central Bureau of Statistic (2021), there was approximately 8.96 million or 13.6% youths (age 18–24 years) in Indonesia attended college in 2021, reflecting an important mass of the young adult population (Hallal et al., 2012). With this big number, maintaining body to be physically active during the transitional period from adolescents into adulthood becomes major public health challenge (Bélanger et al., 2015).

Mental health problem such as stress and anxiety are other important challenges among adolescents (Herdyanto et al., 2020). In addition to decreased motivation to participate in sport, the transformation phase to university or college can be socially and academically frustating for students (Worsley et al., 2021). In previous research assessing mental health among university students, around 60% of subjects experienced high or very high stress (McMahon et al., 2017). Data generated in a last decade from the Behavioural Risk Factor Surveillance System reported that students ages 18–24 show the greatest prevalence of depressive symptoms compared to other populations (Kieling et al., 2011). The same high number was also seen in Indonesian youth, where depression prevalence in the 15-24 year-old population according to National Institute of Health Research and Development (2019) was 6.2%.

The aforementioned mental health disorders also tend to carry over into adulthood with all of its impact that will be acquired in later life, representing the urgency of preventive effort during adolescent period (Bertha & Balázs, 2013). Thus, we conduct this study to analyse sport participation among university students in Indonesia, and to explore associations between sport participation, perceived stress, and life satisfaction among students, especially freshmen across major.

METHOD

Study design and participants

This research was quantitative descriptive study using a cross-sectional design. The participants were undergraduate students majored in sport and non-sport courses in universities located in East Java. The participants enrolled in this study were recruited only if they met following criteria: (1) above 18 years old; (2) registered as active students in one of the faculties at the time of data collection in any academic level (first to fourth year); (3) consent to participate in this study. Ultimately, a total of 511 respondents met the inclusion criteria. After excluding those who failed to complete the entire questionnaire or gave invalid responses, the final participants were 495 students in total, consisting of 254 males dan 241 females. This research was approved by the ethics committee of X University in Surabaya, Indonesia, number 206/EA/KEPK/2023.

Data collection

The questionnaire consisting of self-administrated demographic questions (e.g. age, gender, height, bodyweight, body mass index) followed by a set of instruments to assess sport participation, perceived stress (PS), life satisfaction (LS). Before taking part in the study, all students were provided a written informed consent which appeared at the first page of the questionnaire to inform the participants the terms and conditions of the study as well as the ethical permission. The participants were permitted to complete the questionnaires only after they signed it. Data were collected in August to September 2023. Response was removed or partially excluded if it met the following reasons: 1) invalid or abnormal responses; 2) abstinent.

Sport participation

Data on sports participation among students was obtained through the Baecke (1982) questionnaire. Baecke (1982) divides physical activity into physical activity during work, sports, and free time. However, the data in this study only used data about sports activities carried out, including activities that cause sweating. We determined sports participation through sports index scores obtained from the Baecke questionnaire and categorized them based on mean and standard deviation (SD). Sports participation was classified into high ($x \geq 5.32$), medium ($3.6 \leq x < 5.32$), and low ($x < 3.6$).

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Perceived Stress Scale (PSS-10)

Perceived Stress Scale (PSS-10) is a stress assessment instrument comprised of 10 questions with several options. The Indonesian version of the questionnaire was translated and modified from Klein et al (2016a). Respondents or participants reported the degree to which circumstances in one's life have been uncontrollable, unpredictable, and overloaded during the past month. The degree was listed on a five-point Likert scale (0=never, 1=almost never, 2=sometimes, 3=quite often, 4=very often). Scores for the four positively-stated items (statement 4, 5, 7, 8) were reversed. A final cumulative score on the PSS may range from 0 to 40, which higher scores representing higher perceived stress. The final score of each respondent was then classified into three categories: low stress (0-13); moderate stress (14-26); and high stress (27-40).

The Satisfaction with Life Scale (SWLS)

The Satisfaction with Life Scale (SWLS) is a five-item scale designed to assess a person's general appraisal of life satisfaction. Respondents were asked to give a rating on how much they agreed or disagreed with each of the five items: (a) in many ways my life is close to my ideal; (b) my living conditions are very good; (c) I am content with my life; (d) I have obtained the significant things I want in life so far; and (e) if I could live my life, I would change almost nothing. Each item was rated using a seven-point scale ranging from the highest (7—strongly agree) to the lowest (1—strongly disagree). Higher scores represent greater satisfaction in life. The final score was then accumulated and classified into three categories: dissatisfied (SWLS score 5-19); neutral (SWLS score 20-25); satisfied (SWLS 26-35). SWLS has quite satisfactory reliability (α= 0.84) and inter-item correlation (r>0.60) (Galanakis, 2017).

Data analysis

Socio-demographic factors, sports participation, perceived stress, and life satisfaction score were presented using descriptive statistic (mean ± SD, frequency, and percentage). In addition to descriptive statistic, follow up analysis like independent t-test was performed to analyze significant difference between gender. Furthermore, Pearson correlation and linear regression were performed to evaluate the association between sports participation, stress, and life satisfaction. P-values < 0.05 were considered statistically significant.

RESULTS

Data in present study was collected by completing a set of questionnaires on sports participation by calculating the sports index value, the Perceived Stress Scale (PSS-10) questionnaire to determine stress perceptions and the Satisfaction with Life Scale (SWLS) questionnaire to determine measures a person's global cognitive assessment of life satisfaction.

Table 1. *Descriptive statistic of university students*

Variable	All	Male	Female	Sig.
Age	18.31 ± 0.67	18.38 ± 0.73	18.24 ± 0.59	0.030*
Bodyweight (kg)	57.79 ± 13.98	63.12 ± 15.35	52.18 ± 9.61	0.000*
Height (cm)	162.91 ± 10.94	167.79 ± 12.41	157.77 ± 5.68	0.000*
Body mass index (kg/m²)	22.77 ± 22.37	24.49 ± 30.96	20.95 ± 3.57	0.006*
Sport participation	4.46 ± 0.86	4.71 ± 0.9	4.19 ± 0.65	0.000*
Perceived stress	17.48 ± 5.97	16.55 ± 5.87	18.47 ± 5.92	0.000*
Life satisfaction	22.99 ± 5.37	23.08 ± 5.64	22.91 ± 5.08	0.244

All data were presented in mean and standard deviation (mean ± SD)
* significantly different between male and female (p ≤ 0.05)

Table 1 showed that the average age (18.38 ± 0.73), bodyweight (63.12 ± 15.35), height (167.79 ± 12.41), and body mass index (24.49 ± 30.96) in male students were higher compared to females and both genders. The average score of sports participation and perceived stress between male and female students were significantly different (p=0.000), but the same result was not found in life satisfaction between males and females (p=0.244).

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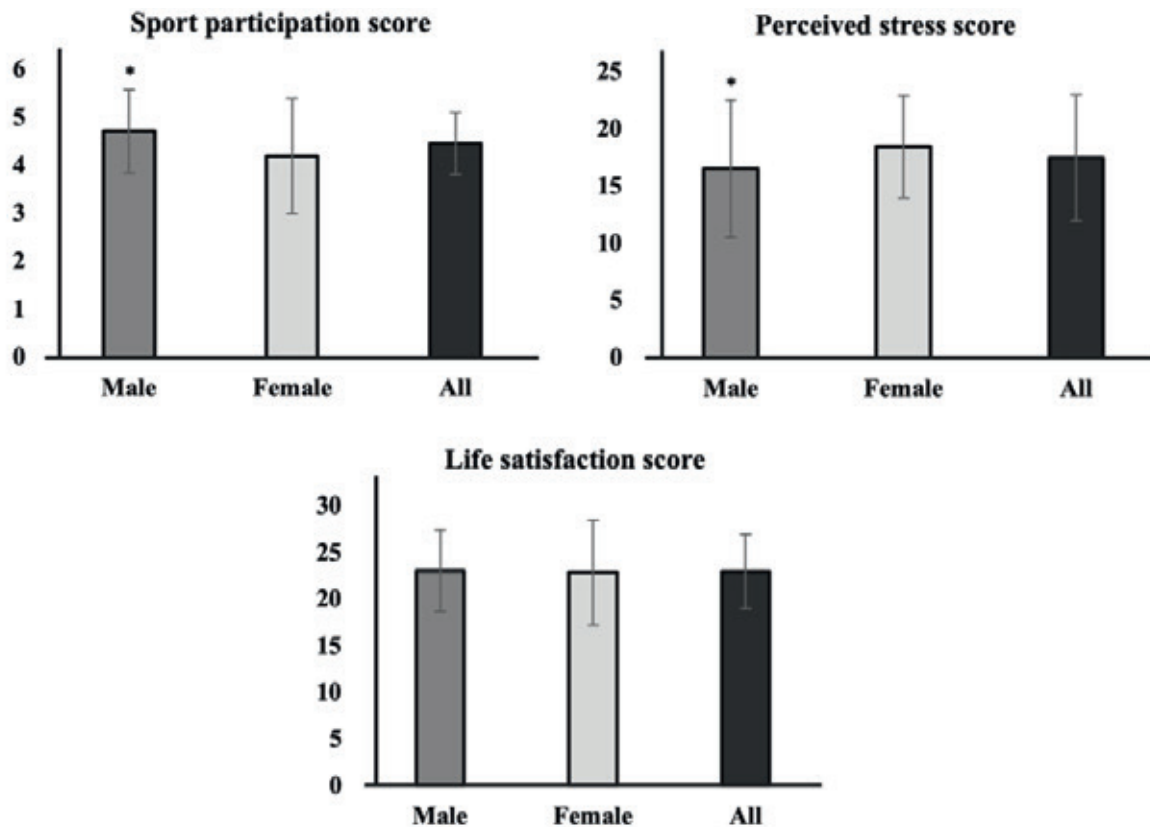
Figure 1. The comparation analysis of the mean score of sports participation, perceived stress, and life satisfaction between genders. Description: (*) significantly different with female groups (p ≤ 0.05). Data were presented in mean ± SD.

From Table 2, it could be seen that majority of students had moderate level of sports participation (77.2%). Most of them also had moderate level of stress (70.3%) and their life satisfaction level fell into neutral category (70.7%).

Table 2. The classification of sports participation, perceived stress, and life satisfaction (N=495)

Variable	Category	Frequency (n)	Percentage (%)
Sports participation	Low	46	9.3
	Moderate	382	77.2
	High	67	13.5
Perceived stress	Low	119	24.0
	Moderate	348	70.3
	High	28	5.7
Life satisfaction	Dissatisfied	71	14.3
	Neutral	350	70.7
	Satisfied	74	14.9

In the correlation test, it can be seen that perceived stress is negatively associated with sports participation (p=0.025, r=-0.101) and life satisfaction (p=0.000, r=-0.283), although the correlations are weak. The negative correlation between those variables means the higher perceived stress, the less students' participation in sports and the less they feel satisfied with their life. On the other hand, Pearson correlation test also reveals that sports participation is positively correlated with life satisfaction (p=0.003), which means that the higher sports participation, the more life satisfaction score will increase (Figure 2).

The regression coefficient value for the sports participation variable has a positive value of 0.655. This shows that if sports participation increases by 1%, then life satisfaction will increase by 0.655, assuming other variables are

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held constant. Meanwhile, the stress perception variable has a negative relationship with life satisfaction, which is, if perceived stress score increases by 1%, then life satisfaction will decrease by 0.245 (Table 3).
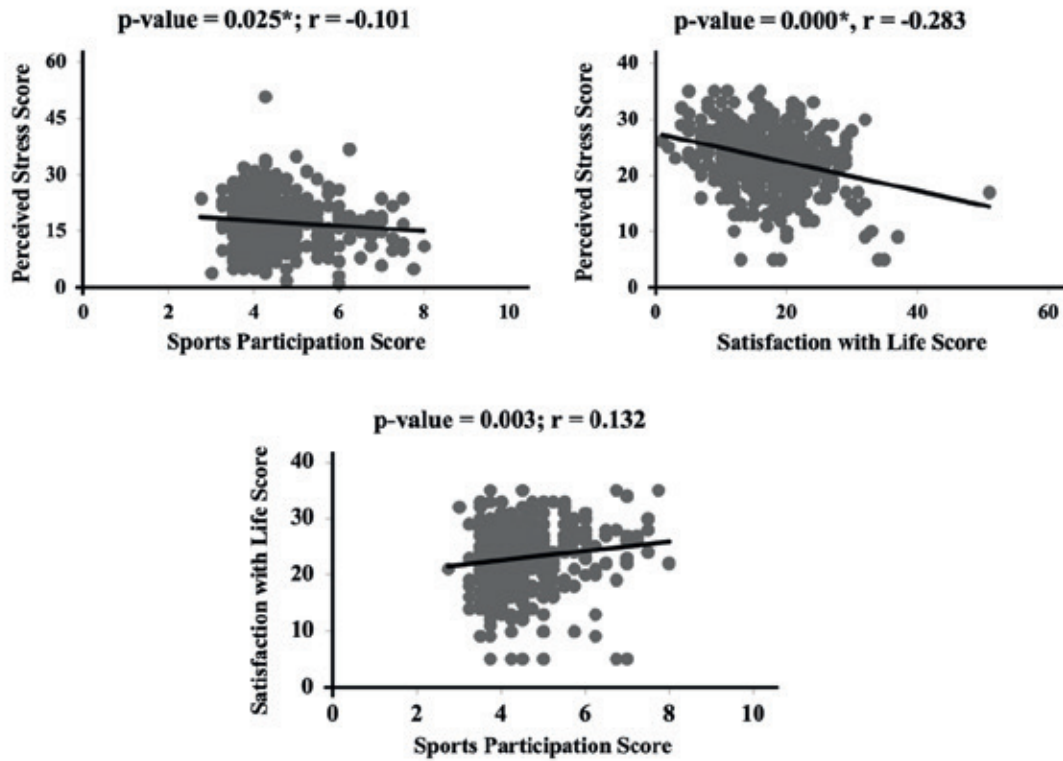
Figure 2. *Correlation between measured variables.*

Description: (*) significantly different with female groups (p ≤ 0.05)

Table 3. *Linier regression of sports participation, perceived stress, and life satisfaction*

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	24.362	1.460		16.688	.000
1	Sports participation	.655	.270	.105	2.427	.016
	Perceived stress	-.245	.039	-.273	-6.313	.000

a. Dependent Variable: Life satisfaction

DISCUSSION

In this cross-sectional study, we observed that the highest percentages of sports participation, perceived stress (PS), and life satisfaction (LS) among university students fell in the medium category. Based on the result of comparation test, there was a significant difference ($p<0.05$) in sports participation and perceived stress between male and female students, while life satisfaction did not show significant different ($p>0.05$). The difference in sports participation between male and female is in line with research conducted by Wang & Boros (2019) that gender differences in physical exercise were very significant, as male participated more in sports than women. This gender difference might also be due to differences in motivation for physical activity (Kilpatrick et al., 2005).

The perception of stress in male and female students is significantly different, this is in accordance with findings reported in the literature, that female generally have higher stress scores and emotional intensity than male (di Fronso et al., 2020). These results are also in line with other research which shows that women have more stressful lives than men

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(Costa et al., 2021). A large population-based study in Europe also found higher mean of perceived stress scores (PSS) in female compared to male (Klein et al., 2016b). Women are likely to be more frustrated and more susceptible to common psychological problems such as depression, stress, and anxiety compared to men (Sandanger et al., 2004). Some people also think that the problems that women often face more compared to men are doubtful-minded, low self-esteem, and self-blame (Asztalos et al., 2012). This might explain why female students in present study reported higher perceived stress compared to their counterpart.

Life satisfaction defined as building emotional judgments by comparing themselves with what is appropriate, and expected, or reasonably demanded (Sirgy et al., 2010). In the results of this study, the life satisfaction scores of male and female students did not differ significantly, which is in accordance with previous researches conducted by Chan (2005) and Mayungbo (2016) that gender differences did not affect life satisfaction. However, contradictory findings were observed in other studies that men have a lower level of life satisfaction than women (Al-Attiyah & Nasser, 2016; Capri et al., 2012; Tükel & Temel, 2020; Turgut, 2021). The average age of students in this study was around 18 years, it might be explained why life satisfaction between male and female student is similar, as previous study observed that the increasing age will be followed by the increase of life satisfaction (Capri et al., 2012), but life satisfaction can vary at certain stages of human life (Myers & Diener, 1995).

Furthermore, another finding from this research is that sports participation was negatively associated with perceived stress, meaning that the higher the sports participation, the lower the perceived stress. Increased stress for students can occur due to many factors such as pressure to adapting to new environment, poor social skills and time management, and heavy coursework they are taking on (Barbayannis et al., 2022; Reddy et al., 2018). Sports participation plays an important role in reducing mental health problems and improving psychological well-being (Herdyanto et al., 2020). Physical activity and psychological stress and are believed to be interrelated, which resulted in physical inactivity (Stults-Kolehmainen & Sinha, 2014). Likewise, in previous study done by Eather et. al. (2023) showed that sports participation in any form (team or individual) brings positive impacts for enhancing psychological state as well as social outcomes among adults. However, team sports is believed to give more additional benefits on mental and social outcomes for adults in later life.

Meanwhile, sports participation is positively related to life satisfaction, which means that the higher sports participation, the more life satisfaction will increase. Previous study stated a two-way correlation between physical activity and life satisfaction (Steptoe, 2019). Physical activity is an important healthy lifestyle (Wibawa et al., 2020), which can increase life satisfaction, and people with higher life satisfaction may participate in more physical activity (Kim et al., 2017). This is in accordance with previous literature that people with higher levels of physical activity tend to have higher life satisfaction and happiness (An et al., 2020). The findings of present study are also in accordance with earlier study which revealed a positive relationship between life satisfaction and sports activities carried out in their free time, so that people tend to participate more in leisure activities as long as they feel satisfied with their lives (Cho, 2019).

Another negative correlation is also observed between and perceived stress and life satisfaction (p<0.001). Previous research that highlighted the influence of stress in estimating life satisfaction shows that higher stress predicts lower life satisfaction (Extremera et al., 2009). Academic stress faced by students has an impact not only on their performance in school but also on their overall quality of life (DelaCruz et al., 2022). Despite another research shows contrast finding that the level of perceived stress and overall quality of life scores do not have a strong relationship, present study believes that the level of perceived stress is related to the physical health component of quality of life.

CONCLUSION

Sports participation plays a crucial role in reducing psychological problems, improving healthy mind and well-being. For students, it is very important to increase sports participation in order to avoid stress and maintain mental health. Students who actively participate in sports tend feel more satisfied and fulfilled with their lives than those who are not actively engage in sports, as sport plays a significant role in maintaining both mental and physical health, thus it may improve quality of life and well-being.

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ANALYZING VOLLEYBALL SERVE STRATEGIES: COMPARING JUMP AND FLOAT SERVES IN THE CROATIAN MEN'S VOLLEYBALL SUPERLEAGUE

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ANALYZING VOLLEYBALL SERVE STRATEGIES: COMPARING JUMP AND FLOAT SERVES IN THE CROATIAN MEN'S VOLLEYBALL SUPERLEAGUE

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Abstract: *This study examines service quality disparities between jump serves and float serves within the Croatian Men's Volleyball Super League, aiming to reveal variations based on playing positions and serve types. Analyzing 99 matches from the 2022/23 season of the top five ranked clubs, the study categorizes serves into float and jump serves. Statistical analysis unveils significant differences in service quality among playing positions, with setters and middle blockers displaying fewer serve errors compared to outside hitters (p=0.01) and opposites (p=0.00). Middle blockers also tend to position the serve reception over 3 meters away from the net more frequently than opposite players (p=0.04). Furthermore, players executing jump serves encounter a higher frequency of service errors (p=0.00) but achieve more points through serving (p=0.01), while compelling opponents to return the ball more immediately (p=0.01). Thus, the jump serve in the Croatian Men's Volleyball Super League demonstrates superiority in scoring points through serving but also results in a significantly higher loss of points compared to the float serve.*
Keywords: *Jump serve, float serve, Croatian men's Superleague*

INTRODUCTION

In modern volleyball, especially at elite levels, the difference between victory and defeat often hinges on intricate details unearthed through comprehensive sports analysis (Drikos et al., 2021). The efficacy of volleyball game analysis is contingent upon numerous factors, notably the exploration of the relationship between game-related parameters and competitive success (Lames & McGarry, 2007).

Numerous studies have explored the relationship between game-related parameters and the outcome of volleyball matches. Notably, research consistently demonstrates that the quality of the volleyball attack significantly influences the result (Bergeles, Barzouka & Nikolaidou, 2009; Drikos et al., 2019; García-de-Alcaraz & Marcelino, 2017; Laporta, Afonso, & Mesquita, 2018). Additionally, the impact of serve quality (Brajković, Marinović & Macan, 2023; Yiannis & Panagiotis, 2005), volleyball blocking (Palao, Santos & Ureña, 2004), and serve reception quality (Drikos et al., 2019; Lirola & Gonzalez, 2009) on match outcomes has also been widely acknowledged.

The volleyball serve is one of the fundamental segments of modern volleyball (Monge, 2007), and it is defined by a significant number of authors as the initial attack (Davila-Romero, Garcia-Hermoso, & Saavedra, 2012; Drikos et al., 2009; Tsivika & Papadopoulou, 2008). The substantial impact of the serve on the ultimate outcome has been affirmed Drikos et al. (2009). However, it is important to note the differing perspectives within the literature. While some authors underline the significant association between serve quality and match results (Drikos, Ntzoufras & Apostolidis, 2019; Montoro-Escaño & Hernández-Mendo, 2014), others have not found such a direct correlation (Drikos et al., 2021; Kountouris et al., 2015).

Three distinct serving techniques can be categorized: the float serve, executed with no spin and both feet on the ground; the float serve with jump, involving no-spin execution while airborne through a vertical jump; and the jump serve, performed with considerable speed and topspin during an elevated vertical jump. The jump serve has gained increasing significance in high-level volleyball while float serve with jump is more commonly employed in female category (Moras et.al., 2008).

Agelonidis (2004) conducted a longitudinal study showing a sharp increase in the prevalence of the jump serve in high-level volleyball tournaments, rising from 20.8% to 99.2%. This rise is attributed to its direct benefits like aces and its effectiveness in disrupting opponents' first attack. Despite its execution risks, the jump serve significantly impedes opponents' first tempo (28.2%) compared to other serve types (49.3%), making it a preferred strategic choice for high-level teams seeking a match advantage.

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In lower-quality leagues, the float serve is favored due to its lower error risk and players' unfamiliarity with jump serves. Analyzing these leagues is crucial, offering insights into areas for improvement and factors enhancing overall quality.

Purpose of the study

The aim of this study is to ascertain the disparities in the quality between jump serves and float serves among the top-ranked teams in the Croatian Men's Volleyball Super League, as well as to determine variations in the service quality based on different player positions.

MATERIALS AND METHODS

Participants

The sample for this research comprised 99 matches played during the season 2022/23 of Croatian men's Superleague. The analysis included matches played by the top 5 ranked clubs. The participants were categorized based on the type of volleyball serve they use and their respective playing positions. The inclusion criteria for players in the study were a minimum of 10 sets played.

Sample of variables

The variables used in this study are detailed in Table 1. To account for varying sets played by clubs, a specific parameter normalized the total serve count based on sets played, enabling fair comparison across clubs. Each club employs an official statistician who meticulously analyzes matches using DataVolley 4, ensuring highly reliable data. Similar studies have adopted this approach, enhancing its credibility (Brajković, Marinović, & Macan, 2023; García-Hermoso, Dávila-Romero & Saavedra, 2013; João et. al., 2010; Marinović & Ambruš, 2020; Marinović et.al., 2023; Millán-Sánchez, 2023).

Table 1. Classification of game-related parameters

Abbreviation	Definition
S=/set	Number of services errors per set
S!/set	Number of services in which reception was further than 3 meters from net per set
S//set	Number of services in which ball returned to server side per set
s-/set	Number of bad services per set
S+/set	Number of good services per set
S#/set	Number of points won by service per set

Statistical analysis

For the purpose of this research, Tibco Statistica Enterprise (version 14.0.0.15) was used. The normality of distribution for all variables was determined using the Kolmogorov-Smirnov test. Descriptive parameters, including the mean (M) and standard deviation (SD) for each serve variable, are presented in Table 2. To assess the differences between service type, the independent sample t test was used. To analyze differences between service quality across different volleyball positions, a one-way ANOVA was utilized. If the one-way ANOVA has indicated the presence of statistically significant differences, the Post hoc Bonferroni test was conducted. The level of statistical significance was set at $p < 0.05$.

Table 2. Descriptive parameters for playing positions

Variable	All (N=49)		Opposite (N=9)		Setter (N=9)		Middle blocker (N=13)		Outside hitter (N=18)	
	M±SD (Min-Max)	max D	M±SD (Min-Max)	max D	M±SD (Min-Max)	max D	M±SD (Min-Max)	max D	M±SD (Min-Max)	max D
S=/set	0.48±0.24 (0.06-0.95)	0.09	0.66±0.17 (0.41-0.87)	0.17	0.34±0.16 (0.17-0.66)	0.16	0.34±0.16 (0.06-0.66)	0.14	0.56±0.26 (0.12-0.95)	0.13
S!/set	0.58±0.24 (0.06-1.35)	0.09	0.45±0.14 (0.24-0.72)	0.18	0.64±0.31 (0.33-1.34)	0.23	0.73±0.18 (0.47-1.00)	0.12	0.52±0.23 (0.00-0.83)	0.17
S//set	0.17±0.04 (0.06-0.45)	0.08	0.20±0.10 (0.03-0.41)	0.24	0.12±0.08 (0.02-0.28)	0.20	0.16±0.06 (0.04-0.22)	0.17	0.18±0.10 (0.00-0.36)	0.11
S-/set	0.66±0.24 (0.16-1.15)	0.10	0.54±0.23 (0.21-0.83)	0.19	0.75±0.18 (0.47-0.99)	0.21	0.78±0.27 (0.30-1.18)	0.10	0.59±0.20 (0.18-0.89)	0.19
S+/set	1.01±0.34 (0.06-1.65)	0.12	0.87±0.27 (0.51-1.30)	0.20	1.05±0.33 (0.46-1.48)	0.18	1.22±0.30 (0.76-1.68)	0.21	0.93±0.44 (0.00-1.49)	0.18
S#/set	0.19±0.14 (0.06-0.55)	0.11	0.24±0.13 (0.11-0.47)	0.21	0.15±0.07 (0.04-0.25)	0.23	0.16±0.07 (0.03-0.26)	0.17	0.23±0.14 (0.06-0.52)	0.16

Legend: M – arithmetic mean; SD – standard deviation; Min – minimal value; Max – maximal value; max D – result of Kolmogorov-Smirnov test

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RESULTS

Descriptive parameters and max D values from Kolmogorov-Smirnov test are presented in table 1.

To test homogeneity of variances, Levene's test was utilized. Heterogeneity was observed only in S#/set variable (p=0,01), for which the Welch correction was applied. The outcomes of the one-way ANOVA (figure 1) demonstrated statistically significant distinctions in serve quality based on the playing position ($F_{(18, 113,62)} = 1,86$, p <0,05). Post hoc Bonferroni tests were subsequently conducted to determine specific pairwise differences across different playing positions.
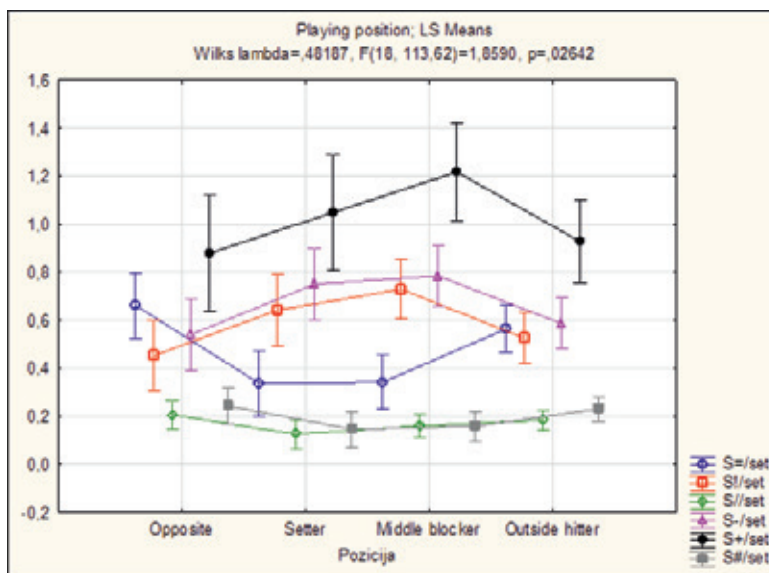
Figure 1. *Differences between service quality across playing positions*

The findings demonstrate statistically significant variations in S=/set between playing positions: Opposite and Setter (p=0.01), Opposite and Middle blocker (p=0.00), and Outside hitter and Middle blocker (p=0.03). In comparison to Opposite and Outside hitters, Setters and Middle blockers displayed fewer serve errors. In S!/set variable, there was statistically significant differences between Opposite and Middle blocker (p=0,04), indicating that Middle blockers tend to serve more frequently in a manner that results in the serve reception being positioned over 3 meters away from the net. No other statistically significant differences were found between playing positions in the remaining variables.

Table 3. *Descriptive parameters and differences between serve type.*

Variable	Float serve (N=24)	Jump serve (N=24)	
	M±SD (Min-Max)	M±SD (Min-Max)	p
S=/set	0.34±0.17 (0.06-0.71)	0.61±0.23 (0.17-0.95)	0.00
S!/set	0.64±0.28 (0.00-1.34)	0.53±0.18 (0.10-0.83)	0.11[#]
S//set	0.14±0.07 (0.00-0.30)	0.21±0.10 (0.02-0.41)	0.01
S-/set	0.69±0.28 (0.18-1.18)	0.62±0.20 (0.22-0.96)	0.34
S+/set	1.08±0.39 (0.41-1.68)	0.95±0.37 (0.00-1.49)	0.26
S#/set	0.15±0.08 (0.03-0.30)	0.24±0.13 (0.06-0.52)	0.01[#]

Legend: *M – arithmetic mean; SD – standard deviation; Min – minimal value; Max – maximal value; p – independent t test, significant at p<0,05;* [#]*-heterogeneit variance, 2-sided p was used*

Players who executed jump serves exhibited a statistically significant higher number of service errors in comparison to those who employed float serves (p=0.00). However, players who utilized jump serves achieved more points through serving (p=0,01) and more frequently compelled opponent receivers to immediately return the ball (p=0,01).

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DISCUSSION

The primary goal of this study was to identify differences in serve quality among playing positions and various types of volleyball serves. The findings emphasize that, even in lower-quality leagues, the volleyball jump serve is advantageous in terms of scoring more points and disrupting the opponent's initial attack organization. However, this technique is also linked to a higher error frequency during execution. These results are consistent with Agelonidis (2004), who similarly highlighted the superior effectiveness of jump serves.

Yiannis & Panagiotis (2005) further highlight that an increase in service effectiveness corresponds to a rise in reception faults. Moras et al. (2008) analyzed 377 serves, revealing a dominant prevalence of jump serves (84.9%). However, the relationship between serve speed and effectiveness did not show substantial correlations. Notably, the jump serve exhibits a relatively higher failure rate, with approximately 1 in 5 jump serves resulting in net or out-of-play situations, compared to an approximately 1 in 12 ratio for alternative serve styles (Katsikadelli, 1997; Agelonidis, 2004).

Despite the elevated risk associated with the jump serve, elite teams are inclined to adopt this high-risk strategy (Marcelino, Mesquita & Afonso, 2008; Moras et al., 2008), primarily due to its lower likelihood of being returned for a first tempo attack compared to other serve types (Agelonidis, 2004). Ciuffarella et al. (2016) analyzed 4552 serves in the 2008-2009 Italian male Top League, identifying the Jump Serve as the most prevalent (69.9%). While introducing heightened defensive challenges and an increased occurrence of errors, the Float Jump Serve and Float Serve are strategically employed to target specific court zones and facilitate defensive preparations.

Understanding player capabilities is crucial due to the distinct advantages and drawbacks of both jump and float serves. Volleyball positions entail differing responsibilities, with specialized roles leading to mastery of specific game components. Outside hitters and opposites engage in attacks more frequently than setters, while the structural aspects of middle blocker attacks align more closely with the jump serve, potentially explaining the preference for float serves among middle blockers and setters.

Compared to high-level volleyball teams, the top five ranked teams in Croatia's men's Superleague show lower use of jump serves. This may stem from delayed entry of male players into Croatian clubs, limiting skill development time. The jump serve, effective with significant power, involves substantial risk-taking leading to potential game losses, prompting players to avoid its use.

In order to enhance the overall quality of the Croatian men's Superleague, it becomes essential to permit players to make errors and accept occasional game sacrifices to foster their development. Given the paramount importance of results in senior categories, emphasis on these aspects should undoubtedly be prioritized in younger age groups. Enabling younger athletes to experiment with and practice more complex elements, free from the pressure of immediate results, will lead to senior players who possess a broader range of mastered skills, which is imperative for competing at the highest echelons. While this paper centers on volleyball serving, the underlying principle can readily be applied to all other aspects of the game.

It is important to acknowledge some limitations of the study. Firstly, the analysis focused solely on the Croatian men's Superleague, which may limit the generalizability of the findings to other leagues or genders. Secondly, the study only examined service quality of five best ranked teams and did not consider others. Future research could expand on these limitations by including a broader range of teams and considering additional variables.

CONCLUSION

While players executing jump serves showed a higher incidence of errors, they also achieved more points and effectively pressured opponents into immediate returns, suggesting the strategic value of jump serving despite its associated risks.

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COMBINATION OF MASSAGE THERAPY AND THERAPY EXERCISE TO ACCELERATE POST-SPORTS INJURY RECOVERY

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Abstract: *This study aims to evaluate the effect of a combination of sports injury massage therapy and exercise therapy on the recovery of wrist and elbow injuries in athletes. This research uses an experimental design with the Randomized Controlled Trial (RCT) method. Participants in this research were students who were members of various sports Student Activity Units. Data collection instruments include a Visual Analog Scale (VAS) to measure pain levels, as well as a Goniometer to measure Range of Motion (ROM) at the wrist and elbow. The data analysis technique was carried out using the independent t-test. The results of data analysis show that combining sports injury massage therapy and exercise therapy has a more positive impact in reducing pain in wrist and elbow injuries compared to just carrying out sports injury massage therapy. The conclusion of this study is that massage therapy for sports injuries is better than exercise therapy where the reduction in massage therapy can reduce pain significantly. However, actually combining the two therapies has a more positive effect on injury recovery than just doing one form of therapy.*
Keywords: *Massage Therapy, Exercise Therapy, Elbow Injuries, Wrist Injuries*

INTRODUCTION

Injuries to the wrist and elbow can range from minor injuries such as muscle strains and swelling to more serious injuries such as broken bones or ligament injuries (Kovářová et al., 2024). Effective recovery from this injury is essential so that athletes can return to optimal sport and prevent re-injury in the future (Naderi et al., 2024). In an effort to speed up the recovery process for wrist and elbow injuries in athletes, there are two types of therapy that are commonly used, namely massage therapy and exercise therapy.

In cases of wrist and elbow injuries, massage therapy can help reduce inflammation and increase flexibility in the injured area (Kuna et al., 2023). So it can be interpreted that massage techniques can also help reduce the formation of scar tissue which can hinder injury recovery (Ashraf et al., 2024). Exercise therapy aims to strengthen the muscles around the wrist and elbow to help support and protect the injured area. A proper exercise program can help restore strength, agility and stability to the wrist and elbow, which are important factors in the recovery process. .

Previous research conducted (Ashraf et al., 2024; Hernández et al., 2024) have shown the benefits of massage therapy and exercise therapy in the recovery of sports injuries in general, but there have not been many studies that specifically examine the effect of both simultaneously on the recovery of wrist and elbow injuries in athletes. Therefore, further research is needed to evaluate the effectiveness of these two therapies together in cases of wrist and elbow injuries.

By understanding the positive impact of massage therapy and exercise therapy on the recovery of wrist and elbow injuries, it is hoped that athletes can recover more quickly from their injuries and return to participating in sports activities with optimal performance (Hernández-Sánchez et al., 2024; Yachsie et al., 2023). In addition, the results of this study can also provide guidance to health professionals and sports coaches in designing effective rehabilitation programs for athletes who experience wrist and elbow injuries.

METHOD

This research is included in the category of experimental research using a Randomized Controlled Trial (RCT) or Randomized Controlled Clinical Trial with Parallel Groups. In this study, the population in this study were students who were members of the Badminton, Table Tennis, Hockey and Gateball Student Activity Units which were determined using purposive sampling. Then they were divided into two different groups, namely the experimental group and the control group which were determined using ordinal pairing and then given treatment.

Table 1. Massage Therapy

No	Wrist	Management	Elbow	Management
1		Frequency: 3x a week Intensity: Medium Time: 30 Seconds Type: Friction		Frequency: 3x a week Intensity: Medium Time: 30 Seconds Type: Friction
2				
3				
4				

Table 2. Exercise Therapy

Exercise Therapy Program	
	Frequency: 3x a week Intensity: 10-30% 1RM Sets: 3-4x Reps: 1-12 Recovery: 30 Seconds Cadence: Medium
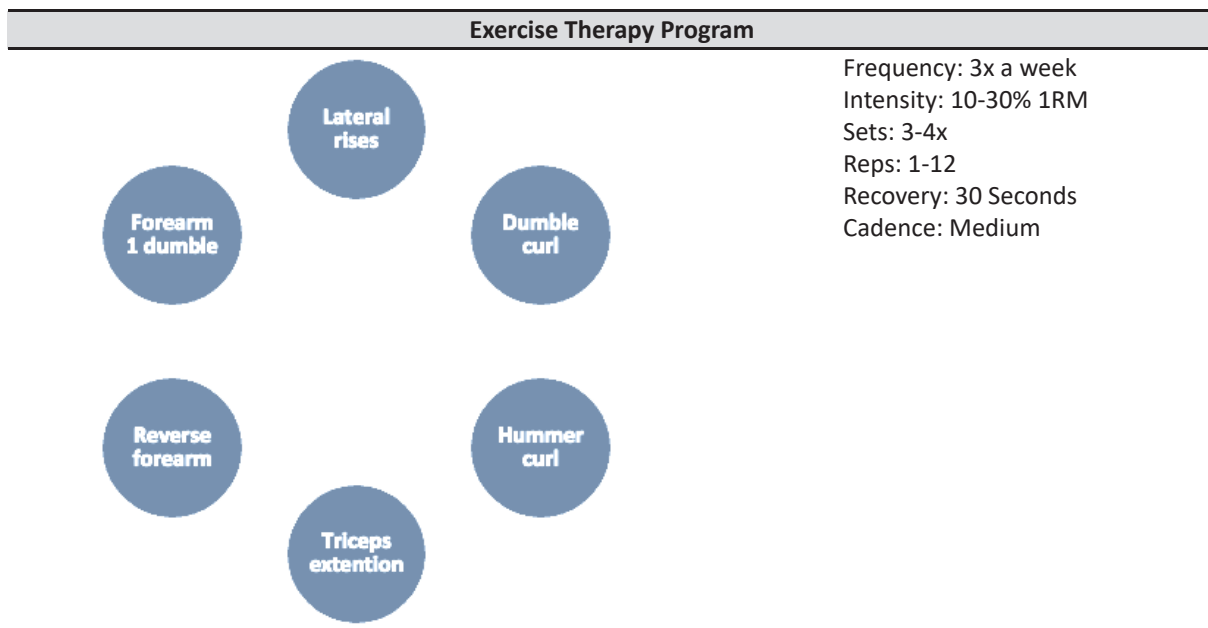
The Massage Therapy and exercise therapy program has been validated by experts and analyzed using Aiken's with a value of (0.93). The instrument in this research uses the Visual Analog Scale (Yao et al., 2024) and Range of Motion (ROM) (Rumampuk et al., 2024). Then continued the research data analysis with the SPSS V.19.0 program.

RESULTS

This study will measure the effect of injury on pain and the degree of ROM in the elbow joint and wrist joint. Below are the results of the research.

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***Table 3.** Results from the Pretest Posttest Massage Therapy and Exercise Therapy*

	N	Minimum	Maximum	Mean	Std. Deviation
Massage Therapy Pretest	16	198	612	432.94	153.002
Massage Therapy Posttest	16	356	623	545.32	182.978
Exercise Therapy Pretest	16	233	524	418.63	113.752
Exercise Therapy Posttest	16	281	544	444.43	117.798
Pretest Combination of both therapies	16	123	234	342.54	135.543
Posttest Combination of both therapies	16	294	435	546.32	197.754
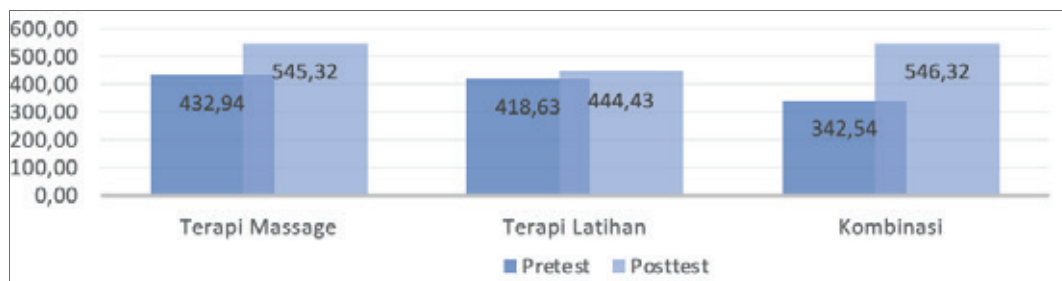
***Graph 1.** Descriptive Statistics*

Based onThe table and diagram above show that by providing this treatment. massage therapy is more dominant in reducing pain for elbow and wrist injuries with a minimum pretest score of 198. a maximum of 612. a mean of 432.94. and a standard deviation of 153.002. With a minimum posttest score of 356. a maximum of 623. a mean of 545.32. and a standard deviation of 82.978. while the pretest score from exercise therapy was a minimum of 233. a maximum of 524. a mean of 418.63. and a standard deviation of 113.752. The posttest scores are minimum 281. maximum 544. mean 444.43. and standard deviation 117.798. Thus, the results obtained were that by giving this treatment both experienced a significant reduction in pain. Meanwhile. with a combination of these two therapies. this combination will be more significant in reducing pain as indicated by the movement of the elbow and wrist not experiencing any obstacles with the maximum final value being 546.32.

DISCUSSION

If someone has an elbow injury. a doctor or medical professional can compare the range of motion in the injured elbow with the normal range of motion in the healthy elbow to identify the extent to which the injury affects the elbow's ability to move normally. That way. they can plan appropriate treatment or rehabilitation to restore normal function to the injured elbow (Dewanti et al.. 2024).

Injury treatment can be done using sports injury therapy and exercise therapy (Sumarjo et al.. 2023). Sports injury therapy is a massage or massage technique that is carried out with the aim of restoring a person's body part that has been injured while exercising (Đukić et al.. 2019; Graha et al.. 2023) Sports injury therapy massage only uses the following techniques. namely "friction and effleurage using the thumb. and followed by pulling (traction) to return the joint to its position (reposition) (Nazari et al.. 2015). This means that massage movements are relatively easy to understand and can be done anywhere and with this treatment it can reduce pain after an injury.

Because heavy training and lack of warm-up can cause injury (Priyonoadi et al.. 2018). With this massage injury treatment. we have provided knowledge and skills to athletes (Heiduk. 2021). So that athletes know the sciences about massage injuries (Nazari et al.. 2015). By knowing existing theories about injuries. the types and forms of treatment. it will minimize the occurrence of errors (Aliberti et al.. 2021). This means that the treatment that has been implemented has had a positive impact on all participants. starting from creating new jobs. providing additional economic opportunities. and providing opportunities for participants to dedicate the knowledge they have gained to the field and society.

Exercise therapy is an important component in the rehabilitation process after injury or chronic disease disorders (Kuna et al.. 2023). The first goal of exercise therapy is to restore physical abilities so that you can carry out daily activities (Youcef et al.. 2022). This exercise therapy has several variations which are quite easy to do and the materials/equipment needed are easy to find (Prasетyo et al.. 2022). If this exercise therapy is structured correctly according to FITT. it will have a significant impact.

According to opinion (Susanto et al.. 2022)states that physical exercise can reduce body weight. improve cardiovascular and respiratory function. reduce LDL and increase HDL. thereby preventing coronary heart disease if this physical exercise is done correctly and regularly. Recommendations for exercise or physical exercise were actually nothing new before the discovery of insulin in 1921. but at that time it was not clear what physical exercise limits should be carried out. such as type of exercise. dose. frequency and intensity of exercise (Smith & Kays. 2022). Therapeutic sports training can also be done with physical movements carried out by the body's muscles and supporting systems. Physical activity is any body movement produced by skeletal muscles that requires energy expenditure (Camera. 2022). Having good and regular physical activity will help your body stay in good condition. both aerobic and anaerobic activities (Li et al.. 2021; Rebelo et al.. 2022; Ribeiro et al.. 2022; Sarmento et al.. 2018).

It can be interpreted that providing a combination of sports injury massage therapy with exercise sessions can reduce pain and increase ROM in sufferers of elbow and wrist injuries. which is characterized by quite significant results. This sports injury massage. if combined with sports therapy. will create a new model of massage so that it can be used as a solution and develop quite good knowledge. Because athletes who are injured will be treated intensively. The treatment method is that the athlete will be given injury massage treatment first until the athlete enters the rehabilitation phase which is supported by exercise therapy. which means that both therapies will provide maximum results. This research has been carried out as closely as possible. but there are still shortcomings/limitations. one of which is the implementation of this research. namely the limitations of researchers in controlling the activities carried out by athletes.

CONCLUSION

The combination of sports injury massage therapy with exercise sessions has a more significant impact on reducing pain in elbow joint injuries. compared to just carrying out sports injury therapy massage. The combination of sports injury massage therapy with exercise sessions has a more significant impact on increasing ROM in elbow joint injuries. compared to just carrying out sports injury therapy massage. The combination of sports injury massage therapy with exercise sessions has a more significant impact on reducing pain in wrist joint injuries. compared to just carrying out sports injury therapy massage. The combination ofhaveorts injury massage therapy with exercise sessions has a more significant impact on increasing ROM in wrist joint injuries. compared to just carrying out sports injury therapy massage.

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Viktoriia Pastukhova, et al.
Effect of Physical Activity on Changes in Mitochondrial Pool of Muscle Fibers

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Effect of Physical Activity on Changes in Mitochondrial Pool of Muscle Fibers

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Abstract: *The purpose of this research was to study the restructuring of adaptive features of skeletal muscles (gastrocnemius and soleus) under conditions of prolonged physical activity on an ultramicroscopic level. Studies were carried out on laboratory animals (rats) of two groups - the control (intact) and the experimental group (exposed to a 30-minute swim test for 5 weeks). The muscle material was studied using electron microscopy. We found that during the process of adaptive restructuring of skeletal muscles, morphological transformations occur at different levels of structural organisation. Changes in muscle tissue during prolonged physical load include increasing deposits of myoglobin with additional focal changes in glycogen content and an increase in mitochondria. A significant increase in the volumetric density of mitochondria was noted in the symplasts of the gastrocnemius and soleus muscles of rats in the experimental group. Additionally, the average cut size of mitochondria increased compared to intact animals. This was due to the appearance of large organelles against the background of a decrease (almost three times) in the number of small mitochondria. The consequence of such transformation can be metabolic reorganisation in myocytes, and changes in the plastic properties of energy generators and contractile structures. The established processes can become a basis for understanding the adaptive restructuring of skeletal muscles of athletes under the influence of long-term physical activity.*

Keywords: *muscles, ultrastructural adaptive changes, mitochondria, physical activity*

INTRODUCTION

High physical loads, characteristic of modern sports, present increased demands on all organs and systems of the organism, including skeletal muscles. The study of changes occurring in muscles under the influence of different motor modes at macroscopic, microscopic and ultramicroscopic levels is of great theoretical and practical importance.

Sports practice shows that purposeful training increases strength and other functional properties of muscles. But there are also such phenomena when at maximum loads and insufficient rest time muscle strength begins to decrease and the athlete cannot repeat the high results shown before (Raeder et al., 2016; Weiss, 1991). It is important to know what changes occur in the muscles and what the athlete's motor regime should be in the future.

The adaptive mechanisms of response to physical activity of slow and fast contractile fibers are different and are of interest for more detailed study. Slowly contracting fibres are characterised by a small contraction speed, a large number of mitochondria, high activity of oxidative enzymes, wide vascularisation, and high glycogen accumulation potential. Rapidly contracting fibres break down ATP much faster, are well susceptible to endurance training, and their activity is associated with the use of anaerobic energy sources (Platonov, 2013). The higher plasticity of rapidly contracting fibres contributes to faster and more powerful contractions (Caiozzo, 2002; Fox et al., 1993; Shoepe et al., 2003). The gastrocnemius and soleus muscles of laboratory rats, which differ in the ratio of fast and slow contractile fibres, were chosen as models for further study.

The present article aims to study adaptive changes in the skeletal muscles of laboratory rats after exercise at the ultramicroscopic level.

MATERIAL AND METHODS

The studies were carried out on 20 white sexually mature rats of the Fischer line with an initial weight of 200-220 g. The animals were equally divided into control (intact rats) and experimental groups. In the experimental group, physi-

cal exercise was applied as daily swimming for 30 minutes with additional weight (10% of body weight) for 5 weeks. The maintenance and use of laboratory animals met the methods and norms of bioethics (Gnadt & Leland, 2001).

We studied both slow muscle fibres (predominant in the soleus muscle) and fast contracting fibres (predominant in the gastrocnemius muscle). Muscle material from both groups was studied using a PEM-125K transmission electron microscope.

After decapitation under ether anaesthesia, muscle pieces were fixed with 2.5% glutaraldehyde solution on phosphate buffer with additional fixation in 1% osmium tetraoxide solution (Madigan et al., 2021). Dehydration was carried out in alcohols of increasing concentration and acetone, poured into the epon-araldite mixture according to the generally accepted technique (Karupu, 1984).

The quantitative material was processed using descriptive statistics methods. The mean (M) and standard deviation (SD) of such indicators as the volumetric and quantitative density of mitochondria in symplasts of gastrocnemius and soleus muscles were evaluated. Statistical reliability in the difference between the results of the control (C) and experimental (E) groups was determined using the non-parametric Wilcoxon T-test (Wiedermann & von Eye, 2013). Differences between groups were considered statistically significant at $p<0.05$. All quantitative calculations were performed using the statistical environment R (https://www.r-project.org).

RESULTS

The results of mitochondrial analysis in the soleus and gastrocnemius muscles for the control and experimental groups are summarised in Table 1.

Table 1. *Mitochondrial indices in symplasts of gastrocnemius and soleus muscles of rats of the control (C) and experimental (E) groups. M – mean, SD – standard deviation, E/C – a ratio of the experimental/control groups, p-value – the statistical significance of the Wilcoxon T-test.*

Indicator	Muscle	Control (C)		Experimental (E)		Changes (E/C ratio)	p-value
		M	Sd	M	SD		
Volumetric density,%	gastrocnemius	3.37	0.57	27.37	7.17	8.12	<0.05
	soleus	3.72	0.79	13.29	4.12	3.57	<0.05
Quantitative density, $10^{-2}/\mu m^3$	gastrocnemius	22.2	5.18	93.19	16.03	4.20	<0.05
	soleus	27.29	0.59	26.01	6.15	0.95	>0.05
Cutting area, $10^{-2} \mu m^2$	gastrocnemius	15.93	0.67	43.68	1.88	2.74	<0.05
	soleus	16.03	1.06	38.12	3.03	2.38	<0.05

Physical load in the experimental group caused a significant increase in the number of mitochondria. Not only the number but also the average mitochondrial slice area increased compared to control animals. This index was more than twice as large in rats subjected to exercise (Table 1). This was observed for both gastrocnemius and soleus muscles. The changes are due to the appearance of large-sized organelles against the background of a decrease in the number of small mitochondria.

The quantitative density of mitochondria in gastrocnemius muscle also increased more than 4 times. Similar changes in this parameter were not observed in the soleus muscle. Despite this, the volumetric density increased significantly in both muscle types. These changes indicate different structural adaptive rearrangements of fast and slow-contracting fibres under physical load.

In addition to quantitative changes in mitochondrial parameters, morphological changes associated with exercise were also observed. Mitochondria are located under the sarcolemma and between sarcomeres but differ in shape and size. The presence of a large number of cristae in mitochondria is also indicative of mitochondria functioning in a strained mode. The accumulation of calcium granules in mitochondria was also noted. Hypertrophy and hyperplasia of mitochondria in symplasts of the gastrocnemius muscle after exercise is accompanied by a significant decrease in the number of glycogen granules compared to the control group. Such changes do not exclude the decompensation of the energy supply of gastrocnemius muscle fibres in some rats under the condition of prolonged exercise.

At the microscopic level, the nuclei in the symplasts of animal gastrocnemius muscles had a well-structured caryolema, which forms deep invaginations. This increases the surface area. Euchromatin uniformly fills the

caryolema. Two adjacent nuclei are found in some places. All this indicates active transcriptional processes during physical activity.

Morphometric analysis of mitochondria of the soleus muscle showed that physical exercise also leads to an increase in their size. The average area of these organelles is more than twice as large as in control animals (Table 1). Mitochondria in the subsarcolemmal zone are larger than organelles located between the fibrils. The increase resulted from the decrease in the number of small mitochondria due to the appearance of larger organelles.

The sarcomeres of the flounder muscles in different animals have a typical ratio of A- and I-zones, Z-lines without compaction. The most characteristic changes in the sarcomeres of calf muscles are localised divergences of myofibrils. Changes in the fine structure of the muscle tissue in the experimental group are characterised by increased deposition of myoglobin, especially at the level of myofibrils, focal changes in glycogen content and an increase in mitochondria.

DISCUSSION

Prolonged physical exertion leads to the fact that muscle hyperfunction is fixed by the corresponding structural rearrangement (Grigoriev & Egorov, 1992; Krivoshchekov & Divert, 2001). In the process of adaptive reactions, morphological transformations occur at various levels of the structural organisation of skeletal muscles. The consequence of such transformations is metabolic rearrangement in myocytes, and, under certain conditions, changes in the properties of their energy-generating and contractile structures. An increase in the number of muscle fibres is not an obligatory characteristic of muscle hypertrophy, although it often accompanies it (Macdougall, 2003).

Currently, there is an opinion that mitochondrial swelling is a sign of increased activity of oxidative enzymes, as well as a sign of decreased ATP content in cells and stimulation of glycolysis (Chinopoulos & Adam-Vizi, 2010; Jeong et al., 2004). The latter plays an important role in the energy supply of myocytes during intensive muscle work. These reversible changes in mitochondria are considered signs indicating an increase in metabolic processes in mitochondria and surrounding cytoplasm as a result of increased energy consumption during muscular work (Liesa & Shirihai, 2013; Schirrmacher, 2020).

The increase in the number of mitochondria in skeletal muscle cells during prolonged exercise is a known phenomenon and its molecular basis is being studied (Safdar et al., 2011). It is known that during exercise, the amount of PGC-1a protein in the cell increases and it moves from the cytoplasm to the nucleus. Recently, it was found that PGC-1a can penetrate not only into the nucleus but also into mitochondria, where it can participate in the activation of genes of the mitochondrial genome (Safdar et al., 2011).

When muscle cells are engaged in prolonged physical work, their energy requirements increase. The adaptive response is to increase the number of mitochondria and the number of enzymes providing ATP synthesis in the already existing mitochondria. Therefore, PGC-1a also moves into the mitochondria where it helps transcription factors to activate gene function. Thus, PGC-1a is part of the mechanism that helps muscles adapt to prolonged exercise (Little et al., 2010; Safdar et al., 2011).

Overall, mitochondrial changes during exercise are multidirectional and involve a variety of adaptive mechanisms:

- increase in the number of mitochondria – physical activity stimulates the process of mitochondrial biogenesis, which leads to an increase in the number of mitochondria in cells. This occurs by increasing the fission of existing mitochondria and the formation of new ones;
- increase in mitochondrial density – physical activity helps to increase the density of mitochondria in muscles. This means that muscle cells contain more mitochondria per unit volume, which promotes more efficient energy production;
- increased mitochondrial enzyme activity – exercise stimulates the activity of mitochondria-related enzymes involved in oxidative phosphorylation. This improves the mitochondria's ability to produce energy;
- increased mitochondrial adaptation – exercise promotes the activation of various signalling pathways that regulate genes associated with mitochondria. This leads to improved mitochondrial adaptation, increased aerobic metabolism and increased efficiency of energy metabolism in muscle;
- increase in mitochondrial efficiency – physical activity improves the efficiency of mitochondria in energy production. This is achieved by increasing the mitochondria's ability to oxidise fats and carbohydrates, which improves energy metabolism in the body.

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The outlined changes at the mitochondrial level during exercise have positive effects on overall physical endurance, body adaptation to physical activity, general health and fitness.

Finally, we cannot fail to mention such general adaptation mechanisms as increased local blood flow in skeletal muscles. They were noted for both groups of the studied muscles. The reaction of the final blood flow of skeletal muscles at physical load is working hyperaemia, which creates conditions for blood inflow due to the opening of reserve capillaries. Anaerobic processes cannot ensure tissue functioning for a long period. The increase in the functional activity of the organ occurs with an obligatory increase in tissue metabolism. Acceleration of oxidative metabolism is impossible without increasing the delivery of blood and, together with it, oxygen to the working organs (Kalliokoski et al., 2005; Saltin et al., 1998).

CONCLUSION

We have investigated the features of adaptive changes in skeletal muscles (gastrocnemius and soleus muscles) of laboratory rats after prolonged physical activity. A complex structural rearrangement at different levels in the mitochondrial pool was found. The gastrocnemius and soleus muscles respond differently to prolonged physical activity, as evidenced by the quantitative density of mitochondria. Adaptive changes were observed in both muscle groups (gastrocnemius and soleus muscles). Mitochondrial volumetric density and mean slice area in the experimental group of rats subjected to exercise increased significantly. The general mechanisms consist of rearrangement at the level of myocytes, replacement of small mitochondria by larger ones, and enhancement of blood flow of skeletal muscles. All this contributes to the understanding of the deep mechanisms of adaptive reorganisation of skeletal muscles under the influence of physical exercise. The changes detected in the study are the basis for understanding the adaptive restructuring of skeletal muscles in athletes under the influence of prolonged exercise.

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Improving Students' Ability to Decision Making and Communicate Effectively Through the use of Hybrid Nonlinear Pedagogical Models

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Abstract: *The objective of this study is to examine and evaluate the influence of hybrid nonlinear educational models on decision-making and communication in the field of physical education. Techniques. The intervention group received instruction in physical education utilizing hybrid pedagogical techniques for a period of 12 weeks. In contrast, the control groups followed the physical education curricula of their schools. Pre-existing scales designed for student usage were utilized for decision-making and communication purposes, both before and during the program. To compare the two groups, we utilized paired sample t-tests, two-way and one-way analyses of variance, and a Pearson correlation analysis. Outcome. The research findings indicate that the intervention group exhibited a significant improvement in decision-making and communication when compared to the control group. The aforementioned conclusions are substantiated by the results of paired sample t-tests and two-way Analysis of Variance (ANOVA). The variance (ANOVA) and one-way ANOVA tests yielded statistically significant results. The F statistic was less than 0.05 (F = 0.000 < 0.05), and the p-value was less than 0.05 (p = 0.000 < 0.05) respectively. Furthermore, the intervention based on nonlinear pedagogy and invasion game learning resulted in an enhancement of decision-making and communication skills. Final remarks. Incorporating hybrid nonlinear pedagogical models into physical education instruction with invasion games might enhance students' communication skills and decision-making abilities. The findings of this study offer encouragement for physical education instructors to adopt teaching methodologies. In addition, research is being carried out to investigate the impacts of nonlinear pedagogy.*

Keywords: *Decision-making, communication, primary school students, nonlinear pedagogy*

INTRODUCTION

Disparities in approaches might be a challenge in the field of physical education (Syrmpas et al., 2017). A student-centered strategy has replaced traditional physical education instruction. Teachers prioritize instruction that focuses on required technical skills, sometimes neglecting the surroundings and students' preferences. The student-centered approach involves the teacher assuming the role of a facilitator, while students are motivated to approach topics critically through independent inquiry (Guangxin et al., 2022; Lee et al., 2017). Divergent approaches can present a significant challenge to the implementation of physical education (Kozin et al., 2022). The conventional teacher-centric approach to physical education instruction has transitioned to a student-centric paradigm. Students are afforded the chance to cultivate independence in the learning process through the utilization of a student-centered technique. The teacher assumes multiple roles, both individually and in groups, serving as a conceptualizer, director, and facilitator for pupils to communicate critical viewpoints (Syahputri & Sukoco, 2020; Yi et al., 2020).

Although a significant proportion of students (usually 80% or more) expressed satisfaction with traditional or teacher-centered physical education classes, there was a demand for a fresh approach (Jaakkola et al., 2017; Rekaa et al., 2019; Silverman, 2017). Physical education has a primary focus on engaging in physical exercise, encompassing both individual and group sports. This distinguishes physical education from most other courses taught in schools. Conversely, there exist pupils who have a dislike for physical education within the school setting, so impeding the successful implementation of physical education instruction. Furthermore, there is compelling evidence indicating that a growing proportion of pupils perceive physical education to be of diminished significance, lacking in interest, and lacking in enjoyment (Gard et al., 2013).

The non-linear pedagogical approach, a component of student-centered learning, emphasizes a learning experience that prioritizes collaborative interaction and enhances multiple student competencies. This approach fosters

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increased motivation among students during an engaging learning process (Lee et al., 2017; Sitepu et al., 2020).

Once it comes to how well students learn, physical education programs should focus on enhancing individual psychomotor, cognitive, perceptual, and affective abilities (Maksymchuk et al., 2018). Physical education is a subject included in the 2013 Curriculum of Indonesia, designed to foster a student-centered learning method. Physical education is a crucial component of the National Education System as it enhances multiple aspects of comprehensive learning outcomes. These include the development of motor skills, emotional intelligence, attitude values, social skills, critical thinking abilities, physical fitness, reasoning intelligence, healthy environmental management, and healthy lifestyles. The primary focus of Physical Education is to establish well-organized educational possibilities that are rooted in religious faith and centered around God (Sutapa et al., 2020).

In general, the outcomes of skills are of great interest to individuals and professionals in the field of sports, such as physical education instructors and sports coaches. They are responsible for studying the mechanics of human movement and interaction on a regular basis. The advantages of establishing efficient strategies to improve the acquisition and development of Physical Literacy have wide-ranging implications beyond sports or physical activities in societies or schools. They play a crucial role in helping individuals acquire functional movement (Silverman, 2017; Yi et al., 2020). Physical literacy encompasses the integration of cognitive processes, perception, fitness, effectiveness, and social connection into daily tasks, hence enhancing an individual's overall functioning (Trecroci et al., 2022).

Nonlinear Pedagogy is a student-centered learning strategy that has a distinct impact on physical education in curricular studies study (Crotti et al., 2021). The pedagogically focused approach of this study enhances the value of all parts and serves as a foundation for curriculum development. Subject or disciplinary expertise is widely recognized as a significant value orientation in the field of physical education. Practitioners strive to provide verbal explanations for teaching perceptual motor abilities, demonstrate techniques, conduct practice activities, and simulate game scenarios (Chow et al., 2006). Additional noteworthy value orientations in educational and curriculum studies encompass the learning process approach, which underscores the significance of the manner in which learning takes place, and the ecological integration of learners within specific learning settings (Gaetano, 2012; Lakhno et al., 2020). Students play a vital role in achieving the best learning outcomes, such as game skills. Teachers support students by demonstrating exemplary behavior that reflects certain values during the learning process. Students play an essential part in achieving the best learning outcomes, such as game skills. Teachers support students by demonstrating exemplary behavior that reflects certain values during the learning process.

Teaching Games for Understanding is a popular nonlinear learning model used in physical education. It focuses on a student-centered approach that encourages exploratory learning in scenarios that resemble games (Biesieda, 2022; Yi, 2010), The Constraints-Led Approach learning paradigm has the ability to offer a framework for physical education, enabling students to understand how to engage in the exploration of tasks based on the surroundings. The purpose of this is to foster individuals who demonstrate greater ingenuity in solving difficulties presented by the instructor. Furthermore, a thorough understanding of the fundamental neurobiological mechanisms is necessary to facilitate the development of skills in the Constraints-Led Approach. Utilizing games as a teaching method can enhance students' understanding of movement exploration, enabling teachers to assess their progress based on motor learning theory, teaching is an evolving and evidence-based kind of creative expression (Renshaw et al., 2010), Physical Education The main goal of Sports Education is to enable students to achieve proficiency in an enjoyable activity and develop self-assurance in performing activities throughout the season. This, in turn, encourages them to sustain their learning and progress, thereby enhancing their chances of engaging in it during their leisure time. Nevertheless, achieving this goal is improbable within the conventional structure of school physical education, characterized by brief modules where parents coordinate competitive games such as 5v5 basketball and 6v6 volleyball (Humphries, 2014).

The study implemented a nonlinear pedagogic learning model in the physical education and sports programs of the experimental group. The aim was to improve students' decision-making and communication skills. The main objective of this curriculum is to comprehensively improve students' communication and decision-making abilities, while also enhancing their overall pleasure of physical education. The program development process encompasses curriculum analysis, the production of a syllabus, and the development of a lesson outline that includes a diverse range of activities. Curriculum analysis highlights core and essential competencies. Competence is an essential talent that students must learn as part of the educational process. We developed a curriculum that includes the identified essential translation competencies (cognitive, affective, and psychomotor), as well as the necessary materials, course

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duration, and suitable activities. Furthermore, the lesson plan provides a comprehensive outline of the syllabus, encompassing the specific day and time of each meeting, the subject matter, the learning activities (including introduction, body, and conclusion), and the allocated study period. Students participated in a 12-week physical exercise program that followed a nonlinear approach. As a result, The aim of this investigation is This study investigated the impact of hybrid nonlinear pedagogical models in physical education on decision-making and communication.

MATERIAL AND METHODS

Methods

In this article, researchers employ a quasi-experimental study paradigm utilizing a control group pre-post test design. The study took place at an elementary school in Yogyakarta, Indonesia.

Participants

Total of 82 students from a singular primary school took part in this investigation. The participants were chosen using a random selection method. Elementary school students often fall within the age range of 10 to 12. The inquiry was carried out in the Indonesian province of Yogyakarta. This province is situated in the western area of Indonesia. The distribution of the sample is displayed in Table 1.

Table 1. Subject characteristics intervention group

Explanation	Frequency	%
Gender		
Male	41	50
Female	41	50
Age		
11	26	35
12	56	65
Class		
5	26	35
6	56	65
School		
Primary School 1	27	32
Primary School 2	29	37
Primary School 2	26	31

Study organization

Observation and documentation serve as data collection methodologies. Data collection for this study involved the use of observation, assessment, and documentation instruments. During this inquiry, researchers collected data on the pre-test and post-test by means of observation. The teacher utilises lesson plans as a type of documentation, along with additional documentation during the pre-post-test and treatment sessions, which span a total of 12 meetings.

Table 2. Design of studies and intervention

Experiment	Paired Sample t-test
Pre-test	Instrumentation Observation
Intervention	12 weeks
Post-test	Instrumentation Observation
Participants	VI C 27 Students Nonlinear pedagogy learning
	VI D 29 Students Linear pedagogy learning
	V C 26 Students Control

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Procedure

At the beginning of the study, we created a new physical education programme for children in the first intervention group. This programme focused on invasion activities and used a nonlinear pedagogy approach. We also developed a scale to measure the children's decision-making and communication skills. In the second intervention group, we implemented a different programme that used invasion games and a linear pedagogy approach. We also used the same scale to assess the children's decision-making and communication skills. For the control group, we followed a regular curriculum that included invasion games in their physical education and sports programmes. We provided additional training to the physical education and sports instructors assigned to the first and second intervention groups, but not to the control group. Each programme has a duration of one semester, which is equivalent to 12 weeks. Both before and after all physical education and sports programmes, we distribute decision-making and communication scales to all pupils.

Table 3. Strategies for treating non-linear learning in experimental testing

	Nonlinear-Linear-Control		
Session	**Variable**	**Physical Education Scope**	**Material**
1	Pre-Test		
2	Nonlinear-linear-control	Invasion Game	Soccer
3	Nonlinear-linear-control	Invasion Game	Basketball
4	Nonlinear-linear-control	Invasion Game	Handball
5	Nonlinear-linear-control	Invasion Game	Futsal
6	Nonlinear-linear-control	Invasion Game	Basketball
7	Nonlinear-linear-control	Invasion Game	Handball
8	Nonlinear-linear-control	Invasion Game	Soccer
9	Nonlinear-linear-control	Invasion Game	Futsal
10	Nonlinear-linear-control	Invasion Game	Handball
11	Nonlinear-linear-control	Invasion Game	Soccer
12	Post-Test		

Statistical analysis

Data analysis is conducted using SPSS Version 27.0 for Windows. A repeated measures analysis of variance (ANOVA) was employed to compare the intervention 1 and 2 groups, together with the control group, both before and after the implementation of the physical education and sports programmes. The one-way ANOVA was employed to assess the disparities in decision-making and communication among groups prior to and following the introduction of the physical education and sports programme. Paired sample t-tests are specifically used to evaluate differences across groups.

RESULTS

According to use parametric methods of statistical analysis, it is necessary to do a normality test on the data:

Table 4. The outcome of the process of determining normality and the subsequent exchange of information

		Kolmogorov-Smirnov			
		Decision Making		**Communication**	
	Class	**df**	**Sig**	**df**	**Sig**
Pre-test	Kontrol	26	0.099	26	0.122
	Nonlinear	27	0.075	27	0.200
	Linear	29	0.056	29	0.129
Post-test	Kontrol	26	0.123	26	0.052
	Nonlinear	27	0.133	27	0.087
	Linear	29	0.200	29	0.151

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Figure 1 demonstrates a notable interaction between the average ratings of the intervention and control groups (F(2.430) = 30.771, p = 0.000), suggesting that the groups exhibited significant differences in the rate of change in their decision-making skills from before the intervention to after the intervention. A unidirectional analysis of variance (ANOVA) also demonstrates statistically significant variations in group decision-making. The intervention nonlinear group experienced significant changes in decision making, with a mean score of 2.43 before testing and a mean score of 3.31 after testing. The linear intervention group cohort experienced a significant decrease in decision making ability, with the mean score dropping from 2.33 before testing to 2.08 after testing. No significant differences exist between the pre- and post-test results for both the first control group (M=2.26) and the second control group (M=2.26). This is additionally supported by the paired sample t-test, which demonstrated a statistically significant disparity.

The study found significant changes in decision making among the participants in the intervention nonlinear group (t(27); p = 0.000). The paired sample t-test conducted on the intervention linear group revealed a statistically significant difference in decision making (t(29); p = 0.000). In contrast, there were no notable differences in decision making among the control group (t(26); p = 0.961).
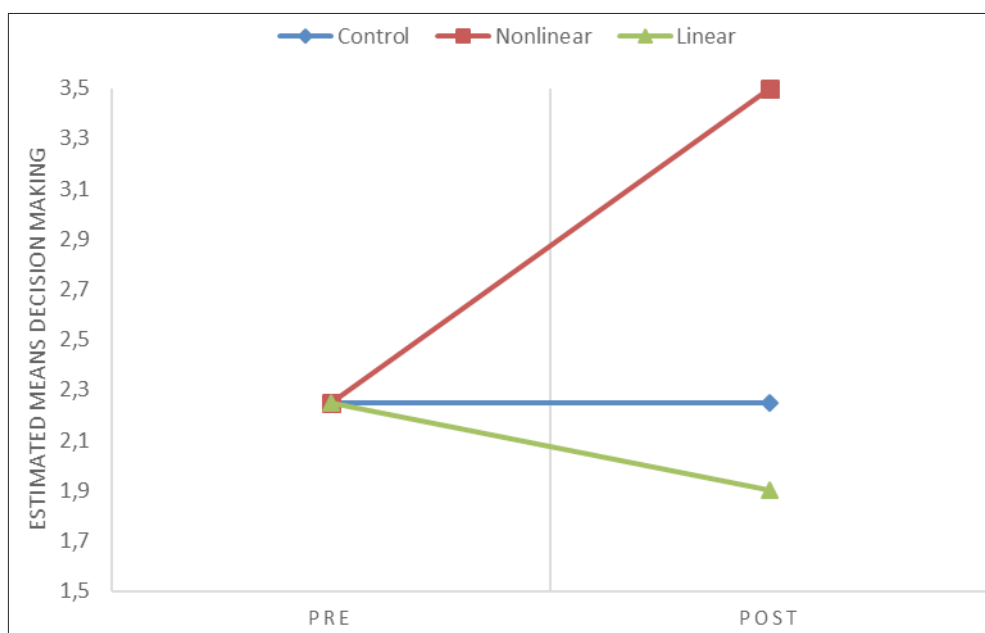
Figure 1. *Comparative decision-making indicator testing students in the experimental and control group (or intervention group) before and after the experiment*

As shown in Figure 2, there was a significant interaction between the intervention and control groups' mean scores. (F(2.386) = 9.436, p = 0.000), indicating that there were significant differences between the groups in the rate of change from pre-intervention to post-intervention in their communication. A one-way ANOVA also reveals significant group differences in communication. There are substantial incremental shifts in communication from before (M=2.38) to after testing (M=3.66) in the intervention nonlinear group group. The linear intervention group experienced a reduction in communication from before (M=2.55) to after testing (M=2.33). Similarly, the control group exhibited a decrease in their pre-test (M=2.28) and post-test (M=2.19) scores. This is also corroborated by the paired sample t-test, which demonstrated statistically significant deviation in communication in the nonlinear intervention group (t(27); p 0.0001). Paired sample t-test in the intervension linear group also showed a significant differences in communication (t(29); p = 0.001). There were no significant differences in communication in the control group (t(26); p = 0.266).

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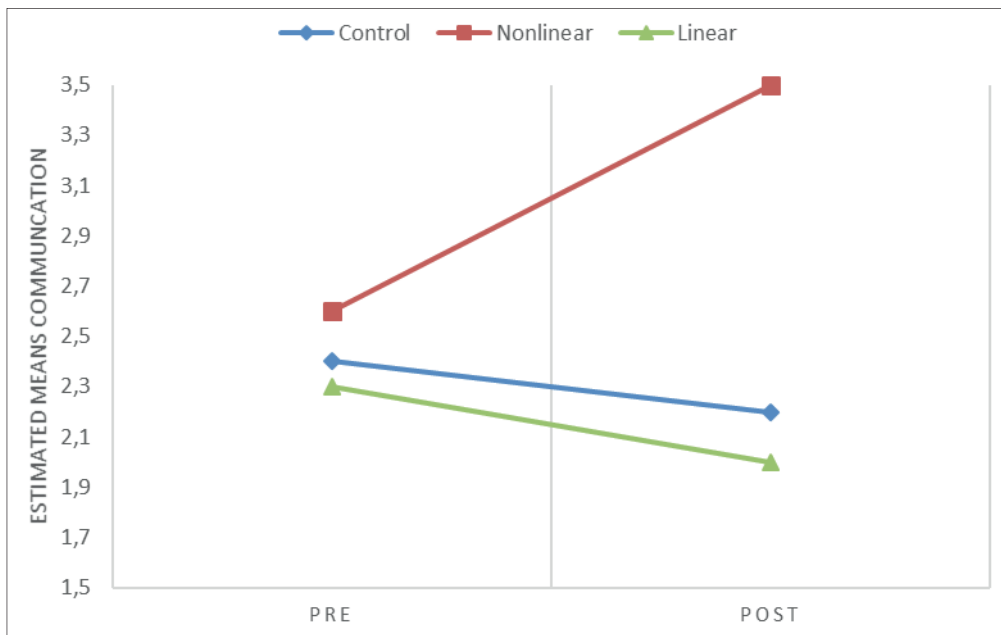
Figure 2. Significant interaction between the intervention and control groups' mean scores

DISCUSSION

The hybrid learning approach based on nonlinear pedagogy prioritizes the decision-making variable as a means to enhance efficacy. The decision-making process in this lesson involves strategic elements, such as executing passes, dribbling, and shooting towards the goal (Práxedes et al., 2018).

Through the manipulation of task conditions, numerous games can be adjusted to facilitate learning and enable players to adapt to diverse practice scenarios. This scenario closely resembles a game characterized by substantial ambiguity regarding the adversary's behavior. By altering varied work conditions, athletes can adapt to the diversity of practice through numerous customized games. Learning that simulates genuine game scenarios by incorporating uncertainty over the behaviors of the opponent (Araújo et al., 2019). Additionally, it enables pupils to enhance their capacity for making informed decisions in the process of learning (Casey & MacPhail, 2018; Harvey et al., 2020).

Communication variables enhance the efficacy of nonlinear pedagogical learning models. Students are unable to acquire knowledge autonomously without the context of developing motor skills. When students in the nonlinear pedagogy group were prompted to discuss aspects of communication with friends and teachers that they found favorable in this learning approach, one student expressed their appreciation for the opportunity to freely voice their opinions. The student claims that his peers hardly heed his opinion, but they do listen to it when he speaks. An important aspect emphasized in the nonlinear approach is the affective component, where the hybrid model enhances students' communication skills. By assuming various roles such as coaches, managers, players, and spectators, students are trained to effectively communicate not only with their peers, but also with teammates, opponents, and coaches (Opstoel et al., 2020; Sanderson et al., 2017).

The nonlinear learning design perspective is further characterized by students assuming several roles in sports, facilitating communication among students. The most efficient method of including communication is through the creative expression of students' thoughts, which fosters the development of their thinking, enhances their vocabulary, and promotes the appropriate use of words (Alawamleh et al., 2022; Shaykhislamov, 2020). In the context of nonlinear learning, students who assume certain responsibilities experience increased cognitive freedom to engage in creative expression of their opinions and ideas. Additionally, they are motivated to excel within a team or group setting.

Following their involvement in physical education, children in the nonlinear pedagogy intervention group shown substantial progress in their decision-making and communication abilities. These findings indicate that students who participate in the nonlinear pedagogy intervention group have notable improvements in their decision-making and communication skills, specifically in the context of sports learning. Sports education enhances students' cognitive abilities, including decision-making, communication, skill development, and creativity (Olson et al., 2017; Práxedes

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et al., 2018). Specialized sports education promotes pupils' independent problem-solving abilities. This method utilizes collective learning through the use of invasion games. Students acquire the capacity to apply their decision-making skills in order to tackle a variety of difficulties associated to games (Green et al., 2021). By incorporating hybrid games that include teaching games of understanding, sports education, and cooperative learning, students can actively engage in and get pleasure from their physical education lessons (Green et al., 2021), It significantly increases their ability to make decisions and communicate effectively.

Physical education exerts a beneficial influence on the decision-making and learning capacities of elementary school students. Sports competitions serve as real-life scenarios that foster a sense of responsibility in communication skills and cultivate students' ability to make informed decisions.

CONCLUSION

The intervention class experienced enhanced decision-making skills following the implementation of a nonlinear pedagogy-based invasion game learning. Based on the findings of the two-way ANOVA, one-way ANOVA, and paired sample t-test, which have F values of 0.05 (F = 0.000 < 0.05) and ρ values less than 0.05 ($\rho = 0.000 < 0.05$), there is a statistically significant difference between the two groups.

The experimental class experienced an improvement in their communication abilities following the implementation of a nonlinear pedagogy-based invasion game learning therapy. This is demonstrated by the outcomes of the two-way ANOVA, one-way ANOVA, and paired sample t-test, which exhibit F values less than 0.05 (F= 0.000 < 0.05) and ρ values less than 0.05 ($\rho = 0.000 < 0.05$), there is a notable difference.

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Influence of a Complex Rehabilitation Process on Quality of Life in Patients With Multiple Sclerosis

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Abstract: *Patients with multiple sclerosis (MS) have a lower quality of life (QoL) than the general population. Rehabilitation is an essential part of the comprehensive treatment of MS patients. The aim was to determine the influence of complex physical therapy on the QoL of MS patients and the association of functional status with certain domains of health-related QoL. We followed 58 MS patients. The complex kinesitherapy used the Bobath concept and occupational therapy with the use of robot-assisted rehabilitation for the upper extremities. Before the start of rehabilitation and at the end, functional status was assessed by the Expanded Disability Status Scale (EDSS) and Berg Balance Scale (BBS). QoL was assessed through the standardized SF36 test and summarized into two scores: physical health component score and mental health component score. The average age of patients was 49.38 years. There was a significant improvement in all patients after the therapy, both in functional status and in QoL. There were no significant correlations between the EDSS and BBS with QoL parameters (individual SF36 categories and two summary scores). Duration of the disease correlated with the EDSS and BBS, but not with QoL. The age of patients did not correlate with functional status or with QoL. Physical therapy improves both functional status and QoL, but improvements do not correlate. There is a need to incorporate QoL assessment into assessments of disease severity, progression, and treatment success to obtain the most relevant results in creating the right treatment strategy.*

Keywords: *Functional status, Neurodegenerative Diseases, Occupational Therapy, Physical therapy*

INTRODUCTION

Multiple sclerosis (MS) is a chronic, incurable inflammatory disease of the central nervous system (CNS). It affects young adults at a time of maximum personal, professional, and social development. It is characterized by fully or partially reversible episodes of neurological deficit lasting several days to weeks (Reich et al., 2018). It has a variable clinical picture that depends on the affected structures of the brain or spinal cord. The most common symptoms are motor weakness, sensory disorders, gait and coordination disorders, and optic neuritis (Saguil et al., 2022). Accompanying disorders are sphincter disorders, sexual dysfunction, pain, speech and swallowing disorders, cognitive dysfunction, and psychological disorders that significantly limit the patient's functioning in everyday life and social activities (Barin et al., 2018). These processes lead to a decrease in physical activity and mobility, which causes a vicious circle and secondary complications that endanger other organ systems. Psychological reactions arise from learning about the presence of the disease.

Research suggests that early initiation of an active lifestyle and exercise in MS patients can promote neuroprotection, neuroregeneration, and neuroplasticity (White et al., 2008). Patients tolerate programmed exercise well, and it is a safe and effective way to improve their quality of life (QoL) by optimizing daily functioning and increasing their participation in various areas of life (Padgett et al., 2013; Dalgas et al., 2009). Rehabilitation is increasingly recognized as an essential part of the comprehensive treatment of patients with MS and it reduces inflammatory cytokines in the immune system, protects the CNS, slows down neurodegeneration, induces neuroplasticity, and slows the disease progression (Centonze et al., 2020; Isaković et al., 2019; Simpson et al., 2015). Various types of physical activity have been proposed for patients with MS, such as aerobic exercises, progressive resistance exercises and interval training, combined endurance and strength training (Ilett et al, 2016). An important place in the treatment of patients belongs to the proprioceptive neuromuscular facilitation and Bobath neurodevelopmental treatment (Kubsik-Gidlewska et al., 2017).

MS patients have a lower QoL than the general population. QoL is influenced by several disease-related factors, such as the degree of disability or type of MS, and factors such as social support, education, age, or employment

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(Wilski et al., 2019). There is an increased prevalence of psychiatric comorbidities, depression and anxiety in patients with MS compared to the general population, which often represents a reactive state (McKay et al., 2018). These conditions change the patient's objective perception of health already after the diagnosis, which further significantly reduces the QoL of these patients. QoL is also affected by general well-being and social functions that are not directly related to the neurological disease, but which patients consider to be even more important determinants of health condition than impaired physical function (Rothwell et al., 1997).

The aim of this research was to determine the influence of complex physical therapy on the functional status and QoL of patients with MS and the association of functional status with certain domains of health-related QoL.

MATERIAL AND METHODS

The research was conducted at the Institute for Physical Medicine, Rehabilitation and Orthopedic Surgery "Dr. Miroslav Zotović", Banjaluka, Bosnia and Herzegovina from March 2022 to November 2023 in accordance with the provisions of good clinical practice with the approval of the Ethics Committee of the mentioned institution *(number of the decision 116-01-3106-2/22)*. During this period, 74 MS patients, both genders, were treated at the Neurorehabilitation Department. The inclusion criteria were: a confirmed diagnosis of MS, persons older than 18 and younger than 70 years of age, and cognitive function according to the Mini Mental Test ≥ 24. Exclusion criteria were: worsening of the MS during the study, relapse of the disease in the last month, confirmed psychiatric diagnosis, newly confirmed neurological, rheumatological or orthopedic disease, worsening of cardiovascular and respiratory system function, and development of an inflammatory disease with febrility.

After the examination by a specialist in physical medicine and rehabilitation and before the start of rehabilitation, patients' functional status was assessed by graduate physiotherapists using the Expanded Disability Status Scale (EDSS) and Berg Balance Scale (BBS), which monitored functional progress during rehabilitation. The EDSS is suitable for detecting the effectiveness of clinical interventions and monitoring the progression of MS (Meyer-Moock et al., 2014). The BBS is a valid and reliable, most commonly used tool for assessing balance and fall risk in patients with MS, assessing static sitting balance, postural changes, transfers, and standing balance (Caselli et al., 2023; Cattaneo et al., 2007).

The evaluation of patients' QoL was done by the standardized SF36 test with eight domains, which can be summarized in two scores, the physical component summary (PCS) score and the mental component summary (MCS) score (Gitman et al., 2023; *Gil-González et al., 2020*).

For all patients, rehabilitation lasted five weeks, five days a week. Physical therapy has been adapted to the individual needs of the patient. The first segment was kinesitherapy, which included a program lasting 45 to 60 minutes, according to the patient's ability. The Bobath concept was a central part of the treatment, with a proven positive impact on balance, postural control and indirectly adaptive neuroplasticity index (*Castelli et al., 2022*). It emphasizes the critical role of postural stability (essential for selective movements and balance) and represents a part of the comprehensive treatment of MS patients (Ilett et al., 2016; *Raine, 2007;* Abreu-Corrales et al., 2023). Walking, balance and coordination exercises were conducted, and also exercises to improve muscle strength, improve or maintain range of motion, breathing exercises, and walking exercises at the loom. Exercises to strengthen the muscles of the pelvic floor were part of the program, depending on the type of damage to the sphincter functions (is it the result of CNS damage or bladder detrusor insufficiency). Before kinesitherapy, in patients with spasticity, the Novafon® device for a mild vibration massage was used to cause relaxation, which enables the implementation of the program.

The occupational therapy was also used, two times a day, lasting 30 to 45 minutes. It enables optimal functional independence in various areas of life, self-care, work professional abilities, and socialization. Robot-assisted training was also conducted on the Hocoma Armeo®Senso medical device for upper limbs, which uses three sensors and a handheld module to track movements and provide real-time feedback on improved performance. All patients were able to perform this training. At the end of the rehabilitation, the EDSS, BBS and SF36 testing was repeated.

The obtained results were statistically processed with SPSS version 29 software (IBM corporation, New York, USA), using methods of descriptive statistics, correlation analysis and t-test. A p-value of <0.05 was considered statistically significant.

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RESULTS

The inclusion criteria were fulfilled by 58 patients. The average age of patients was 49.38 years (range 31 to 68 years). 74.1 % of patients were female, and 25.9 % were male. In all patients, there was a significant improvement, both in functional status and in QoL (table 1).

Table 1. EDSS and parameters of quality of life before and after therapy (mean ±SD)

	EDSS	BBS	SF36	PCS	MCS
Before therapy	5.3±1.8	24.31±11.2	43.9±17.0	39.4±16.2	48.4±18.4
After therapy	4.6±1.7	32.33±12.2	53.7±18.5	48.2±17.8	57.7±19.8
Δ	-0.7±0.6 *	8.02±7.94*	9.7±13.5 *	8.8±12.4 *	9.2±14.3 *

*EDSS - Expanded Disability Status Scale, BBS- Berg Balance Scale, PCS- physical component summary score, MCS- mental component summary score. *p<0.001 testing withing groups using paired samples t test*

When compared individually, in all categories of SF36 there was a significant improvement after the therapy (table 2).

Table 2. Comparisons of individual 36 categories before and after therapy

	N	ρ	p
Physical functioning	58	.824	.000
Role limitations due to physical health	58	.682	.000
Role limitations due to emotional problems	58	.541	.000
Energy/fatigue	58	.596	.000
Emotional well-being	58	.747	.000
Social functioning	58	.766	.000
Pain	58	.579	.000
General health	58	.767	.000
Health change	58	.748	.000

Correlations of EDSS and SF36 categories showed weak and statistically nonsignificant correlations (table 3).

Table 3. Correlation of EDSS and SF36 categories before and after therapy

	EDSS before therapy		EDSS after therapy	
	r	p	r	p
Physical functioning	-.134	.324	-.155	.255
Role limitations due to physical health	-.213	.114	-.255	.057
Role limitations due to emotional problems	-.089	.515	-.164	.228
Energy/fatigue	.138	.309	-.019	.892
Emotional well-being	.126	.356	.081	.554
Social functioning	-.179	.186	-.116	.396
Pain	-.018	.893	-.055	.688
General health	-.081	.554	-.162	.233
Health change	-.149	.275	-.134	.324

EDSS - Expanded Disability Status Scale.

Also, there were no statistically significant correlations between EDSS, PCS and MCS (table 4).

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Table 4. Correlations between EDSS with PCS and MCS

Therapy	EDSS		BBS	
	Before r (p)	After r (p)	Before r (p)	After r (p)
PCS	-.119 (.375)	-.211 (.112)	-.126 (.345)	.021 (.877)
MCS	-.049 (.712)	-.116 (.386)	-.184 (.092)	-.034 (.799)

EDSS - Expanded Disability Status Scale, PCS- physical component summary score, MCS- mental component summary score.

Duration of the disease showed significant correlations with EDSS and BBS, but not with values of QoL (table 5).

Table 5. Correlation of the disease duration with examined parameters before and after therapy

	Duration of the disease (months)	
	ρ	p
EDSS before therapy	.534	.000*
EDSS after therapy	.55	.009*
BBS before therapy	-.508	.000*
BBS after therapy	-.338	.009*
PCS before therapy	.166	.214
PCS after therapy	.112	.401
MCS before therapy	.223	.092
MCS after therapy	.128	.339
SF36 before therapy	.186	.163
SF36 after therapy	.122	.361

EDSS - Expanded Disability Status Scale, BBS- Berg Balance Scale, PCS- physical component summary score, MCS- mental component summary score.

The age of patients also did not show statistically significant correlations with EDSS, BBS, PCS, and MCS (table 6).

Table 6. Correlation of age of patients with functional parameters and quality of life before and after therapy

	EDSS before therapy	EDSS after therapy	BBS before therapy	BBS after therapy	PCS before therapy	PCS after therapy	MCS before therapy	MCS after therapy
r	.228	.203	-.215	.006	-.172	-.171	-.220	-.190
p	.085	.127	.105	.964	.198	.198	.097	.152

EDSS - Expanded Disability Status Scale, BBS- Berg Balance Scale, PCS- physical component summary score, MCS- mental component summary score.

DISCUSSION

Organized rehabilitation from the very beginning of MS gives a real result because of individualized assessment, monitoring and adjustment of interventions (*Centonze* et al, 2020). Physical therapy improves the mobility of patients and prevents muscular atrophy, increases muscle strength, affects spasticity, improves tone, balance and coordination, and maintains or improve range of motion. In our research, an individual approach was applied to all patients with adaptation to the clinical condition, taking care to schedule the program over twelve hours to prevent patient exhaustion. Fatigue, overheating and signs of increased spasticity have to be monitored carefully (*Kwolek et al., 2010; Kubsik-Gidlewska et al., 2017*).

In our research, the basis of the treatment was the application of the Bobath concept. It assumes that the essence of motor deficits, as a consequence of MS, is a dysfunction of postural reflexes required for coordination in space. Correct muscle tone and active movements can be achieved by inhibiting pathological postural patterns (*Woszczak,*

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2005; Lada, 2010). The advantage of the concept is the possibility of positioning the patient in all positions, which enables work with patients with severe motor deficits. Impaired postural control and balance (during sitting, standing, and walking) are regularly seen in MS patients, so exercises were also carried out to restore these functions. Also, means of kinesitherapy and occupational therapy were added.

The success of rehabilitation was estimated with the EDSS instrument, the gold standard in everyday practice for patients with MS (Cohen et al., 2021). It ranges from 0, defined as a "neurologically normal finding" to 10, which represents a fatal outcome of MS. A study reported that impaired balance and coordination of the upper extremities was also found in patients with an EDSS score of 0 compared to healthy controls (Krieger et al., 2022). In our sample at the end of rehabilitation there was a statistically significant decrease in the EDSS score. Several patients had an EDSS of seven to 8.5 before the treatment, and by the end values decreased to 4.5 to 6.5. It means that, from the need for a wheelchair, they came to a state of mobility with aids or limited independent mobility. In contrast, a smaller number, with relatively low EDSS values, did not show significant progress. So there is a multifactorial influence on success in rehabilitation, and the patient's passivity and lack of interest in rehabilitation, or the existence of psychological imbalances are often reasons for inadequate progress in treatment, regardless of physical activation. For patients with significant progress, their knowledge of the importance of rehabilitation, insight into the improvement of other patients or the final availability of such a complex rehabilitation program helped. Compared to years of life, there was no statistically significant correlation with EDSS values before and after rehabilitation. Comparing the EDSS values and the duration of the disease before and after rehabilitation, there was a significant statistical correlation, with the increase in disease duration the values of the EDSS score also increased, which is expected for a progressive neurological disease.

People with MS are at greater risk of falling than the general population and older subjects, with a reported prevalence of falls of 48% to 63% (Nilsagard et al., 2009). It was found that 63.5% to 82.6% of patients report a fear of falling, which reduces their activities (Finlayson et al., 2006). The risk of falling, circumstances, consequences and causes are different in patients with MS than in a healthy person of the same age and gender. These patients fall more with a higher likelihood of injury, often indoors, even in younger individuals with less disability (Mazumder et al., 2014). BBS is a sensitive and specific measure for identifying the risk of falling (Ayvat et al., 2024). As a result of a complex rehabilitation, the BBS value improved statistically significantly in our patients. Clinical studies confirm this, giving significant results on the effectiveness of physiotherapy (Caselli et al., 2023). The minimum clinically important difference in the BBS is 3 points for patients with MS to perceive as a clinical change in balance performance (Gervasoni et al., 2017). In individual samples of our patients, only four patients did not achieve more than 2 points by the end of rehabilitation. These were middle-aged patients with an average duration of the disease of about four years, with an EDSS value of 2 to 4, a person without the need for assistance in everyday life and a BBS value of 39 to 41. Improvement in the functional state assessed by the EDSS was not a measure of improvement obtained by BBS. Data indicated that there was no linear relationship between fall status and mobility function, although at a certain threshold, further decline in mobility function was associated with fewer falls, probably due to reduced exposure to fall risk (Matsuda et al., 2012). We did not find statistically significant correlations of BBS with age of patients. The rate of decline is lower in women than in men and decreases with increasing age (Nilsagård et al., 2015). In our patients, BBS correlated statistically significantly with the duration of the disease, as expected due to the damage of the systems responsible for the balance with the progression of the disease.

The results obtained from our patients confirm the importance of organized rehabilitation in patients with MS, which is also confirmed by basic brain research (Lozinski et al., 2022). MRI in patients after kinesitherapy improves connectivity between brain regions even after eight weeks. Activity in patients with mild sensorimotor deficits of the upper extremities restores brain activity that coincides with a reduction in compensatory activity in other brain areas and reduces overall brain damage.

QoL in patients with MS is not systematically assessed in routine clinical practice. Health-related QoL is a concept used to represent a patient's perception of their health status (*Post, 2014; Ysrraelit et al., 2017*). A patient's perception of QoL can even predict disease progression and disability (*Walton et al., 2020; Visschedijk et al., 2004*). QoL is mainly based on the subjective measurement of a patient's health status, offering a quantitative method for monitoring health status (*Gitman et al., 2023*). The values of all SF36 domains and two summary scores of QoL, PCS and MCS, significantly improved after rehabilitation. The best results were obtained in the domain of physical

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functioning, while the lowest results were in the domain of limitations due to emotional difficulties. At the beginning of treatment, our patients had an interview with a psychologist and a social worker. The importance of social support for better QoL is already emphasized (*Gil-González et al., 2020*). Our results showed no significant correlation between age and PCS and MCS. It would be expected that with aging and MS progression there will be a worse QoL. This was found in a research where old age was related to poorer outcomes in domains of SF36 except mental health (*Ysrraelit et al., 2017*). Older patients, neurological damage and disability were identified as risk factors for QoL (*Calandri et al, 2017*).

MS is most often diagnosed at a younger age, and the non-existence of this difference with age and its association with QoL in our work can be linked to the fact that patients who are diagnosed with MS, with no possibility of cure, need time to come to terms with this emotional shock and to cope with future challenges (*Gil-González et al., 2020*). Also they need to adapt to a life with the disease and to provide themselves with as much QoL as possible. The results of our work did not find a statistically significant correlation between the duration of the disease and the PCS and MCS. Literature data shows the existence of a correlation between the duration of the disease and employment in patients with MS and the total SF36 score in univariate analysis, however, this correlation was not significant in multivariate analysis (*Contentti et al, 2017*). Also, a study did not show the existence of a correlation between the duration of MS and QoL (*Morales et al., 2007*). This means that the experience of the disease, its acceptance, living with it and achieving QoL is equally demanding both at the beginning and in the advanced stages of the disease, regardless of the degree of dysfunctionality.

In our sample, EDSS, PCS and MCS scores improved after rehabilitation, but the EDSS did not correlate with PCS and MCS. Also, the eight domains of the SF36 had no significant correlations with the EDSS. A previous study showed that patients and doctors disagreed about which health domains are most important in MS (*Kremenchutzky et al., 2013*). The combination of relapse, progression of physical disability, and disease activity assessed by NMR reflect only part of the impact of MS on the patient's daily life. Measurements of health-related QoL have been considered as relevant assessments of disease progression, response to treatment, and the level of assistance patients need (*Lysandropoulos et al., 2015*). Therefore, researchers recommend that assessment of disease-related QoL should be included along with other parameters (clinical and biological) when assessing response to disease treatment. The inclusion of the individual perspective of the patient is a key element in improving healthcare outcomes (*Giovannoni et al., 2015*).

The main limitation of our study is that patients did not have organized psychological treatments, which we believe would have given significantly better MCS values.

CONCLUSION

In patients with MS, functional state and QoL significantly improve after organized physical therapy, but there is no correlation between them. Duration of the disease has a significant correlation with functional state, but not with quality of life. Age of patients does not correlate with functional status or with quality of life. Health professionals need to incorporate QoL assessment into assessments of disease severity, progression and treatment success to obtain the most relevant results in creating the right treatment strategy.

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Perception of the Interpretation of Early Recognition and Support of Sports Gifted Students

Percepcija tumačenja ranog prepoznavanja i podrške sportski nadarenih učenika

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Abstract: The research was conducted on a sample of 102 respondents (teachers/professors) employed in elementary schools in the Zenica-Doboj Canton of the Federation of Bosnia and Herzegovina. The main goal of the research is to determine the attitudes and possible differences in the attitudes of teachers and professors regarding the early recognition and development of athletically gifted students who transition from classroom to subject classes, in the activities that the student engages in with regard to the gender, work status, age and level of education of the respondents. As a measuring instrument in the research, a questionnaire with a five-point Likert scale was used, in which each statement has 5 answers (I do not agree at all, I do not agree, I have no opinion/I am neutral, I agree, I completely agree). The survey questionnaire contained seven indicators for the assessment of early recognition and support for the development of sports gifted students, as well as questions related to the respondent's gender, workplace/position, age and level of education. The results of the t-test and the analysis of variance of the different groups with LSD Post Hoc comparison tests were used to determine any statistically significant differences between the groups of respondents with regard to gender, workplace/position, age and level of education. The obtained results indicate that there are no statistically significant differences in the attitudes of teachers/professors regarding the early recognition and development of athletically gifted students in the activities that the student engages in with regard to gender and age, and the differences in the attitudes of the respondents were determined with regard to work status and level of education of the respondents.

Keywords: respondents, perception, support, early recognition, development, sports talent

Sažetak: Istraživanje je provedeno na uzorku od 102 ispitanika (nastavnika/profesora) zaposlenih u osnovnim školama Zeničko-dobojskog kantona Federacije Bosne i Hercegovine. Osnovni cilj istraživanja je utvrđivanje stavova i eventualnih razlika u stavovima nastavnika i profesora o ranom prepoznavanju i razvoju sportski nadarenih učenika koji prelaze iz razredne u predmetnu nastavu, u aktivnostima kojima se učenik bavi s obzirom na spol, radni status, starosnu dob i stepen obrazovanja ispitanika. Kao mjerni instrumenat u istraživanju primijenjen je anketni upitnik petostepene Likertove skale u kojem svaka tvrdnja ima 5 odgovora (uopšte se ne slažem, ne slažem se, nemam mišljenje/neutralan sam, slažem se, potpuno se slažem). Anketni upitnik je sadržavao sedam indikatora za procjenu ranog prepoznavanja i podrške razvoja sportski nadarenih učenika, kao i pitanja koja se odnose na spol, radno mjesto/poziciju, starosnu dob i stepen obrazovanja ispitanika. Za utvrđivanje eventualnih statistički značajnih razlika između grupa ispitanika s obzirom na spol, radno mjesto/poziciju, starosnu dob i stepen obrazovanja ispitanika primijenjeni su rezultati t-testa i analiza varijanse različitih grupa sa LSD Post Hoc testovima poređenja. Dobijeni rezultati ukazuju da nema statistički značajnih razlika u stavovima nastavnika/profesora o ranom prepoznavanju i razvoju sportski nadarenih učenika u aktivnostima kojima se učenik bavi s obzirom na spol i starosnu dob, a razlike u stavovima ispitanika su utvrđene s obzirom na radni status i stepen obrazovanja ispitanika.

Ključne riječi: ispitanici, percepcija, podrška, rano prepoznavanje, razvoj, sportska nadarenost

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INTRODUCTION

Sports talent is a natural talent present in sports at different levels of performance, from those individuals who do not yet participate, all the way to elite competitors" (Sturza-Milić, 2009a, p. 220). According to Malina (2010, in Čoh, 2016, p.2), talent in sports is a combination of above-average biomotor skills, creativity and inner motivation. Specially gifted children have several characteristics in common. These characteristics are: gifted children have similar behavior, the environment is crucial for the realization of their giftedness, if giftedness is not adequately stimulated, motivation is lost, gifted children experience the world and the environment in a different way than their peers, their needs are different, working with them is a big challenge, but also a big effort for parents, teachers and coaches. Finally, gifted children deserve gifted coaches and teachers.

According to Čoh (2016), a special current issue of identifying gifted children for sports is that gifted children, as a rule, show above-average abilities in several areas. Sport is only one of their possible choices. Sports practice opens up numerous questions, among which stand out: Is the early inclusion of gifted children or children in general, in particular sports generally beneficial? Is early specialization useful? Sports practice does not have clear answers. (Čoh, 2016, p. 3)

The role and significance of the school and teachers in this process is extremely important. The role of the school in the upbringing and education of the child is extremely important. As Đorđević (1998) points out, the role of schools and teachers in the identification and encouragement of gifted students has long since begun to attract the attention of a large number of researchers both in our country and in the world. Taking into account the role of the school in identifying and encouraging giftedness in children, Milić (2013) points out that "the identification of gifted students is a long-term process, which includes the entire analysis of one student, which means that it cannot be based on only one indicator, the results of which are our schools, unfortunately crucial for the assessment of giftedness" (Milić, 2013, pp. 113-114).

Bearing in mind that the educational process in schools is organized, planned and systematically led by professionally-pedagogically trained teachers, this presupposes that favorable conditions and opportunities for proper and successful education have been created in schools. That is why, from a social point of view, the school represents a developed and powerful factor in educational and wider educational activity (Vukasović, 1998, p. 237). In school, teacher and student communicate creatively through teaching and build the teaching process. A teacher is a person who or-

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Sportska nadarenost je prirodna nadarenost prisutna u sportu na različitim nivoima izvođenja, od onih pojedinaca koji još ne učestvuju, pa sve do elitnih takmičara" (Sturza-Milić, 2009a, str. 220). Talentovanost u sportu je, smatra Malina (2010, u Čoh, 2016, str.2) kombinacija nadprosječnih biomotoričkih sposobnosti, kreativnosti i unutrašnje motivacije. Posebno nadarena djeca imaju nekoliko zajedničkih svojstava. Ta svojstva su: nadarena djeca su sličnog ponašanja, okolina je ključna za realizaciju njihove nadarenosti, ako nadarenost nije adekvatno potaknuta, gubi se motivacija, nadarena djeca doživljavaju svijet i okolinu na drugačiji način od njhovih vršnjaka, njihove potrebe su drugačije, rad sa njima je veliki izazov, ali i veliki napor za roditelje, učitelje i trenere. Na kraju, nadarena djeca zaslužuju nadarene trenere i učitelje.

Posebna je aktuelna problematika identifikacije nadarene djece za sport, smatra Čoh (2016) je ta što nadarena djeca po pravilu pokazuju nadprosječne sposobnosti na više područja. Sport je samo jedna od njihovih mogućih opredeljenja. Sportska praksa otvara brojna pitanja, između kojih se izdvajaju: Dali je rano uključivanje nadarene djece ili djece u opšte, u pojedine sportove opšte korisno? Da li je rana specijalizacija korisna. Sportska praksa nema sasvim jasnih odgovora. (Čoh, 2016, str. 3)

Uloga i značaj škole i nastavnika u ovom procesu je od izuzetne važnosti. Uloga škole u odgoju i obrazovanju djeteta je izuzetno značajna. Kako ističe Đorđević (1998), uloga škole i nastavnika u identifikaciji i podsticanju nadarenih učenika je odavno počela zaokupljati pažnju velikog broja istraživača kako kod nas tako i u svijetu. Uzimajući u obzir ulogu škole u identifikaciji i podsticanju nadarenosti kod djece Milić (2013), ističe da je „identifikacija nadarenih učenika dugotrajan proces, koji uključuje cjelokupnu analizu jednog učenika, što znači da ne može biti zasnovana na samo jednom pokazatelju, čiji su rezultati u našim školama, nažalost presudni za procjenu nadarenosti." (Milić, 2013, str. 113-114).

Imajući u vidu da je odgojno-obrazovni proces u školama organizovan, planski i sistematski vođen od strane stručno-pedagoški osposobljenih učitelja i nastavnika to pretpostavlja da su u školama stvoreni povoljni uslovi i mogućnosti za pravilan i uspješan odgoj. Zato škola sa društvenog gledišta predstavlja razvijen i snažan faktor obrazovnog i šireg odgojnog djelovanja (Vukasović,1998, str. 237). U školi, nastavnik i učenik komuniciraju stvaralačkim putem nastave i grade nastavni proces. Nastavnik je ličnost koja organizuje i formira odgojno-obrazovni proces na način koji mu istovremeno

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ganizes and forms the educational process in a way that simultaneously enables him to be a partner in communication and interaction with students. The quantity and quality of learning, teaching and educational procedures, forms of leadership, class-teaching climate largely depend on the teacher's personality, which together leads to certain educational results. In order to achieve such results, teachers are expected to have a high level of knowledge, general culture, moral values, as well as personality traits that are significant for the function of a teacher. (Pedagogical encyclopedia II, 1989). A teacher is a professionally-pedagogically qualified person who plans, prepares and carries out lessons and the entire educational work in schools and other pedagogical institutions.

Psychomotor abilities are most often included in the category of abilities that are included in general physical development or are separated as talent for certain sports activities. Psychomotor abilities refer to the ability to control one's own movements. The main components in this sense are good coordination, dexterity in various athletic disciplines, prominence in motor skills, precision of movement, good manipulative skills, high level of physical energy, etc. Depending on the individual sports branch, different combinations of these components can be found (Nešković, 2003).

On the basis of all that has been stated above, it should be especially emphasized that for those who deal with children (parents, educators and school employees), it is necessary to know about the forms of giftedness and its manifestation, as well as the early recognition and development of sports-gifted students, because that is the only way it can help gifted individuals to express and direct their genius in a certain field in the right way.

METHOD OF WORK

A sample of respondents
The sample of respondents consisted of classroom teachers and physical education teachers of elementary schools from the area of the Zenica-Doboj Canton of the Federation of Bosnia and Herzegovina. The total number of teacher/professor respondents was 102, 82 classroom teachers and 20 physical education teachers.

Structure of the sample of respondents
A total of 102 respondents (teachers/professors) participated in the research.

In relation to gender, the research included 80 or 78.40% of respondents (teachers) of the female gender and 22 or 21.60% (teachers of the male gender).

In relation to work status/position, the research cov-

omogućava partnerstvo u komunikaciji i interakciji sa učenicima. Od ličnosti nastavnika u velikoj mjeri zavise kvantitet i kvalitet učenja, nastavni i odgojni postupci, oblici rukovođenja, razredno-nastavna klima, što zajedno dovodi do određenih odgojnih rezultata. Da bi se takvi rezultati mogli postići od nastavnika se očekuje visok nivo znanja, opšta kultura, moralne vrijednosti, kao i takve osobine ličnosti koje su značajne za funkciju nastavnika. (Pedagoška enciklopedija II, 1989). Nastavnik je stručno-pedagoški osposobljena osoba koja planira, priprema i izvodi nastavu i cjelokupan odgojno-obrazovni rad u školi i drugim pedagoškim institucijama.

Psihomotorne sposobnosti se najčešće ubrajaju u kategorija sposobnosti koje su uklopljene u opšti fizički razvoj ili je izdvojena kao talentovanost za određene sportske djelatnosti. Psihomotorne sposobnosti se odnose na sposobnost kontrole sopstvenih pokreta. Glavne komponente u tom smislu predstavljaju dobra koordinacija, spretnost u raznim atletskim disciplinama, istaknutost u motoričkim vještinama, preciznost pokreta, dobre manipunativne vještine, visok nivo fizičke energije itd. U zavisnosti od pojedine sportske grane mogu se naći različite kombinacije ovih komponenti (Nešković, 2003).

Na osnovu svega što je prethodno navedeno treba posebno naglasiti da je za one koji se bave djecom (roditelji, odgajatelji i zaposleni u školi) neophodno znanje o oblicima nadarenosti i njenom ispoljavanju, te ranom prepoznavanju i razvoju sportski nadarenih učenika jer se jedino na taj način može pomoći nadarenim pojedincima da svoju genijalnost u određenom području ispolje i usmjere na pravi način.

METOD RADA

Uzorak ispitanika
Uzorak ispitanika činili su nastavnici razredne nastave i profesori fizičkog vaspitanja osnovnih škola sa područja Zeničko-dobojskog kantona Federacije Bosne i Hercegovine. Ukupan broj ispitanika nastavnika/profesora iznosio je 102 i to 82 nastavnika razredne nastave i 20 profesora fizičkog vaspitanja.

Struktura uzorka ispitanika
U istraživanju je učestvovalo ukupno 102 ispitanika (nastavnika/profesora).

U odnosu na spol istraživanjem je obuhvaćeno 80 ili 78,40% ispitanika (učitelja/nastavnika) ženskog spola i 22 ili 21,60% (učitelja/nastavnika muškog spola.

U odnosu na radni status/radno mjesto istraživa-

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ered 82 or 80.40 classroom teachers and 20 or 19.60% of physical education teachers.

In relation to age, respondents were divided into four categories: up to 25 years old 4 respondents (teachers/professors) or 3.90%, from 26-35 years old 17 respondents (teachers/professors) or 16.70%, from 36-45 years 59 respondents (teachers/professors) or 57.80% and from 46-55 years 22 respondents (teachers/professors) or 21.60%.

In relation to the level of education, 68 or 66.70% of the respondents with a higher education, 25 respondents or 24.50% with a higher education and 9 or 8.80% of the respondents with a master's or doctorate degree participated in the research.

Sample variables

The measuring instruments used in the research were a questionnaire and an assessment scale. The questionnaire for the assessment of attitudes was constructed according to the Likert scale model, where each statement is marked with five modalities (1-I do not agree at all, 2-I do not agree, 3-I have no opinion/I am neutral, 4-I agree, 5-completely I agree.).

The questionnaire included general information about the respondents (gender, workplace/position, age, level of education) and 7 indicators of developmentally appropriate practice with a scale of familiarity with the phrase "developmentally appropriate practice". Respondents (teachers/professors) were given clear and precise instructions on how to answer unclear statements and questions (survey questionnaire and assessment scale).

Scale of indicators of knowledge of developmentally appropriate practice

The scale of indicators of knowledge of the characteristics of developmentally appropriate practice in order to identify and encourage giftedness in children consisted of seven positions, which teachers should rate as: 1 = I do not agree at all, 2 = I do not agree, 3 = I have no opinion/I am neutral, 4 = agree and 5 = completely agree.

Respondents were able to declare themselves or opt for one of the five modalities. The content of indicators for the identification and treatment of athletically gifted students during the transition from classroom to subject teaching in primary schools referred to:
1. Creating the program in relation to the student's abilities..................................RPP 1
2. Designing activities taking into account the student's developmental age and interests........RPP 2
3. Normative approach to student development ....RPP 3
4. General pedagogical approach to the gifted student..RPP 4

U odnosu na starosnu dob ispitanici su podijeljeni u četiri kategorije i to: do 25 godina 4 ispitanika (nastavnika/profesora) ili 3,90%, od 26-35 godina starosti 17 ispitanika (nastavnika/profesora) ili 16,70%, od 36-45 godina 59 ispitanika (nastavnika/profesora) ili 57,80% i od 46-55 godina 22 ispitanika (nastavnika/profesora) ili 21,60%.

U odnosu na stepen obrazovanja u istraživanju je učestvovalo 68 ili 66,70% ispitanika sa visokom stručnom spremom 25 ispitanika ili 24,50% sa višom stručnom spremom i 9 ili 8,80% ispitanika master ili doktor nauka.

Uzorak varijabli

Mjerni instrumenti koji su korišteni u istraživanju predstavljali su anketni list i skala procjene. Anketni list za procjenu stavova konstruisan je po modelu Likertove skale pri čemu je svaka tvrdnja označena sa pet modaliteta (1-uopšte se ne slažem, 2-ne slažem se, 3-nemam mišljenje/neutralan sam, 4-slažem se, 5-potpuno se slažem.).

Anketni list je obuhvatao opšte podatke o ispitanicima (spol, radno mjesto/poziciju, starosnu dob, stepen obrazovanja) i 7 indikatora razvojno primjerene prakse sa skalom poznavanja sintagme "razvojno primjerena praksa". Ispitanicima (nastavnici/profesori) su data jasna i precizna uputstva o načinu davanja odgovora, nejasnih tvrdnji i pitanja (anketni upitnik i skala procjene).

Skala pokazatelja poznavanja razvojno primjerene prakse

Skalu pokazatelja poznavanja obilježja razvojno primjerena praksa u cilju identifikacije i podsticanja darovitosti kod djece činilo je sedam stavova, koje bi nastavnici trebali ocijeniti kao: 1 = uopšte se ne slažem, 2 = ne slažem se, 3 = nemam mišljenja/neutralan sam, 4 = slažem se i 5 =potpuno se slažem.

Ispitanici su se mogli izjasniti odnosno opredijeliti za jedan od pet modaliteta. Sadržaj pokazatelja identifikacije i tretmana sportski nadarenih učenika pri prijelazu iz razredne u predmetnu nastavu u osnovnim školama odnosio se na:
1. Kreiranje programa u odnosu na učenikove sposobnosti ....RPP 1
2. Dizajniranje aktivnosti obzirom na učenikovu razvojnu dob i interese...............................RPP 2
3. Normativni pristup učenikovom razvoju ....RPP 3
4. Opšti pedagoški pristup nadarenom učeniku..RPP 4

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5. The student's behavior in accordance
   with his age .... RPP 5
6. Adaptation of the curriculum to the
   gifted student....................................... RPP 6
7. Possibilities of enriching content and
   supporting student autonomy........................... RPP 7

Statistical data processing

Basic status parameters were calculated and determined for all applied variables of developmentally appropriate practice. Arithmetic mean (AS) was calculated from measures of central tendency, and standard deviation (St. Dev.) from measures of variability.

To determine statistically significant differences between groups of respondents, the t-test and analysis of variance of different groups with LSD Post Hoc comparison tests were used.

THE RESULTS

Table 1 shows the calculated values of measures of central tendency, variability and frequency distribution of developmentally appropriate practice (DPP) variables. The calculated arithmetic mean (AS) of all indicators of 4.13 shows that teachers very well recognize early sports talent in students, which is particularly important for creating programs in relation to students' abilities and their further development. The value of the standard deviation (St.Dev.) of 0.84 indicates that the dispersion around the arithmetic mean is very small, which is also confirmed by the coefficient of variability (CV) of 20.34% and thus the very good homogeneity of the obtained results for this sample of respondents.

The vast majority of respondents (91.20%) believe that the phrase "developmentally appropriate practice" means creating a program in relation to the student's abilities. 5.90% of respondents have no opinion and 2.90% disagree with the stated statement.

Analyzing the results, we see that 88.20% of the respondents agree and completely agree that the phrase "developmentally appropriate practice" means designing activities taking into account the student's developmental age and interests. 10.80% of teachers/professors are neutral and one respondent (1.00%) disagrees with the stated statement.

The respondents in the majority (75.50%) declared that under the phrase "developmentally appropriate practice" implies a normative approach to student development. 16.70% of respondents have no opinion. The percentage of negative answers is 7.80%.

From Table 1, we see that 82.30% of respondents believe that the term "developmentally appropriate prac-

5. Učenikovo ponašanje u skladu s njegovom
   uzrasnom dobi...................................... RPP 5
6. Prilagođavanje nastavnog programa
   nadarenom učeniku.................................. RPP 6
7. Mogućnosti obogaćivanja sadržaja i
   podržavanja učenikove autonomije .... RPP 7

Statistička obrada podataka

Za sve primijenjene varijable razvojno primjerene prakse izračunati su i utvrđeni osnovni statustučki parametri. Od mjera centralne tendencije izračunata je aritmetička sredina (AS), a od mjera varijabilnosti standardna devijacija (St. Dev.).

Za utvrđivanje statistički značajnih razlika između grupa ispitanika primijenjen je t-test i analiza varijanse različitih grupa sa *LSD Post Hoc* testovima poređenja.

REZULTATI

U tabeli 1 prikazane su izračunate vrijednosti *m*jera centralne tendencije, varijabilnosti i distribucije frekvencije varijabli razvojno primjerene prakse (RPP). Izračunata aritmetička sredina (AS) svih indikatora od 4,13 pokazuje da nastavnici veoma dobro prepoznaju ranu sportsku nadarenost kod učenika koja je posebno važna za izradu programa u odnosu na učenikove sposobnosti i njihov dalji razvoj. Vrijednost standardne devijacije (St. Dev.) od 0,84 ukazuje da je rasipanje oko aritmetičke sredine veoma malo, što potvrđuje i koeficijent varijabilnosti (CV) od 20,34% a time i veoma dobru homogenost dobivenih rezultata za ovaj uzorak ispitanika.

Velika većina ispitanika (91,20%) smatra da se pod sintagmom „razvojno primjerena praksa" podrazumijeva *kreiranje programa u odnosu na učenikove sposobnosti.* Bez mišljenja je 5,90% ispitanika i 2,90% se ne slaže s navedenom tvrdnjom.

Analizom rezultata vidimo da se 88,20% ispitanika slaže i potpuno slaže da se pod sintagmom „razvojno primjerena praksa" podrazumijeva *dizajniranje aktivnosti obzirom na učenikovu razvojnu dob i interese.* Neutralno je 10,80% nastavnika/profesora i jedan ispitanik (1,00%) se ne slaže s navedenom tvrdnjom.

Ispitanici u većini (75,50%) su se izjasnili da se pod sintagmom „razvojno primjerena praksa" podrazumijeva *normativni pristup učenikovom razvoju.* Bez mišljenja je 16,70% ispitanika. Procenat negativnih odgovora iznosi 7,80%.

Iz Tabele 1 vidimo da 82,30% ispitanika smatra da se se pod sintagmom „razvojno primjerena praksa" podrazumijeva *opšti pedagoški pristup nadarenom učeniku.* Bez mišljenja je 8,80% nastavnika/profesora, dok

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tice" means a general pedagogical approach to a gifted student. 8.80% of teachers/professors have no opinion, while 5.90% do not agree and 2.90% do not agree at all with the stated statement.

Based on the results, we see that 74.50% of the respondents agree and completely agree that the term "developmentally appropriate practice" refers to the student's behavior in accordance with his age. 17.60% of teachers/professors are neutral, while 7.80% of respondents do not agree or do not agree at all with the statement offered.

The majority of respondents (85.30%) agreed that under the phrase "developmentally appropriate practice" means adapting the curriculum to the gifted student. 5.90% of respondents do not agree with this statement, while 8.80% of respondents are neutral.

For the claim that the phrase "developmentally appropriate practice" implies possibilities 86.30% responded positively to enriching content and supporting student autonomy teacher/professor. 10.80% of respondents have no opinion and 2.90% disagree with the stated statement.

Therefore, the most positive answers were for the first claim, i.e. that under the phrase "developmental appropriate practice" implies creating a program in relation to the student's abilities.

se 5,90% ne slaže i 2,90% uopće ne slaže s navedenom tvrdnjom.

Na osnovu rezultata vidimo da se 74,50% ispitanika slaže i potpuno slaže da se pod sintagmom „razvojno primjerena praksa" podrazumijeva *učenikovo ponašanje u skladu s njegovom uzrasnom dobi*. Neutralno je 17,60% nastavnika/profesora dok se 7,80% ispitanika ne slaže i uopće ne slaže s ponuđenom tvrdnjom.

Većina ispitanika (85,30%) se složila da se pod sintagmom „razvojno primjerena praksa" podrazumijeva *prilagođavanje nastavnog programa nadarenom učeniku*. S navedenom tvrdnjom se ne slaže 5,90% ispitanika dok je 8,80% ispitanika neutralno.

Za tvrdnju da se pod sintagmom „razvojno primjerena praksa" podrazumijevaju mogućnosti *obogaćivanja sadržaja i podržavanje učenikove autonomije* pozitivno je odgovorilo 86,30% nastavnika/profesora. Bez mišljenja je 10,80% ispitanih i 2,90% se ne slaže s navedenom tvrdnjom.

Dakle, najviše pozitivnih odgovora bilo je za prvu tvrdnju tj. da se pod sintagmom „razvojno primjerena praksa" podrazumijeva kreiranje programa u odnosu na učenikove sposobnosti.

Table 1. Measures of central tendency, variability and frequency distribution of characteristics of developmentally appropriate practice (RPP)

Tabela 1. Mjere centralne tendencije, varijabilnosti i distribucije frekvencije obilježja razvojno primjerena praksa (RPP)

Indicator / Indikator	N	AS	St. Dev.	1%	2%	3%	4%	5%
RPP 1	102	4.43	.74	0.00	2.90	5.90	36.30	54.90
RPP2	102	4.32	.71	0.00	1.00	10.80	43.10	45.10
RPP 3	102	3.80	.90	3.90	3.90	16.70	58.80	16.70
RPP 4	102	3.94	.91	2.90	5.90	8.80	58.80	23.50
RPP 5	102	3.79	.87	2.90	4.90	17.60	58.80	15.70
RPP 6	102	4.32	.94	2.00	3.90	8.80	30.40	54.90
RPP7	102	4.30	.78	0.00	2.90	10.80	39.20	47.10

Legend: RPP-developmentally appropriate practice 1-7; N-total number of respondents; AS-arithmetic mean; St. Dev.-standard deviation

Legenda: RPP-razvojno primjerena praksa 1-7; N-ukupan broj ispitanika; AS-aritmetička sredina; St. Dev.-standardna devijacija

Table 2 shows the results of the t-test of the interpretation of developmentally appropriate practice in relation to the gender of the respondents. The value of t = 1.430 and its significance Sig.= .156 show us that there is no statistically significant difference in the attitudes of teachers/professors with regard to their gender in the perception of the interpretation of developmentally appropriate practice. The results indicate that the respondents (classroom teachers and subject teachers) regardless of gender. have similar attitudes in the interpretation of de-

U tabeli 2 prikazani su rezultati t-testa tumačenja razvojno primjerene prakse u odnosu na *spol ispitanika*. Vrijednost t = 1,430 i njegova značajnost Sig.= ,156 nam ukazuju da ne postoji statistički značajna razlika u stavovima nastavnika/profesora s obzirom na njihov spol u percepciji tumačenja razvojno primjerene prakse. Rezultati ukazuju da ispitanici (nastavnici razredne nastave i profesori predmetne nastave) bez obzira na spol imaju slične stavove u tumačenju obilježja razvojno primjerene što je po-

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velopmentally appropriate features. which is particularly important for the development of programs in relation to students' abilities and their further development.

sebno važno za izradu programa u odnosu na učenikove sposobnosti i njihov daljnji razvoj.

Table 2. *Developmentally appropriate practice - comparison by gender (t-test)*

Tabela 2. *Razvojno primjerena praksa – upoređivanje po spolu (t-test)*

Parameters / Parametri	Sex / Spol	N	AS	St. Dev.	Differences AS / Razl. AS	F	Significance / Znač.	t-value / t-vrijed.	Sig.
RPPZ	Ž	80	4.15	.32	.12	3.272	.073	1.430	.156
	M	22	4.03	.43					

Legend: RPPZ-developmentally appropriate practice (collective); N-total number of respondents; AS-arithmetic mean; St.Dev.-standard deviation; Different AS-difference of arithmetic means; F and Means - Levene's test of equality of variances; t-value. and Sig.- value of the t-test and its significance

Legenda: RPPZ-razvojno primjerena praksa (zbirno); N-ukupan broj ispitanika; AS-aritmetička sredina; St.Dev.-standardna devijacija; Razl. AS-razlika aritmetičkih sredina; F i Znač.- Levenov test jednakosti varijansi; t-vrijed. i Sig.-vrijednost t-testa i njegova značajnost

Table 3 shows the results of the t-test of the interpretation of sports developmentally appropriate practice in relation to the work status/job of the respondents. The value t= 2.370 and its significance Sig.= .020 indicate that there is a statistically significant difference (at the level of p<0.05) in the attitudes of teachers/professors with regard to work status/position in the perception of the interpretation of developmentally appropriate practice. Based on the value of the arithmetic mean (AS=4.17). it is evident that classroom teachers have more positive opinions compared to professors' views on the early recognition of athletically gifted students. which is particularly important for creating programs in relation to students' abilities and their further development.

U tabeli 3 prikazani su rezultati t-testa tumačenja sportske razvojno primjerene prakse u odnosu na *radni status/radno mjesto* ispitanika. Vrijednost t= 2,370 i njegova značajnost Sig.= **,020** ukazuju da postoji statistički značajna razlika (na nivou p<0,05) u stavovima nastavnika/profesora s obzirom na radni status/poziciju u percepciji tumačenja razvojno primjerene prakse. Na osnovu vrijednosti aritmetičke sredine (AS=4,17) vidljivo je da nastavnici razredne nastave imaju pozitivnija mišljenja u odnosu na stavove profesora o ranom prepoznavanju sportski nadarenih učenika koja je posebno važna za izradu programa u odnosu na učenikove sposobnosti i njihov daljnji razvoj.

Table 3. *Developmentally appropriate practice - comparison by work status (t-test)*

Tabela 3. *Razvojno primjerena praksa – upoređivanje po radnom statusu (t-test)*

Parameters / Parametri	Sex / Spol	N	AS	St. Dev.	Differences AS / Razl. AS	F	Significance / Znač.	t-value / t-vrijed.	Sig.
RPPZ	Nastavnik	82	4.17	.34	.21	.043	.836	2.370	.020
	Profesor	20	3.96	.35					

Legend: RPPZ-developmentally appropriate practice (collective); N-total number of respondents; AS-arithmetic mean; St.Dev.-standard deviation; Different AS-difference of arithmetic means; F and Means - Levene's test of equality of variances; t-value. and Sig.- value of the t-test and its significance

Legenda: RPPZ-razvojno primjerena praksa (zbirno); N-ukupan broj ispitanika; AS-aritmetička sredina; St.Dev.-standardna devijacija; Razl. AS-razlika aritmetičkih sredina; F i Znač.- Levenov test jednakosti varijansi; t-vrijed. i Sig.-vrijednost t-testa i njegova značajnost

Table 4 shows the results of the F-test of the interpretation of developmentally appropriate practice in relation to the age of the respondents and its statistical significance. The F-test value (1.033) and its significance (Sig. .382) show that there is no statistically significant difference between teachers/professors with regard to age in the perception of the interpretation of developmentally appropriate practice.

U tabeli 4 prikazani su rezultati F-testa tumačenja razvojno primjerene prakse u odnosu na *starosnu dob* ispitanika i njegova statistička značajnost. Vrijednost F-testa (1,033) i njegova značajnost (Sig. ,382) pokazuju da ne postoji statistički značajna razlika između nastavnika/profesora s obzirom na starosnu dob u percepciji tumačenja razvojno primjerene prakse.

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Table 4. *Developmentally appropriate practice - comparison by age (F-test)*

Tabela 4. *Razvojno primjerena praksa - upoređivanje obzirom na starosnu dob (F-test)*

Parameters / Parametri	N	df	F	Sig.
RPPZ	102	3	1.033	.382

Legend: N-total number of respondents; RPPZ- developmentally appropriate practice (collective); df- number of degrees of freedom; F and Sig. - the value of the F-test and its significance

Legenda: N-ukupan broj ispitanika; RPPZ-razvojno primjerena praksa (zbirno); df- broj stepena slobode; F i Sig.- vrijednost F-testa i njegova značajnost

Table 5 shows the results of the LSD Post Hoc test of attitudes about developmentally appropriate practice-comparison with regard to the age of the respondents. The analysis of table 5 shows that there are no statistically significant differences between age groups when it comes to the interpretation of developmentally appropriate practices. These results indicate that there is no statistically significant difference in teachers' views on the early recognition of sports talent. which is particularly important for developing programs in relation to students' abilities and their further development. considering the age of the respondents.

U tabeli 5 prikazane su rezultati LSD Post Hoc testa stavova o razvojno primjerenoj praksi-upoređivanje s obzirom na starosnu dob ispitanika. Analizom tabele 5 vidljivo je da ne postoje statistički značajne razlike između dobnih skupina kada je u pitanju tumačenje razvojno primjerene prakse. Ovi rezultati ukazuju da ne postoji statistički značajna razlika u stavovima nastavnika o ranom prepoznavanju sportske nadarenosti koja je posebno važna za izradu programa u odnosu na učenikove sposobnosti i njihov daljnji razvoj, s obzirom na dob ispitanika.

Table 5. *Developmentally appropriate practice - age comparison (LSD Post Hoc test)*

Tabela 5. *Razvojno primjerena praksa – upoređivanje obzirom na starosnu dob (LSD Post Hoc testa)*

Age / Dob		Difference AS / Razlika AS	SE	Sig.
Up to 25 years / Do 25 godina	26 to 35 years / 26 do 35 godina	-.036	.193	.854
	36 to 45 years / 36 do 45 godina	-.058	.180	.748
	46 to 55 years / 46 do 55 godina	.094	.189	.620
26 to 35 years / 26 do 35 godina	to 25 years / do 25 godina	.036	.193	.854
	36 to 45 years / 36 do 45 godina	-.022	.096	.818
	46 to 55 years / 46 do 55 godina	.130	.112	.251
36 to 45 years / 36 do 45 godina	to 25 years / do 25 godina	.058	.180	.748
	26 to 35 years / 26 do 35 godina	.022	.096	.818
	46 to 55 years / 46 do 55 godina	.152	.087	.084
46 to 55 years / 46 do 55 godina	to 25 years / do 25 godina	-.094	.189	.620
	26 to 35 years / 26 do 35 godina	-.130	.112	.251
	36 to 45 years / 36 do 45 godina	-.152	.087	.084

*Legend: Difference AS – difference of arithmetic means; SE- standard error; Sig. - statistical significance; *- there is a statistically significant difference at the p < 0.05 level*

*Legenda: Razlika AS –razlika aritmetičkih sredina; SE- standardna greška; Sig.- statistička značajnost; *- postoji statistički značajna razlika na nivou p < 0,05*

Table 6 shows the results of the F-test of the interpretation of developmentally appropriate practice in relation to the level of education of the respondents and its statistical significance. The F-test value (5.235) and its significance (Sig. .007) show that there is a statistically significant difference (at the p<0.05 level) between teachers/professors with regard to the level of education in the perception of the interpretation of developmentally appropriate practice.

U tabeli 6 prikazani su rezultati F-testa tumačenja razvojno primjerene prakse u odnosu na *stepen obrazovanja* ispitanika i njegova statistička značajnost. Vrijednost F-testa (5,235) i njegova značajnost (Sig. ,007) pokazuju da postoji statistički značajna razlika (na nivou p<0,05 između nastavnika/profesora s obzirom na stepen obrazovanja u percepciji tumačenja razvojno primjerene prakse.

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Table 6. *Developmentally appropriate practice - comparison by level of education (F-test)*

Tabela 6. *Razvojno primjerena praksa - upoređivanje obzirom na stepen obrazovanja (F-test)*

Parameters / Parametri	N	df	F	Sig.
RPPZ	102	2	5.235	.007

Legend: *N-total number of respondents; RPPZ-developmentally appropriate practice (collective); df- number of steps freedom; F and Sig. - the value of the F-test and its significance*

Legenda: *N-ukupan broj ispitanika; RPPZ-razvojno primjerena praksa (zbirno); df- broj stepena slobode; F i Sig.- vrijednost F-testa i njegova značajnost*

Table 7 shows the results of the LSD Post Hoc test of attitudes about developmentally appropriate practice-comparison with regard to the level of education of the respondents (LSD Post Hoc test). Analyzing the results of the Post Hoc test. it is evident that there are statistically significant differences between teachers/professors with regard to the highest achieved level of education in the perception of the interpretation of developmentally appropriate practice. Differences were found between respondents with higher and higher education. Among the other respondents. the differences are not statistically significant.

U tabeli 7 prikazani su rezultati LSD Post Hoc testa stavova o razvojno primjerenoj praksi-upoređivanje s obzirom na stepen obrazovanja ispitanika (LSD Post Hoc test). Analizom rezultata Post Hoc testa vidljivo je da postoje statistički značajne razlike između nastavnika/profesora obzirom na najviši postignuti stepen obrazovanja u percepciji tumačenja razvojno primjerene prakse. Razlike su utvrđene između ispitanika sa višom i visokom stručnom spremom. Između ostalih ispitanika razlike nisu statistički značajne.

Table 7. *Comparison of significance with regard to level of education (LSD Post Hoc test)*

Tabela 7. *Upoređivanje značajnosti obzirom na stepen obrazovanja (LSD Post Hoc testa)*

Level of education / Stepen obrazovanja		Difference AS / Razlika AS	SE	Sig.
high school education / VŠS	*higher vocational education* / VSS	-.231*	.078	.004
	Master's degree and Doctor of Science / Mr i Dr	-.013	.130	.922
higher vocational education / VSS	*high school education* / VŠS	.231*	.078	.004
	Master's degree and Doctor of Science / Mr i Dr	.218	.119	.069
Master's degree and Doctor of Science / Mr i Dr	*high school education* / VŠS	.013	.130	.922
	higher vocational education / VSS	-.218	.119	.069

Legend: *Difference AS – difference of arithmetic means; SE- standard error; Sig.-statistical significance * - there is a statistically significant difference at the p < 0.05 level*

Legenda: *Razlika AS –razlika aritmetičkih sredina; SE-standardna greška; Sig.-statistička značajnost * - postoji statistički značajna razlika na nivou p < 0,05*

Analyzing the obtained results. it can be concluded that there is no statistically significant difference in the perception of teachers and professors regarding the early recognition of athletically gifted students. which is particularly important for creating programs in relation to the student's abilities and their further development. considering the gender and age of the respondents.

However. the obtained results indicate that there is a statistically significant difference in the perception of teachers and professors regarding the early recognition of athletically gifted students. which is particularly important for creating programs in relation to the student's abilities and their further development. considering the work status and level of education of the respondents.

Analizirajući dobivene rezultate može se konstatovati da ne postoji statistički značajna razlika u percepciji nastavnika i profesora o ranom prepoznavanju sportski nadarenih učenika koja je posebno važna za izradu programa u odnosu na učenikove sposobnosti i njihov daljnji razvoj, s obzirom na *spol i dob ispitanika.*

Međutim, dobiveni rezultati ukazuju da postoji statistički značajna razlika u percepciji nastavnika i profesora o ranom prepoznavanju sportski nadarenih učenika koja je posebno važna za izradu programa u odnosu na učenikove sposobnosti i njihov daljnji razvoj, s obzirom *na radni status i stepen obrazovanja i*spitanika.

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DISCUSSION

Parents and schools play an irreplaceable role in the identification and support of talented students. Đorđević and Maksić (2005) believe that the opinion of many is confirmed that parents. teachers and students are very interested in creating conditions that would ensure adequate education and treatment of gifted students. Studying the role of teachers in the process of encouraging giftedness in students. Kopas-Vukašinović (2012) points out that the teacher should "create a social context in which it is possible to encourage children's interest in experiential learning and the need for each of them to be an active factor in their own development.

Grandić and Letić (2009) believe that the formula for a teacher's successful work with gifted students is his constant openness and focus on personal and professional development. because practice has shown that those teachers who have received some form of training or professional development for working with them they show a greater dose of patience and sensitivity when working with them. For the better position of gifted students in schools. George (2003) points out that every school should have a person who would be in charge of implementing educational forms for the needs of gifted students.

Also. the results of previous investigations indicate that the curriculum and program should be adapted for sports-gifted students that will motivate and encourage their giftedness and values. but this does not mean separating them from the peer group with similar interests and psychophysical abilities (Cvetković - Lay. Sekulić - Majurec. 1998; Raič et al. 1998; Đorđić. 2004; Trancle and Cushion. 2006).

The fact that there is very little significant research into the phenomenon of sports giftedness in our country imposes the need for a systematic study of this problem (Stojković. 2009; Bajrić et al.. 2019).

Rajović (2009) points out that the problem of identifying giftedness in general is a very difficult task and that there is still no generally accepted strategy or model on the basis of which giftedness could be identified in the right way. The same author believes that the development of giftedness depends almost entirely on the timely action of the family. school and social community (environment).

The system of regular schooling. educational process and activity is expressed for the needs of the average child - student. Gifted children are included in the regular system of upbringing and education. and for each such gifted child. an individual plan and program should be created. which would be created jointly by the classroom

DISKUSIJA

U identifikaciji i podršci talentovanih učenika nezamjenljivu ulogu imaju roditelji i škola. Đorđević i Maksić (2005), smatraju da je potvrđeno mišljenje mnogih da su roditelji, nastavnici i učenici vrlo zainteresovani za stvaranje uslova koji bi obezbijdili adekvatno obrazovanje i tretman nadarenih učenika. Proučavajući ulogu nastavnika/učitelja u procesu podsticanja nadarenosti kod učenika Kopas-Vukašinović (2012), ističe da nastavnik treba „stvoriti socijalni kontekst u kojem je moguće podsticati dječiju zainteresovanost za iskustveno učenje i potrebu da svako od njih bude aktivan činilac sopstvenog razvoja.

Grandić i Letić (2009), smatraju da je formula za uspješan rad nastavnika sa nadarenim učenicima njegova konstantna otvorenost i usmjerenost na lični i profesionalni razvoj, jer praksa je pokazala da oni nastavnici koji su bili obuhvaćeni nekim vidom obuke ili stručnog usavršavanja za rad sa njima pokazuju veću dozu strpljenja i senzibiliteta u radu sa nima. Radi boljeg položaja nadarenih učenika u školama George (2003), ističe da bi svaka škola trebala imati osobu koja bi bila zadužena za sprovođenje odgojno-obrazovnih oblika za potrebe nadarenih učenika.

Takođe, rezultati dosadašnjih istaživanja ukazuju da sportski nadarenim učenicima treba prilagoditi nastavni plan i program koji će motivisati i podsticati njhovu nadarenost i vrijednosti, ali to ne podrazumijeva izdvajanje iz vršnjačke grupe sličnih interesovanja i psihofizičkih sposobnosti (Cvetković - Lay, Sekulić – Majurec, 1998; Raič i sar. 1998; Đorđić, 2004; Trancle i Cushion, 2006).

Činjenica da je kod nas vrlo malo značajnijih istraživanja fenomena sportske nadarenosti, to nameće potrebu sistematskog proučavanja ovog problema (Stojković, 2009; Bajrić i sar., 2019).

Rajović (2009), ističe da je problem identifikacije nadarenosti uopšte veoma težak posao i da još uvijek nije ponuđena opšte prihvaćena strategija ili model na osnovu kojih bi se na pravi način mogla identifikovati nadarenost. Isti autor smatra da razvijanje nadarenosti gotovo u potpunosti zavisi od pravovrmenog djelovanja porodice, škole i društvene zajednice (okruženja).

Sistem redovnog školovanja, odgojno-obrazovnog procesa i djelovanja izražen je za potrebe prosječnog djeteta - učenika. Nadarena djeca uključena su u redovni sistem odgoja i obrazovanja, a za svako takvo nadareno dijete trebao bi se izraditi

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teachers and subject teachers of the school attended by such a student. In the countries of the European Union and North America. they have long understood the importance of teaching programs based on an individual approach to the student. including an individual approach to gifted students. therefore such curricula and programs are regularly implemented for gifted students of both preschool and school age. The programs often differ. but they have a common origin. which is to use an individual approach to provide the best and most suitable contents from the school system in a way that meets the needs of such students. The regular teaching process in our schools includes all children. so even gifted children are integrated into regular. supplementary or elective classes. By identifying sports gifted students in the regular educational process. such a program should be created in an extremely individual form for each gifted student. Classroom teachers play a big role in this. because during their daily work they were able to get to know each student better. his preferences. possibilities. and also his athletic talent. Experience shows that classroom teaching has always been more student-oriented than subject teaching. and the teacher had more time to devote to the student than a strictly subject-oriented teacher in subject teaching. In this sense. the cooperation of class teachers and subject teachers is also necessary. Teachers should cooperate with each other in their work so that the interest of gifted students is not misdirected (Group of authors. 2009; according to Baier. 2012).

Karnes. Shwedel and Williams (1983) believe that teachers in working with gifted children must not be rigid and inflexible. Also. the aforementioned authors believe that it is a mistake for gifted students to learn and practice things they already know. because while working with other children. the gifted student will be bored. and that is why the enriched plan and program enables the teacher to meet the gifted student by to solve more demanding and difficult tasks. One of the mistakes that teachers often repeat when working with gifted children is that they think that a gifted child is gifted in every sense.

The authors believe that the sporting talent of students represents a great capital of a society that should be recognized. encouraged and developed in a timely manner. in which teachers/professors. schools and families should take part. That is why it is very important to develop good and fundamental programs for the early identification of sports-gifted students so that they can later be encouraged and properly developed. which imposes the need to leave the framework of the current work system that is "turned" towards the average student.

individualni plan i program koji bi zajedno izradili učitelji razredne nastave i nastavnici predmetne nastave škole koju pohađa takav učenik. U zemljama Europske unije i Sjeverne Amerike odavno su shvatili važnost nastavnih programa koji se temelje na individualnom pristupu učeniku, pa tako i individualnom pristupu nadarenim učenicima, stoga se takvi nastavni planovi i programi redovno provode za nadarene učenike kako predškolske tako i školske uzrasne dobi. Programi se često razlikuju, ali imaju zajedničko ishodište, a to je individualnim pristupom dati najbolje i najprikladnije sadržaje iz školskog sistema na način koji odgovara potrebama takvih učenika. Redovni nastavni proces u našim školama uključuje svu djecu, pa su tako i nadarena djeca integrisana u redovnu, dopunsku ili izbornu nastavu. Identifikacijom sportski nadarenih učenika u redovnom odgojno-obrazovnom procesu, takav program bi u izrazito individualnom obliku trebalo načiniti za svakog nadarenog učenika. Tu veliku ulogu imaju učitelji razredne nastave jer su tokom svakodnevnog rada mogli bolje upoznati svakog učenika, njegove sklonosti, mogućnosti, pa tako i sportsku nadarenost. Iskustva govore da je razredna nastava uvijek bila više orijentisana na učenika nego predmetna nastava, a i učitelj je imao više vremena da se posveti učeniku od strogo predmetnog učitelja u predmetnoj nastavi. U tom smislu neophodna je i saradnja razrednih učitelja i predmetnih nastavnika. Učitelji trebaju međusobno sarađivati u radu kako se interes nadarenih učenika ne bi pogrešno usmjerio (Grupa autora, 2009; prema Baier, 2012).

Karnes, Shwedel i Wiliams (1983), smatraju da učitelji i nastavnici u radu sa nadarenom djecom nikako ne smeju biti kruti i nefleksibilani. Takođe, pomenuti autori smatraju da je greška da nadareni učenici uče i vježbaju stvari koje već znaju, jer za vrijeme rada sa ostalom djecom nadarenom učeniku će biti dosadno, te zato obogaćeni plan i program omogućava učitelju da nadarenom učeniku izađe u susret tako što će mu dati da rješava zahtjevnije i teže zadatke. Jedna od grešaka koju učitelji/ nastavnici često ponavljaju u radu sa nadarenom djecom jeste ta da smatraju da je nadareno dijete nadareno u svakom smislu.

Autori smatraju da sportska nadarenost učenika predstavlja veliki kapital jednog društva koju treba pravovremeno prepoznati, podsticati i razvijati u kojoj učešće trebaju uzeti nastavnici/profesori, škola i porodica. Zato je veoma važno razraditi dobre i temeljne programe za ranu identifikaciju sportski nadarenih učenika kako bi

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CONCLUSION

The calculated and established basic statistical parameters of all indicators (AS=4.13; St.Dev.=0.84 and CV=20.34%) show that the respondents very well recognize early sports talent in students. which is especially important for creating programs in relation to the student's abilities and their further development.

Analysis of T test results and analysis of variance of different groups with LSD Post Hoc comparison tests indicate that there are no statistically significant differences between teachers/professors in the perception of early recognition and support of athletically gifted students in relation to gender and age. and the differences were determined in relation to work status and level of education.

Due to the importance of the problem of early identification and support of athletically gifted students. the involvement of all participants in educational institutions and other institutions of the social community is necessary.

Bearing in mind the significance of the problem of identification and support of sports gifted students. the main problem of defining the methodology of identification of such students arises. which could be offered by some future research on this issue.

It is obvious that we need to leave the framework of the current work system that is "focused" on the average student and that does not include the early identification of gifted children and their better treatment in terms of motivation and creating better conditions for the development of the necessary anthropological characteristics and abilities.

Experiences and previous research indicate the need to create individual teaching programs that are based on an individual approach to the student. including an individual approach to gifted students. which should be implemented regularly. The programs are often different. but they have a common origin. which is to use an individual approach to provide the best and most appropriate contents from the school system in a way that meets the needs of gifted students.

se kasnije mogli podsticati i pravilno razvijati što nameće potrebu napuštanja okvira dosadašnjeg sistema rada koji je „okrenut'' prosječnom učeniku.

ZAKLJUČAK

Izračunati i utvrđeni osnovni statistički parametri svih indikatora (AS=4,13; St.Dev.=0,84 i CV=20,34%) pokazuje da ispitanici veoma dobro prepoznaju ranu sportsku nadarenost kod učenika koja je posebno važna za izradu programa u odnosu na učenikove sposobnosti i njihov dalji razvoj.

Analiza rezultata T testa i analize varijanse različitih grupa sa *LSD Post Hoc* testovima poređenja ukazuju da između nastavnika/profesora nema statistički značajnih razlika u percepciji ranog prepoznavanja i podrške sportski nadarenih učenika u odnosu na spol i starosnu dob a razlike su utvrđene u odnosu na radni status i stepen obrazovanja.

Zbog značaja problema rane identifikacije i podrške sportski nadarenih učenika neophodna je uključenost svih učesnika odgojno obrazovnih i drugih ustanova društvene zajednice.

Imajući u vidu značajnost problema identifikacije i podrške sportski nadarenih učenika nameće se glavni problem definisanja metodologije identifikacije takvih učenika što bi mogla ponuditi neka buduća istraživanja ove problematike.

Očigledno je da treba napustiti okvire dosadašnjeg sistema rada koji je „okrenut'' prosječnom učeniku i koji ne obuhvata ranu identifi kaciju nadarene djece i njihov kvalitetniji tretman u smislu motivacije i stvaranja boljih uslova za razvijanje potrebnih antropoloških karakteristika i sposobnosti.

Iskustva i dosadašnja istraživanja ukazuju na potrebu izrade individualnih nastavnih programa koji se temelje na individualnom pristupu učeniku, pa tako i individualnom pristupu nadarenim učenicima koje treba redovno sprovoditi. Programi se često razlikuju, ali imaju zajedničko ishodište, a to je individualnim pristupom dati najbolje i najprikladnije sadržaje iz školskog sistema na način koji odgovara potrebama nadarenih učenika.

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PRIMARY SCHOOL CHILDREN: CONTRIBUTION OF NUTRITIONAL STATUS IN EXPLANATION OF THEIR EXPLOSIVE AND REPETITIVE STRENGTH

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PRIMARY SCHOOL CHILDREN: CONTRIBUTION OF NUTRITIONAL STATUS IN EXPLANATION OF THEIR EXPLOSIVE AND REPETITIVE STRENGTH

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Abstract: *Recent studies have attested the fact that now days children are living a sedentary life, which causes an excessive increase in body weight, thus negatively affecting their health and motor skills. Furthermore, studies up to this point have proven that there are differences in the motor skills of pupils with different nutritional status.*
The aim of this research was to determine impact of nutritional status on motor skills of primary school children also to determine whether there are differences in motor abilities with respect to gender. The research was conducted on a sample of 239 pupils (128 girls and 111 boys) of the fourth grade. The variable sample consisted of 2 anthropometric variables (body weight and body height) and 6 variables for estimating explosive and repetitive strength. The obtained results of this research have shown that for boys there are negative correlation between their BMI and tests: long jump, high jump, squats and sit-ups. For the sample of girls, the BMI positively correlates with test throwing a medicine ball and negatively with test sit-ups. Furthermore, boys achieve better results in motor tests than girls.
Keywords: body mass index, children, motor performance, elementary education

INTRODUCTION

Excess body weight can be explained as an excess of body mass for a person's height, while obesity is considered the phenomenon of excessive accumulation of body fat in the body (Zavrsnik, 2004). Nowadays, overweight and obese children of younger school age are becoming more and more common. That is the reason why the overweight and obesity of children is becoming a serious public health problem. Previous researches support the fact that obesity in childhood can have negative effects on overall motor development (Morano, Colella, & Caroli, 2011). Moreover, most of the research conducted so far has shown that excess body weight and obesity negatively affect the level of motor skills in children of younger school age, and that there are differences in the motor skills of children with different nutritional status (Prskalo, Badrić & Bogović, 2015). Various factors such as physical activity, fitness level, and motor competence can influence the appearance of obesity in children (Bryant, Duncan, and Birch, 2014). It is establish that low level of physical activity is correlated with higher BMI in children (Janssen and LeBlanc 2010). Also children who are overweighed and obese are disadvantaged in antigravity motor skills (Barnett et. all, 2016; Prskalo, Badrić and Kunješić 2015). Increased body mass index causes reduced motor abilities in primary age school children. During the performing physical activities obese children feel tired more quickly than children with normal body weight, and that children are unable to persist doing activities for longer period of time and they become slower in doing physical activities (Ishud, & Romadona, 2020). In general, the result of the study conducted by Wibowo, Budiman and Sumarno (2020) shows that male children are better than female children in fine and gross motor skill mastery.

The main goal of this research was to determine whether the nutritional status assessed through the body mass index of younger school-aged children correlates with their motor skills (explosive and repetitive strength). The secondary goal was to determine whether there are statistically significant differences in the motor status of children with regard to their gender and nutritional status. In accordance with the set goals, the following hypotheses were set:

1. The body mass index (BMI) of children correlates negatively and statistically significantly with the results on tests for evaluating repetitive and explosive strength. It is expected that male and female students with a higher BMI will achieve worse results on tests for assessing explosive and repetitive strength.

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2. There are statistically significant differences between male and female students in tests for assessing explosive and repetitive strength. Male students are expected to achieve better results than female students in all tests.

METHODS

Study participants

The research was conducted on a sample of 239 4th grade students of elementary schools in Zadar County, Croatia. In the total sample 128 were girls (normal weighted 90 and over-weighted or obese 38) 111 were boys (normal weighted 66 and over-weighted or obese 45). The research was approved in advance by the Faculty Council of the Department of Teacher and Preschool Teacher Education of the University of Zadar, Croatia. Parents gave their written consist to allow researchers to test their children. Also, the research was anonymous and voluntary.

Variables

The survey consisted of three parts. The first part was aimed at collecting socio-demographic data on gender, age, and elementary school grade. The second part of the research was related to the collection of information on the level of nutritional status and included measures of the students' body height and body weight. Taking into account the values of children's body mass and body height, their body mass index was calculated as weight divided by height squared (kg/m2). Overweight was defined according to the definitions of the WHO (2006). The third part was focused on measuring 6 variables for estimating explosive and repetitive strength: long jump, high jump, throwing a medicine ball (all three assessing explosive strength), and squat, sit up, spine (all three assessing repetitive strength).

Statistical analysis

The collected data were processed by the program Statistic for Windows 13.0 (StatSoft). Basic descriptive indicators were calculated: arithmetic mean and standard deviation. The normality of the distribution was tested by the Kolmogorov-Smirnov test. T test was used to establish differences in motor abilities of primary school children with the regard of their gender. A series of simple regression analyzes were used to determine the contribution of children's nutritional status in explaining their explosive and repetitive strength.

RESULTS AND DISCUSSION

From the results presented in Table 1, it is evident that boys achieve better results in all variables assessing explosive strength and in two variables assessing repetitive strength compared to girls (Table 1). In the test that evaluates the repetitive strength of the lower extremities (squats), no statistically significant difference was obtained with regard to the children's gender (t=-1.42; p=0.16). Furthermore in this research, boys and girls in primary education do not differ statistically significantly in terms of body mass index (t= -1.92; p=0.06). The greatest variation of results for both boys and girls was obtained for all three variables that assess repetitive strength. The results of the Kolmogorov Smirnov test indicate that only one variable that assesses the explosive power of the upper extremities (Max D= 0.12; K-S p<0.05) and just for the sample of girls specify a statistically significant deviation from the normal distribution of results, therefore parametric statistics (regression analysis and t test for independent samples) was being applied in the statistical processing of the data.

In this research, the results obtained on the tests: long jump, high jump, and sit-ups are better compared to the results obtained for the same tests in the research conducted by Lončar (2011). In addition to the above, in the same study, no differences were found in the motor skills of fourth-grade students with regard to gender. On contrary, gender differences of the results assessing motor abilities in favour of boys, were obtained in the results of the research conducted by Cetinić and Petrić (2010). Additionally, in this study, boys achieved better results in test long jump than the normative values for population of Croatian fourth grade male pupils, while girls achieved slightly worse results compared to the previously mentioned normative values (Findak, Metikoš, and Mraković, M., 1992). Similary to the results from this research, concerning the gender differences in motor abilities, Pejčić, Malacko and Tomljenović (2008) indicated that male pupils compared to female achieve better results in tests of explosive and static strength, coordination and aerobic endurance if they have reduced body weight values and a reduced proportion of fat tissue, and vice versa.

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Table 1. *Descriptive parameters of Body mass index and variables assessing explosive and repetitive strength for boys (N=111) and girls (N=128) and differences in those variables concerning gender (t test results)*

Variable	Gender	Mean	SD	max D	K-S	t test	p
BMI	Male	19.42	3.16	0.13	p < .05*	-1.92	0.06
	Female	18.58	3.50	0.15	p < .01*		
LONG JUP	Male	1.54	0.24	0.06	p > .20	-7.04	0.00*
	Female	1.33	0.22	0.08	p > .20		
HIGH JUMP	Male	25.14	4.68	0.08	p > .20	-4,57	0.00*
	Female	22.53	4.13	0.10	p < .15		
THROWING A BALL	Male	5.47	1.17	0.11	p < .20	-6,38	0.00*
	Female	4.55	1.06	0.12	p < .05*		
SQUATS	Male	42.20	8.58	0.08	p > .20	-1,42	0.16
	Female	40.83	6.29	0.10	p < .15		
SIT-USP	Male	34.77	8.31	0.09	p > .20	-4,73	0.00*
	Female	29.73	8.10	0.10	p < .20		
SPINES	Male	37.08	7.77	0.08	p > .20	-3,98	0.00*
	Female	33.44	6.39	0.10	p < .20		

Legend: *N- number of examinees; SD- standard deviation; Max D- maximum deviation; K-S - Kolmogorov Simirnov test of normality; **- statistically significant difference; *- statistically significant deviation from the normal distribution of results (level of significance= p<0,05 and p<0,01); BMI- body mass index*

For the sample of boys (Table 2), the body mass index correlates negatively and statistically significantly with two tests for assessing explosive strength (long jump β=-0.35 and high jump β=-0.41) and with two tests for assessing repetitive strength (squats β=-0.19 and sit-ups β=-0.24). For the sample of girls, the body mass index positively and statistically significantly correlates with one test for evaluating explosive strength (throwing a medicine ball β=0.26) and negatively and statistically significantly correlates with one test for evaluating repetitive strength (sit-ups β=-0.20). The body mass index for boys contributes to the explanation of the variables of long jump (R^2=0.35), high jump (R^2=0.41), squats (R^2=0.19), and sit-ups (R^2=0.24), and for girls' body mass index contributes to the explanation of the variables of long jump (R^2=0.32), throwing a medicine ball (R^2=0.26), and sit-ups (R^2=0.20) (Table 2).

In the research of D'Hondt et al. (2014) children's BMI at baseline predicted and explained 37.6% of the variance in gross motor coordination with age (D'Hondt, Deforche, Gentier, Verstuyf, Vaeyens, Bourdeaudhuij, et al., 2014). Webster, Sur, Stevens, & Robinson (2021) established that different components of body composition (i.e., fat free mass) were associated with different aspects of fundamental motor skills competency. Also, they argued that „excess body fat may be a morphological constraint to proficient locomotor performance when transporting the body through space ".

Table 2. *Results of a series of simple regression analyzes of the contribution of body mass index as predictor variable in explaining explosive and repetitive strength as criterion variables of primary girls and boys*

VARIABLE	EXPLOSIVE STRENGHT								
	LONG JUMP			HIGH JUMP			THROWING A BALL		
	β	SE β	p	β	SE β	p	β	SE β	p
BMI$_M$	-0.35	0.09	0.00*	-0.41	21.47	0.00*	0.16	0.09	0.09
	Mult. R= 0.35			Mult. R= 0.41			Mult. R= 0.16		
	St. Err.= 22.64			St. Err.=4.3			St. Err.= 115.68		
	F=15.26			F=21.47			F=2.89		
	p< 0.00*			p< 0.00*			p< 0.09		

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	β	SE β	p	β	SE β	p	β	SE β	p
BMI$_F$	-0.32	0.08	0.00*	-0.09	0.09	0.32	0.26	0.09	0.09
	Mult. R=0.32			Mult. R= 0.09			Mult. R= 0.26		
	St. Err.=20.65			St. Err.= 4.13			St. Err.= 103.10		
	F=14.63			F=0.99			F=9.27		
	p< 0,00*			p< 0.32			p< 0.00*		
REPETITIVE STRENGHT									
VARIABLE	**SQUATS**			**SIT-UPS**			**SPINES**		
	β	SE β	p	β	SE β	p	β	SE β	p
BMI$_M$	-0.19	0.09	0.04	-0.24	0.09	0.01	-0.12	0.1	0.22
	Mult. R=0.19			Mult. R=0. 24			Mult. R=0. 12		
	St. Err.=8.46			St. Err.=8.11			St. Err.=7.75		
	F=4.27			F=6.65			F=1.5		
	p<0.04**			p<0.01*			p<0.22		
	β	SE β	p	β	SE β	p	β	SE β	p
BMI$_F$	-0.17	0.09	0.06	-0.20	0.09	0.02	-0.11	0.09	0.20
	Mult. R=0. 17			Mult. R=0. 20			Mult. R=0. 11		
	St. Err.=6.22			St. Err.=7.95			St. Err.=6.37		
	F=3.78			F=5.70			F=1.66		
	p<0.06			p<0.02*			p<0.20		

Legend: TA- *Mult. R-multiple correlation; St. Err.- standard error of estimation; F-significance; p-significance level of multiple correlation coefficient; β- standardize partial regression coefficient, SEβ – standard error of standard regression coefficient; significant level of regression coefficients, *statistical significance (*p<0.01, **p<0.05); BMI$_M$- boys body mass index; BMI$_F$- girls body mass index*

As well in the research conducted by Babin, Bavčević and Moretti (2006) on first-grade girls, the negative impact of an increased amount of subcutaneous fat on the results in strength tests was proven. Furthermore, Awad and Aneis (2022) have confirmed in their research that children who were normal weight or underweight had higher motor skills than those who were overweight or obese.

CONCLUSON

Considering the results of the conducted research, it is necessary to implement interventions in the direction of raising the level of physical activity of overweight and obese students. Furthermore, since research has confirmed the lower level of motor skills of girls compared to boys, it is necessary to work on the motivation of schoolgirls so that they are more involved in the implementation of various forms of physical activities, either in the school environment or outside of it.

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Structure of Football on the Basis of Situational Efficiency Indicators of World Championships 2010, 2014, 2018

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Structure of Football on the Basis of Situational Efficiency Indicators of World Championships 2010, 2014, 2018

Struktura nogometa na osnovu indikatora situacione efikasnosti svjetskih prvenstava 2010, 2014, 2018. godine

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Abstract: *The aim of this research was to determine the structure of football through indicators of situational efficiency in world championship matches. The research sample consisted of 370 soccer players who played all 90 minutes of the Round of 16 matches of the three world soccer championships WC2010 (N = 124), WC2014 (N = 126) and WC2018 (N = 120). 30 variables of situational efficiency were used, which were taken from the official website of the World Football Federation (www.fifa.com). To determine the structure of football, we used factor analysis, the method of principal components with oblique direct oblimin transformation was used, and the Kaiser-Gutman criterion was used to determine the significance of the extracted factors. Analyzing the results, the explanation of the common variance was the highest at WC 2010 (83.52 %), followed by WC 2014 (81.97 %), and the lowest explained variance was at WC 2018 (76.30 %). In the structure of football at WC 2010 and WC 2014, 6 latent factors were singled out, and at WC 2018, 4 latent factors were singled out, which are differently saturated with situational indicators. We conclude that changes have occurred in the structure of football over a period of 8 years, which is shown by the number and structure of factors that have been fished out. The structure of football has changed in such a way that the number of factors has been reduced from 6 to 4, and the structure of isolated factors clearly defines modern football. Based on the results, the guidelines and standards on which football training should be based can be clearly determined, while using certain training tools, training stimuli and appropriate training loads in order to achieve a high level of physical preparation, a high level of technique in movement, a high rhythm of the game and tactical maturity of football players.*

Keywords: *top football players, indicators, situational efficiency, World Cup*

Sažetak: *Cilj ovog istraživanja bio je utvrđivanje strukture nogometa kroz indikatore situacione efikasnosti na utakmicama svjetskih prvenstava. Uzorak istraživanja činilo je 370 nogometaša koji su odigrali svih 90 minuta utakmica osmine finala tri svjetska nogometna prvenstva SP2010 (N=124), SP2014 (N =126) i SP2018 (N =120) godine. Korišteno je 30 varijabli situacione efikasnosti koje su preuzete sa oficijalne stranice Svjetske nogometne federacije (www.fifa.com). Za utvrđivanje strukture nogometa, korištena je faktorska analiza, metoda glavnih komponenata sa kosom direkt oblimin transformacijom, a za utvrđivanje značajnosti izlovanih faktora korišten je Kaiser-Gutmanovim kriterij. Analizom rezultata objašnjenost zajedničke varijanse bila najveća na SP 2010 (83,52 %), zatim na SP 2014, (81,97 %), a najmanja objašnjena varijansa bilo je na SP 2018 godine (76,30 %). U strukturi nogometa na SP 2010 i SP 2014 izdvojilo se 6 latentnih faktora, a na SP 2018 izdvojila su se 4 latentna faktora, koji su različito zasićeni sutuacionim indikatorima. Zaključujemo da su se u vremenskom razdoblju od 8 godina desile promjene u strukturi nogometa, što nam pokazuje broj i struktura izlovanih faktora. Promijenila se struktura nogometa na način da se smanjio broj faktora sa 6 na 4, a struktura izolovanih faktora jasno definiše savremeni nogomet. Na osnovu rezultat mogu se jasno odrediti smjernice i standardi na kojima treba da se bazira nogometni trening, pri tom koristeći određena trenažna sredstva, trenažne stimuluse i odgovarajuća trenažna opterećenja kako bi se postigao visok nivo fizičke pripremljenosti, visok nivo tehnike u kretanju, visok ritam igre i taktička zrelost nogometaša.*

Ključne riječi: *vrhunski nogometaši, indikatori, situaciona efikasnost, Svjetsko prvenstvo*

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STRUKTURA NOGOMETA NA OSNOVU INDIKATORA SITUACIONE EFIKASNOSTI SVJETSKIH PRVENSTAVA 2010, 2014, 2018. GODINE

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INTRODUCTION

A soccer game can be considered like a complex, self-organized, unstable, unpredictable and highly dynamic system in which players from competing teams try to maintain the stability of their own attack, organize and defend the balance and destabilize the balance of the opposite team (Davids, Araujo, Correia, & Vilar, 2013; Garganta, 2009; Vilar, Araujo, Davids, & Button, 2012). In that period, football is continuously developing, especially in the direction of increasing the physical demands and loads to which football players are exposed during training and competition (Jazvin, Palić, Ademović, Skender 2021). Professional soccer players have a better developed ability to repeat sprints compared to amateurs, which confirms the previously proven role of this ability in modern soccer. (Sekulić, Ž., Ilić, N., Dragosavljević, D. 2019) The permanent development of the soccer game, year after year, leads to the fact that soccer players run more and more, and that their movements are more dynamic and faster. Top football players progress year by year in the amount and intensity of movement, which requires the need of football experts to determine what characterizes the profile of football players who play at a high level or are they are in the final stages of major competitions (Ademović, Palić, Čolakhodžić, Popo, 2021; Čolakhodžić, Đedović, Skender, Novaković and Popo, 2017; Ademović, Čolakhodžić, Talović and Kajmović, 2012). Until now, research on soccer players has mainly studied the motor and functional abilities of soccer players, certain situational parameters and their connection with success in the game, as well as the anthropological profile of individual players considering their position. The effect of situational parameters is dominantly related to the position in the game (Ademović, 2016). For a better understanding of the limitations that affect sports success, the analysis of situational performance represents a very important role in all sports and especially in sports games (Carling, Reilly and Williams, 2009). In soccer, match performance can be defined as a complex interaction of various technical, tactical, mental (Carling et al., 2009) and physiological factors (Drust, Atkinson, and Reilly, 2007). The complex movement structures of football consist of a large number of changes of direction, sprints, jumps, duels and kicks (Krustrup, Dvorak, et al., 2010), which requires a large energy consumption (Krustrup et al., 2014). It is very important to determine the factors of the latent structure of football, that is, to gain a clearer perception of what precedes the activities of football players. Knowing that structure gives us a clear picture for the implementation of such training programs, aimed at improving the physical as well as technical and tactical skills of football players, in order to meet the demands of the

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Nogometnom igrom, može se smatrati složen, samoorganiziran, nestabilan, nepredvidljiv i visoko dinamičan sistem u kojem igrači iz konkurentskih ekipa pokušavaju zadržati stabilnost vlastitog napada, organizovati i braniti ravnotežu i destabilizirati ravnotežu suprotne ekipe (Davids, Araujo, Correia, & Vilar, 2013; Garganta, 2009; Vilar, Araujo, Davids i Button, 2012). U tom razdoblju nogomet se kontinuirano razvija, posebno u smjeru povećanja fizičkih zahtjeva i opterećenja kojima su nogometaši izloženi tokom treninga i takmičenja (Jazvin, Palić, Ademović, Skender 2021). Profesionalni nogometaši imaju bolje razvijenu sposobnost ponavljanja sprinta u odnosu na amatere, što potvrđuje ranije dokazanu ulogu ove sposobnosti u savremenom nogometu. (Sekulić, Ž., Ilić, N., Dragosavljević, D. 2019) Permanentan razvoj nogometne igre, iz godine u godinu dovodi do toga da nogometaši trče sve više i više, a da su njihovi pokreti sve dinamičniji i brži. Vrhunski nogometaši iz godine u godinu napreduje u količini i intezitetima kretanja, što iziskuje potrebu nogometnih stručnjaka, da utvrde šta to karakteriše profil nogometaša koji igraju na visokom nivou ili se nalaze u završnici velikih takmičenja (Ademović, Palić, Čolakhodžić, Popo, 2021; Čolakhodžić, Đedović, Skender, Novaković i Popo, 2017; Ademović, Čolakhodžić, Talović i Kajmović, 2012). Istraživanja na nogometašima do sada su uglavnom proučavala motoričke i funkcionalne sposobnosti nogometaša, određene situacijske parametre i njihovu povezanost sa uspjehom u igri, kao i antropološki profil pojedinih igrača obzirom na njihovu poziciju. Učinak situacijskih parametara dominatno je povezan sa pozicijom u igri (Ademović, 2016). Za bolje razumjevanje ograničenja koja utiču na sportski uspjeh, analiza situacijske izvedbe predstavlja vrlo važnu ulogu u svim sportovima a posebno u sportskim igrama (Carling, Reilly and Williams, 2009). U nogometu, izvedba na utakmici može se definisati kao složena interakcija različitih tehničkih, taktičkih, mentalnih (Carling i saradnici, 2009) i fiziološki faktora (Drust, Atkinson i Reilly, 2007). Složene kretne strukture nogometa sastoje se od velikog broja promjena pravca, sprinteva, skokova, duela i udaraca (Krustrup, Dvorak, et al., 2010) što iziskuje veliku energetsku potrošnju (Krustrup et al., 2014). Jako je bitno utvrditi faktore latentne strukture nogometa, odnosno, da se stekne jasnija percepcija onoga što prethodi aktivnostima nogometaša. Poznavanje te strukture daje nam jasnu sliku za provedbu takvih trenažnih programa, usmjerenih na poboljšanje fizičke kao i tehničke i taktičke vještine nogometaša, da bi se

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game at a high level. Structural analysis provides an insight into all phases of the football game, movement structures, substructures and structural units of technique and tactics, as well as the amount and intensity of movement of football players. In addition to the structure of technical-tactical elements, structural analysis provides information on the repetition of different movements without and with the ball during a football match (Mihačić and Ujević, 2003). Knowing the structure of the football game means understanding all phases and subphases of the game flow, as well as the positions of individual players, which helps us recognize certain situations in the game. When they are going from one phase to another, it is essential that the players understand and perform tasks in the game using appropriate technical-tactical programs. Knowledge of those programs would help the selection in football clubs, and tend towards the improvement of training technology in working with younger categories. Determining the structure of that system is very difficult and demanding for the simple reason of the complexity of that structure, so there is very little research investigating the structure of the football game. Based on that, the goal of this research was to determine the structure of football through indicators of situational efficiency in world championship matches and to determine the factors that determine success in football.

METHODS OF WORK

Sample of respondents

The study was conducted on a sample of 370 top football players who played all 90 minutes of the Round of 16 matches of the three most recent World Cups (SP2010, SP2014, SP2018). The first group of respondents consisted of soccer players participating in the 1/8 finals of the World Cup 2010 (n = 124), and the participants in the eighth finals were the selections: Uruguay, South Korea, the USA, Ghana, Germany, England, Argentina, Mexico, the Netherlands, Slovakia, Brazil, Chile, Paraguay, Japan, Spain and Portugal. The second group of respondents consisted of soccer players participating in the 2014 FIFA World Cup (n=126), and the teams participating in the round of 16 were: Brazil, Chile, Colombia, Uruguay, the Netherlands, Mexico, Costa Rica, Greece, France, Nigeria, Germany, Algeria , Argentina, Switzerland, Belgium and the USA. The third group of respondents consisted of soccer players participating in the 2018 FIFA World Cup (n=120). The participants in the round of 16 of the last World Cup were: France, Argentina, Uruguay, Portugal, Spain, Russia, Croatia, Denmark, Brazil, Mexico, Belgium, Japan, Sweden, Switzerland, Colombia and England.

zadovoljili zahtijevi u igri na visokom novou. Strukturalna analiza omogućava uvid u sve faze nogometne igre, strukture kretanja, substrukture i strukturalne jedinice tehnike i taktike, kao i količine i inteziteta kretanja nogometaša. Osim strukture tehničko-taktičkih elemenata, strukturalnom analizom dobivamo informacije o ponavljanju različitih kretanja bez i s loptom tokom nogometne utakmice (Mihačić i Ujević, 2003). Poznavanje strukture nogometne igre znači razumijevanje svih faza i podfaza toka igre, kao i pozicija pojedinih igrača, što nam pomaže da prepoznamo određene situacije u igri. Kod prelaza iz jedne faze u drugu osnovno je da igrači razumiju i ostvaruju poslove u igri koristeći odgovarajuće tehničko-taktičke programe. Poznavanje tih programa pomoglo bi selekciji u nogometnim klubovima, i težilo prema poboljšanju trenažne tehnologije u radu sa mlađim kategorijama. Utvrđivanje strukture tog sistema je veoma teško i zahtjevno iz prostog razloga složenosti te strukture, tako da je veoma je malo istraživanja koja istražuju strukturu nogometne igre. Na osnovu toga, cilj ovog istraživanja je bio je utvrđivanje strukture nogometa kroz indikatore situacione efikasnosti na utakmicama svjetskih prvenstava i određivanje faktora koji determiniraju uspjeh u nogometu.

METODE RADA

Uzorak ispitanika

Ispitivanje je provedeno na uzorku od 370 vrhunskih nogometaša koji su odigrali svih 90 minuta utakmica osmine finala tri posljednja svjetska nogometna prvenstva (SP2010, SP2014, SP2018). Prvu grupu ispitanika činili su nogometaši učesnici 1/8 finala SP2010 godine (n =124), a učesnice osmine finala bile su selekcije: Urugvaj, Južna Koreja, SAD-e, Gana, Njemačka, Engleska, Argentina, Meksiko, Nizozemska, Slovačka, Brazil, Čile, Paragvaj, Japan, Španija i Portugal. Drugu grupu ispitanika činili su nogometaši učesnici Svjetskog nogometnog prvenstva 2014. godine (n=126), a ekipe učesnice osmine finala bile su: Brazil, Čile, Kolumbija, Urugvaj, Nizozemska, Meksiko, Kostarika, Grčka, Francuska, Nigerija, Njemačka, Alžir, Argentina, Švicarska, Belgija i SAD-e. Treću grupu ispitanika činili su nogometaši učesnici Svjetskog nogometnog prvenstva 2018. Godine (n=120). Učesnice osmine finala posljednjeg Svjetskog nogometnog prvenstva bile su: Francuska, Argentina, Urugvaj, Portugal, Španija, Rusija, Hrvatska, Danska, Brazil, Meksiko, Belgija, Japan, Švedska, Švicarska, Kolumbija i Engleska.

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Table 1. Basic descriptive parameters of the respondents　　*Tabela 1. Osnovni deskriptivni parametri ispitanika*

VARIJABLES / VARIJABLE	WC / SP 2010 (n=124)		WC / SP 2014 (n=126)		WC / SP 2018 (n=120)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
AGE / AGE (godine)	26.77	3.70	27.35	3.536	28.15	3.72
AVIS (cm)	179.71	6.17	181.48	6.924	182.32	6.95
SEPRD (m)	10053.40	864.08	9825.37	1100.48	9777.30	1006.93
SEPRDPP (m)	5113.70	433.55	5156.68	549.52	4897.99	557.20
SEPRDDP (m)	4939.65	475.52	4661.56	885.69	4880.12	514.26
SEPRDPL (m)	4176.65	869.84	3920.21	965.51	3819.86	1267.36
SEPRDBPL (m)	4408.06	840.41	4102.44	1029.78	4502.67	1326.96
SEBRSP (No)	99.42	30.54	34.00	11.10	30.40	11.22
SEBRSPPP (No)	51.39	17.91	18.74	6.69	15.91	6.66
SEBRSPDP (No)	48.09	16.02	15.33	6.85	14.49	5.83
SEMAXB (km/h)	23.53	2.55	28.39	1.94	28.81	2.24
SEMAXBPP (km/h)	21.96	2.37	27.03	2.60	27.41	2.81
SEMAXBDP (km/h)	22.47	2.72	26.89	2.71	28.35	2.40
SEBUDO (No)	36.04	14.91	41.20	18.37	39.80	21.38
SEBNDO (No)	50.73	16.91	53.86	19.97	46.99	22.39
SEBDUDO (No)	4.37	3.01	4.00	3.43	3.92	3.35
SEBNDDO (No)	8.43	4.41	7.09	4.59	6.01	4.27
SEBSUDO (No)	23.18	10.75	27.17	13.89	26.42	16.10
SEBSNDO (No)	31.28	11.26	33.80	14.50	29.71	16.38
SEBKUDO (No)	8.44	4.75	10.02	5.79	9.48	6.52
SEBKNDO	11.98	5.26	12.89	6.70	11.43	6.91
SEPUDL (%)	68.42	11.59	74.90	10.89	82.23	9.74

Variable sample

The data was taken from the official website of the World Football Association (www.fifa.com). which presents all parameters of team success. as well as individual data on the situational efficiency of all players participating in the last three world football championships (WC 2010. WC 2014. WC 2018). To determine the structure of the football game. the following indicators were taken: AGE - age (years). AVIS - body height (cm). SEPRD - length of distance covered (m). SEPRDPP - length of distance covered in the first half (m). SEPRDDP - length distances traveled in the second half (m). SEPRDPL - length of distance traveled in possession of the ball (m). SEPRDBPL - length of distance traveled without possession of the ball (m). SEBRSP - number of sprints (No). SEBRSPPP - number of sprints in the first half (No). SEBRSPDP – Number of sprints in the second half (No). SEMAXBPP – maximum achieved speed in the first half (km/h). SEMAXBDP – maximum achieved speed in the second half (km/h). SEMAXB – maximum achieved speed (km/h). SEVANIS - weather activities - low (%). SEVASRE - weather activities - medium (%). SEVAVIS - weather activities - high (%). SEVAZI - I zone 0–7 km/h (%). SEVAZII - II zone 7–15 km/h (%). SEVAZIII – III

Uzorak varijabli

Podaci su preuzeti sa oficijalne stranice Svjetske nogometne asocijacije (www.fifa.com) na kojoj su predstavljeni svi parametri uspješnosti ekipa, kao i pojedinačni podaci o situacionoj efikasnosti svih igrača učesnika tri posljednja svjetska nogometna prvenstva (SP 2010, SP2014, SP 2018). Za utvrđivanje strukture nogometne igre uzeti su sljedeći indikatori: AGE – starosna dob (godine), AVIS – tjelesna visina (cm), SEPRD – dužina pređene distance (m), SEPRDPP – dužina pređene distance u prvom poluvremenu (m), SEPRDDP – dužina pređene distance u drugom poluvremenu (m), SEPRDPL – dužina pređene distance u posjedu lopte (m), SEPRDBPL – dužina pređene distance bez posjeda lopte (m), SEBRSP – broj sprinteva (No), SEBRSPPP – Broj sprinteva u prvom poluvremenu (No), SEBRSPDP – Broj sprinteva u drugom poluvremenu (No), SEMAXBPP – maksimalna ostvarena brzina u prvom poluvremenu (km/h), SEMAXBDP – maksimalna ostvarena brzina u drugom poluvremenu (km/h), SEMAXB – maksimalna ostvarena brzina (km/h), SEVANIS – vremenske aktivnosti – niske (%), SEVASRE – vremenske aktivnosti – srednje (%), SEVAVIS – vremenske aktivnosti – visoke (%), SEVAZI – I zona 0–7 km/h (%), SEVAZII – II zona 7–15 km/h

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zone 15–20 km/h (%). SEVAZIV – IV zone 0–25 km/h (%). SEVAZV – V zone > 25 km/h (%) . SEBUDO – number of successful additions (No). SEBNDO – number of unsuccessful additions (No). SEBDUDO – number of long successful additions (No). SEBNDDO – number of long unsuccessful additions (No). SEBSUDO – number of medium successful additions (No). SEBSNDO – number of medium unsuccessful passes (No). SEBKUDO – number of short successful passes (No). SEBKNDO – number of short unsuccessful passes (No). SEPUDL – percentage of successful ball distribution (%).

Methods of data processing

The data were processed in the software program package for social sciences (Statistical Package for Social Sciences – IBM SPSS. Version 26.0). Factor analysis determined the structure of the researched space on a given sample of respondents. Starting from the inercorrelation matrices of the variables of the researched spaces. the method of principal components (Hoteling's factorial procedure) with oblique direct oblimin transformation was used. The significance of isolated main factors was determined by the Kaiser-Gutman criterion. according to which any isolated factor whose variance or characteristic root is equal to or greater than 1 is considered significant. With the KMO and Bartlett test of sphericity. information was obtained that speaks about the suitability of the matrix of intercorrelations of manifest variables for analysis using the factor analysis method. In the tables. the characteristic roots of the matrix R are listed and marked with (Eigenvalue). The relative cumulative contributions of the characteristic roots are marked with (% of Var). Those characteristic roots are in fact variances of latent dimensions defined as main components (Čolakhodžić. E. 2021). In the assembly matrix. the coordinates are presented. i.e. parallel projections of the vector of manifest variables onto the system of latent dimensions. The values presented in the assembly table are actually the saturation of individual manifest variables with the factors marked at the top of the column. In the structure matrix. the orthogonal projections of the vector of manifest variables onto the vectors of latent dimensions are presented. The values presented in the tables are actually correlations of individual manifest variables with the factors marked at the top of the table. The structure matrix was obtained by rotating the initial coordinate system of the isolated main components from the rectangular system into oblique solutions. using the direct oblimin method.

(%), SEVAZIII – III zona 15–20 km/h (%), SEVAZIV – IV zona 0–25 km/h (%), SEVAZV – V zona > 25 km/h (%), SEBUDO – broj uspješnih dodavanja (No), SEBNDO – broj neuspješnih dodavanja (No), SEBDUDO – broj dugih uspješnih dodavanja (No), SEBNDDO – broj dugih neuspješnih dodavanja (No), SEBSUDO – broj srednjih uspješnih dodavanja (No), SEBSNDO – broj srednjih neuspješnih dodavanja (No), SEBKUDO – broj kratkih uspješnih dodavanja (No) , SEBKNDO – broj kratkih neuspješnih dodavanja (No), SEPUDL – procenat uspješnosti distribucije lopte (%).

Metode obrade podataka

Podaci su obrađeni u softverskom programski paket za društvene nauke (Statistical Package for Social Sciences – IBM SPSS, Version 26.0). Faktorskom analizom utvrđena je struktura istraživanog prostora na datom uzorku ispitanika. Polazeći od matrica inerkorelacija varijabli istraživanih prostora, korištena je metoda glavnih komponenata (Hotelingov faktorski postupak) sa kosom direkt oblimin transformacijom. Kaiser-Gutmanovim kriterijem utvrđena je značajnost izolovanih glavnih faktora prema kojem se smatra značajnom svaki izolovani faktor čija je varijanca, odnosno karakteristični korijen jednak 1 ili veći od 1. KMO and Bartlett"s testom sphericiteta dobiven je podatak koji govori o podobnosti matrice interkorelacija manifestnih varijabli za analiziranje metodom faktorske analize. U tabelama su navedeni karakteristični korjenovi matrice R i označeni sa (Eigenvalue). Relativni kumulativni doprinosi karakterističnih korjenova označeni su s oznakom (% of Var). Ti karakteristični korjenovi su u stvari varijance latentnih dimenzija definisane kao glavne komponente (Čolakhodžić, E. 2021). U matrici sklopa iznesene su koordinate, tj. paralelne projekcije vektora manifestnih varijabli na sistem latentnih dimenzija. Vrijednosti iznesene u tabeli sklopa su ustvari saturacije pojedinih manifestnih varijabli faktorima koji su označeni na vrhovima kolone. U matrici strukture iznesene su ortogonalne projekcije vektora manifestnih varijabli na vektore latentnih dimenzija. Vrijednosti iznesene u tabelama su u stvari korelacije pojedinih manifestnih varijabli s faktorima koji su označeni na vrhu tabele. Matricu strukture smo dobili rotacijom incijalnog koordinatnog sistema izolovanih glavnih komponenata iz pravouglog sistema u kose solucije, direktnom oblimin metodom.

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RESULTS

In order to determine the structure of football in the researched area (situational efficiency). a factor analysis was performed for each group of respondents. that is. for each world championship individually (WC 2010. WC 2014. WC 2018). and then a comparison was made of the obtained structures of the isolated factors of the soccer game for every world championship. A sample of 124 respondents analyzed the situational efficiency of football players participating in the World Cup 2010. The structure was analyzed by the method of principal components with oblique direct oblimin transformation. With the KMO and Bartlett's test (table 2). we obtained data that tell us about the suitability of the matrix for analysis using the factor analysis method (Sig.= .00). Using the principal components method. 6 isolated factors were extracted for soccer players at the 2010 World Cup. which consume 83.52% of the common valid variance (table 3). The first factor exhausts the most information about the applied system of variables – 35.86%. the second factor exhausts 21.35%. while the others exhaust a smaller percentage of information. The third factor consumes 9.24%. the fourth 6.97%. the fifth 5.44%. and the sixth 4.63% of the total variance. On the basis of the assembly matrix (table 4) and the structure matrix (table 5). we see that the variables of the distance traveled (SEPRD. SEPRDPP. SEPRDDP. SEPRDPL) and the variables characterizing the intensity of the game (SEVANIS. SEVASRE. SEVAVIS) were separated into the first factor. so this factor can be defined as a factor of physical demands in football. The second isolated factor can be interpreted as a factor of technical success in football. because the variables that explained the distribution of passing the ball (SEBUDO. SEBND. SEBKUDO. SEBKNDO) stood out the most. In the case of the third isolated factor. all maximum speed variables (SEMAXB. SEMAXBPP. SEMAXBDP) were extracted. so this factor was defined as a pure factor of the speed of performing football actions. The largest projections in the fourth isolated factor have the variables of successful and unsuccessful long and medium passes (SEBDUDO. SEBNDDO. SEBSUDO. SEBSNDO). which can be characterized as another factor of technical success in football. In the fifth isolated factor. one variable of the distance covered without possession of the ball (SEPRDBPL) and the percentage of ball distribution (SEPUDL) were singled out. which can be interpreted as a factor of physical demands and passing the ball. In the sixth factor. all the sprint variables (SEBRSP. SEBRSPPP. SEBRSPDP) were singled out. and it was defined as the sprint factor in soccer. Correlation of the matrix of isolated components (table 6) shows that the first factor has the highest correlation with the sixth factor (-.40). which can be characterized as a moderate correlation. while it has a low correlation with the second (.29) isolated factor.

REZULTATI

U cilju utvrđivanja strukture nogometa u istraživanom prostoru (situaciona efikasnost) urađena je faktorska analiza za svaku grupu ispitanika, odnosno za svako svjetsko prvenstvo pojadinačno (SP 2010, SP 2014, SP 2018), a nakon toga izvršena je komparacija dobivenih struktura izolovanih faktora nogometne igre za svako svjetsko prvenstvo. Na uzorku od 124 ispitanika analizirana je situaciona efikasnost nogometaša učesnika SP 2010. godine. Struktura je analizirana metodom glavnih komponenti s kosom direkt oblimin transformacijom. KMO and Bartlett's testom (tabela 2) dobili smo podatke koji nam govore o podobnosti matrice za analiziranje metodom faktorske analize (Sig.= ,00). Metodom glavnih komponenata kod nogometaša na SP 2010. godine ekstrahovano je 6 izoliranih faktora koji iscrpljuju 83,52% zajedničke valjane varijanse (tabela 3). Prvi faktor iscrpljuje najviše informacija o primijenjenom sistemu varijabli – 35,86%, drugi faktor iscrpljuje 21,35%, dok ostali iscrpljuju manji postotak informacija. Treći faktor iscrpljuje 9,24%, četvrti 6,97%, peti 5,44%, a šesti 4,63% ukupne varijanse. Na osnovu matrice sklopa (tabela 4) i matrice strukture (tabela 5) vidimo da su se u prvi faktor izdvojile varijable pređene udaljenosti (SEPRD, SEPRD-PP, SEPRDDP, SEPRDPL) i varijable koje karakterišu intenzitet igre (SEVANIS, SEVASRE, SEVAVIS), pa se ovaj faktor može definisati kao faktor fizičkih zahtjeva u nogometu. Drugi izolirani faktor se može interpretirati kao faktor tehničke uspješnosti u nogometu, jer su se najviše izdvojile varijable koje objašnjavaju distribuciju dodavanja lopte (SEBUDO, SEBND, SEBKUDO, SEB-KNDO). Kod trećeg izoliranog faktora izdvojile su se sve varijable maksimalne brzine (SEMAXB, SEMAXBPP, SEMAXBDP), pa je ovaj faktor definisan kao čistim faktorom brzine izvođenja nogometnih radnji. Najveće projekcije u četvrtom izoliranom faktoru imaju varijable uspješna i neuspješna duga i srednja dodavanja (SEBDU-DO, SEBNDDO, SEBSUDO, SEBSNDO), što se može okarakterisati kao još jedan faktor tehničke uspješnosti u nogometu. U petom izolovanom faktoru izdvojila se jedna varijabla pređene distance bez posjeda lopte (SE-PRDBPL) i procenat distribucije lopte (SEPUDL), što se može interpretirati kao faktor fizičkih zahtjeva i dodavanja lopte. U šestom faktoru izdvojile su se sve varijable sprinta (SEBRSP, SEBRSPPP, SEBRSPDP), i definisan je kao faktor sprinta u nogometu. Korelacijom matrice izoliranih komponenti (tabela 6) vidimo da prvi faktor ima najveću povezanost sa šestim faktorom (-,40), što se može okarakterisati kao umjerena povezanost, dok nisku povezanost ima s drugim (,29) izolovanim faktorom.

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Table 2. Value of KMO and Bartlett's test at the 2010 World Cup

Tabela 2. Vrijednost KMO and Bartlett's testa kod Svjetskog prvenstva 2010. godine

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.704
Bartlett's Test of Sphericity	Approx. Chi-Square	5564.296
	df	253
	Sig.	.000

Table 3. Factor analysis in the area of situational efficiency of the 2010 World Cup

Tabela 3. Faktorska analiza u prostoru situacione efikasnosti Svjetskog prvenstva 2010. godine

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.249	35.864	35.864	8.249	35.864	35.864	6.798
2	4.911	21.352	57.216	4.911	21.352	57.216	4.809
3	2.127	9.247	66.462	2.127	9.247	66.462	2.917
4	1.605	6.978	73.440	1.605	6.978	73.440	4.271
5	1.253	5.448	78.888	1.253	5.448	78.888	1.611
6	1.065	4.633	83.520	1.065	4.633	83.520	4.861

Table 4. Situational efficiency matrix of the 2010 World Cup

Tabela 4. Matrica sklopa situacione efikasnosti Svjetskog prvenstva 2010. godine

Varijables / Varijable	Component					
	1	2	3	4	5	6
SEPRD (m)	.905	.050	.008	-.062	.059	-.150
SEPRDPP (m)	.840	.035	-.030	-.017	-.016	-.203
SEPRDDP (m)	.878	.058	.042	-.097	.122	-.087
SEPRDPL (m)	.209	.379	.210	.236	-.314	-.265
SEPRDBPL (m)	.555	-.044	.070	.043	-.542	.100
SEBRSP (No)	.118	.070	.030	.067	.033	-.903
SEBRSPPP (No)	.016	.125	-.006	.156	-.092	-.862
SEBRSPDP (No)	.213	-.002	.068	-.059	.169	-.741
SEMAXB (km/h)	-.034	-.026	.975	.008	.165	-.006
SEMAXBPP (km/h)	.112	-.115	.502	-.100	.554	-.147
SEMAXBDP (km/h)	-.062	.078	.904	.025	-.176	.059
SEVANIS (%)	-.820	.026	.025	-.021	.065	.206
SEVASRE (%)	.988	-.077	-.061	.031	.000	.136
SEVAVIS (%)	.578	.101	-.005	.002	.006	-.509
SEBUDO (No)	.126	.564	-.071	.502	.250	.141
SEBNDO (No)	.096	.506	-.005	.546	.092	.004
SEBDUDO (No)	-.082	-.153	-.071	.934	.076	-.107
SEBNDDO (No)	-.073	-.114	.039	.945	-.188	-.087
SEBSUDO (No)	.229	.399	-.038	.515	.303	.274
SEBSNDO (No)	.233	.413	.017	.559	.122	.169
SEBKUDO (No)	-.052	.964	-.076	-.137	.054	-.090
SEBKNDO (No)	-.029	.962	.078	-.115	-.115	-.119
SEPUDL (%)	.073	.231	-.276	.219	.578	.252

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Table 5. Matrix of the situational efficiency structure of the 2010 World Cup

Tabela 5. Matrica strukture situacione efikasnosti Svjetskog prvenstva 2010. godine

Variables / Varijable	Component					
	1	2	3	4	5	6
SEPRD (m)	.967	.320	.145	.109	.021	-.520
SEPRDPP (m)	.927	.299	.118	.137	-.054	-.536
SEPRDDP (m)	.913	.308	.157	.074	.087	-.457
SEPRDPL (m)	.498	.493	.281	.339	-.290	-.475
SEPRDBPL (m)	.534	.044	.111	.096	-.560	-.183
SEBRSP (No)	.515	.230	.341	.061	-.029	-.962
SEBRSPPP (No)	.429	.264	.272	.151	-.134	-.879
SEBRSPDP (No)	.501	.142	.346	-.063	.098	-.841
SEMAXB (km/h)	.044	-.065	.965	-.149	.109	-.318
SEMAXBPP (km/h)	.146	-.051	.555	-.177	.491	-.318
SEMAXBDP (km/h)	.028	-.013	.879	-.103	-.207	-.253
SEVANIS (%)	-.899	-.238	-.123	-.148	.110	.528
SEVASRE (%)	.911	.213	-.021	.198	-.028	-.230
SEVAVIS (%)	.812	.329	.218	.113	-.038	-.750
SEBUDO (No)	.310	.793	-.231	.744	.362	.100
SEBNDO (No)	.337	.730	-.115	.738	.185	-.052
SEBDUDO (No)	.073	.163	-.180	.877	.098	.024
SEBNDDO (No)	.107	.163	-.065	.874	-.165	-.023
SEBSUDO (No)	.314	.653	-.231	.724	.398	.202
SEBSNDO (No)	.384	.666	-.136	.751	.210	.063
SEBKUDO (No)	.234	.924	-.086	.186	.178	-.151
SEBKNDO (No)	.293	.908	.087	.179	.000	-.255
SEPUDL (%)	.034	.393	-.436	.393	.653	.351

Table 6. Intercorrelation matrix of isolated components of situational efficiency of the 2010 World Cup

Tabela 6. Matrica interkorelacije izolovanih komponenti situacione efikasnosti Svjetskog prvenstva 2010. godine

Component	1	2	3	4	5	6
1	1.000	.294	.090	.178	-.033	-.402
2	.294	1.000	-.056	.335	.137	-.110
3	.090	-.056	1.000	-.153	-.054	-.350
4	.178	.335	-.153	1.000	.048	.053
5	-.033	.137	-.054	.048	1.000	.078
6	-.402	-.110	-.350	.053	.078	1.000

The situational efficiency of soccer players participating in the 2014 World Cup was analyzed on a sample of 126 respondents. No statistically significant results of KMO's eligibility test for further procedure were obtained at WC 2014. Regardless of the result. we performed further factor analysis procedures to determine potential isolated factors. because the purpose of factor analysis in this research was to determine the structure of the research space. According to the Keizer-Guttman criterion. a total of 81.97% of the common valid variance. which can be explained by 6 isolated factors. was exhausted from the total space of variables for football

Na uzorku od 126 ispitanika analizirana je situaciona efikasnost nogometaša učesnika SP 2014. godine. Na SP 2014. nisu dobijeni statistički značajni rezultati KMO-ovog testa podobnosti za dalju proceduru. Bez obzira na rezultat, uradili smo dalju procedure faktorske analize kako bi utvrdili potencijalne izolovane faktore, jer je svrha faktorske analize u ovom istraživanju bila da se utvrdi struktura istraživanog prostora. Iz ukupog prostora varijabli kod nogometa na SP 2014. godine po Keiser-Guttmanovom kriteriju iscrpljeno je ukupno 81,97% zajedničke valjane varijanse koja se može objasniti sa 6 izolovanih faktora (tabela 7). Kao što vidimo u matrici sklopa (tabela

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at the 2014 World Cup (table 7). As we can see in the assembly matrix (table 8) and the structure matrix (table 9). the largest part of the explained variance is consumed by the first factor. where all the variables that characterize the intensity of the game (SEVANIS. SEVASRE. SEVAVIS) and one variable of the distance covered in the first halftime (SEPRDPP). so this factor can be called the factor of physical demands in football. The second isolated factor was called the factor of technical success in football. because the variables that explained the distribution of passing the ball. namely: long successful and unsuccessful passes (SEBDUDO. SEBNDDO). medium successful and unsuccessful passes (SEBSUDO. SEBSNDO) and the percentage of successful passing the ball (SEPUDL). In the third factor. two variables of sprint (SEBRSP. SEBRSPDP) and two variables of distance covered (SEBRSPDP. SEBRSP) were separated. defined as a mixed factor of physical demands and speed of performing football actions.

8) i matrici structure (tabela 9), najveći dio objašnjene varijanse iscrpljuje prvi faktor, gdje su se izdvojile sve varijable koje karakterišu intenzitet igre (SEVANIS, SEVASRE, SEVAVIS) i jedna varijabla pređene udaljenosti u prvom poluvremenu (SEPRDPP), pa se ovaj faktor može nazvati faktor fizičkih zahtjeva u nogometu. Drugi izolirani faktor nazvan je faktor tehničke uspješnosti u nogometu, jer su se najviše izdvojile varijable koje objašnjavaju distribuciju dodavanja lopte, i to: duga uspješna i nespješna dodavanja (SEBDUDO, SEBNDDO), srednja uspješna i neuspješna dodavanja (SEBSUDO, SEBSNDO) te procenat upješnih dodavanja lopte (SEPUDL). Kod trećeg faktora izdvojile su se dvije varijable sprinta (SEBRSP, SEBRSPDP) i dvije varijable pređene udaljenosti (SEBRSPDP, SEBRSP), definisan kao mješoviti faktor fizičkih zahtjeva i brzine izvođenja nogometnih radnji. Najveće projekcije u četvrtom izoliranom faktoru imaju varijable uspješna i neuspješna dodavanja (SEBUDO, SEBNDO), uspješna i neuspješna kratka dodavanja (SEBKUDO, SEBKNDO) i pređena distanca u posjedu lopte (SEPRDPL), tako da i ovaj faktor možemo nazvati mješovitim faktorom fizičkih zahtjeva i uspješnih dodavanja lopte. U petom faktoru izdvojile su se 2 varijable maksimalne brzine (SEMAXBPP, SEMAXB) i varijabla broj sprinteva u prvom poluvremenu (SEBRSPPP), te je ovaj faktor definisan kao faktor visokog intenziteta igre. Šesti izolovani faktor može se interpretirati kao mješoviti faktor fizičkih zahtjeva i brzine izvođenja nogometnih radnji, jer se izdvojila jedna varijabla maksimalne brzine u prvom poluvremenu (SEMAXBDP) i pređene distance bez posjeda lopte (SEPRDBPL). Analizom korelacione matrice izoliranih komponenti (tabela 10) vidimo da prvi faktor ima najveću povezanost s četvrtim (,277) i trećim (,273) izolovanim faktorom.

Table 7. *Factor analysis in the area of situational efficiency of the 2014 World Cup*

Tabela 7. *Faktorska analiza u prostoru situacione efikasnosti Svjetskog prvenstva 2014. godine*

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.545	28.457	28.457	6.545	28.457	28.457	4.959
2	5.239	22.777	51.234	5.239	22.777	51.234	4.416
3	2.406	10.462	61.696	2.406	10.462	61.696	4.045
4	2.232	9.705	71.401	2.232	9.705	71.401	4.764
5	1.301	5.656	77.057	1.301	5.656	77.057	2.290
6	1.130	4.913	81.971	1.130	4.913	81.971	1.603

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Table 8. *Matrix of the situational efficiency assembly of the 2014 World Cup*

Tabela 8. *Matrica sklopa situacione efikasnosti Svjetskog prvenstva 2014. godine*

Variables / Varijable	Component					
	1	2	3	4	5	6
SEPRD (m)	.478	.139	.698	-.134	.115	.148
SEPRDPP (m)	.940	-.043	-.006	-.017	-.050	-.037
SEPRDDP (m)	.029	.210	.856	-.160	.181	.219
SEPRDPL (m)	.028	.225	.454	.561	-.006	-.027
SEPRDBPL (m)	.435	-.038	.095	.004	.144	.601
SEBRSP (No)	.153	-.166	.740	.162	-.307	-.180
SEBRSPPP (No)	.366	-.189	.283	.205	-.461	-.291
SEBRSPDP (No)	-.124	-.102	.938	.065	-.041	.007
SEMAXB (km/h)	-.064	.003	-.111	.025	-.752	.563
SEMAXBPP (km/h)	.051	.151	-.034	-.081	-.879	-.034
SEMAXBDP (km/h)	-.239	-.115	.202	.194	-.201	.654
SEVANIS (%)	-.921	.046	-.062	-.107	.059	.050
SEVASRE (%)	.927	.165	-.124	.014	.081	.125
SEVAVIS (%)	.760	-.201	.195	.161	-.157	-.176
SEBUDO (No)	.062	.612	-.095	.634	.054	-.065
SEBNDO (No)	.017	.539	-.043	.716	-.002	-.039
SEBDUDO (No)	-.040	.932	.102	-.168	-.084	-.018
SEBNDDO (No)	-.061	.880	.099	-.078	-.113	-.003
SEBSUDO (No)	.027	.637	-.135	.517	.081	-.122
SEBSNDO (No)	.007	.582	-.111	.599	.042	-.090
SEBKUDO (No)	.158	-.139	-.039	.869	.023	.098
SEBKNDO (No)	.086	-.258	.040	.898	-.035	.099
SEPUDL (%)	.119	.542	-.155	.099	.237	-.017

Table 9. *Situational efficiency structure matrix of the 2014 World Cup*

Tabela 9. *Matrica strukture situacione efikasnosti Svjetskog prvenstva 2014. godine*

Variables / Varijable	Component					
	1	2	3	4	5	6
SEPRD (m)	.631	.063	.810	.050	.040	.231
SEPRDPP (m)	.933	-.062	.257	.240	-.014	-.060
SEPRDDP (m)	.218	.127	.836	-.087	.071	.332
SEPRDPL (m)	.305	.295	.474	.640	-.090	-.009
SEPRDBPL (m)	.452	-.072	.279	.080	.128	.603
SEBRSP (No)	.394	-.241	.836	.250	-.482	-.066
SEBRSPPP (No)	.491	-.243	.455	.339	-.547	-.248
SEBRSPDP (No)	.149	-.173	.925	.070	-.248	.154
SEMAXB (km/h)	-.137	-.175	.097	.031	-.743	.559
SEMAXBPP (km/h)	-.019	-.029	.123	.031	-.834	-.035
SEMAXBDP (km/h)	-.156	-.185	.292	.100	-.297	.693
SEVANIS (%)	-.966	.047	-.327	-.364	.047	.068
SEVASRE (%)	.895	.173	.120	.282	.174	.064
SEVAVIS (%)	.858	-.210	.432	.366	-.210	-.159
SEBUDO (No)	.209	.755	-.110	.760	.144	-.166
SEBNDO (No)	.199	.681	-.045	.823	.056	-.128
SEBDUDO (No)	-.072	.878	.019	.010	.090	-.069

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SEBNDDO (No)	-.069	.836	.028	.086	.043	-.054
SEBSUDO (No)	.133	.771	-.182	.637	.193	-.225
SEBSNDO (No)	.141	.720	-.142	.706	.131	-.187
SEBKUDO (No)	.387	.022	.077	.877	-.059	.054
SEBKNDO (No)	.343	-.108	.159	.873	-.162	.077
SEPUDL (%)	.109	.619	-.207	.207	.369	-.097

Table 10. *Intercorrelation matrix of isolated components of situational efficiency of the 2014 World Cup*

Tabela 10. *Matrica interkorelacije izolovanih komponenti situacione efikasnosti Svjetskog prvenstva 2014. godine*

Component	1	2	3	4	5	6
1	1.000	-.011	.273	.277	.044	-.029
2	-.011	1.000	-.081	.189	.194	-.084
3	.273	-.081	1.000	.059	-.188	.147
4	.277	.189	.059	1.000	-.079	-.052
5	.044	.194	-.188	-.079	1.000	-.015
6	-.029	-.084	.147	-.052	-.015	1.000

The third group of respondents (N = 120) consisted of soccer players participating in the World Championship in 2018. where. as in the two previous championships. situational efficiency was analyzed. The structure was analyzed by the method of principal components with oblique direct oblimin transformation. The value of KMO and Bartlett's test is statistically significant (Sig =.00) and amounts to .65 (table 11). According to the Keizer-Guttman criterion. a total of 76.30% of the common valid variance. which can be explained by 4 isolated factors. was exhausted from the total space of variables for football at the WC 2018 (table 12). By analyzing the assembly matrix (table 13) and the structure of the matrix (table 14). we see that the variables of the distance covered (SEPRD. SEPRDPP. SEPRDDP. SEPRDBPL) and the variables characterizing the low intensity of the game (SEVAZ-I. SEVAZ-II. SEVAZ) were separated into the first factor -III). so this factor is called the factor of physical demands in soccer. The second isolated factor was called the factor of technical success. because the variables explaining the distribution of passing the ball (SEBUDO. SEBNDO. SEBDUDO. SEBNDDO. SEBSUDO. SEBSNDO. SEPUDL) were singled out the most. In the third factor. all sprint variables (SEBRSP. SEBRSPPP. SEBRSPDP). maximum running speed variables (SEMAXB. SEMAXBPP. SEMAXBDP) and variables characterizing high game intensity (SEVAZ-IV. SEVAZ-V) were singled out. so this factor was named the high intensity factor of the game. The fourth isolated factor is a mixed factor composed of the projections of the variables short successful and unsuccessful passes (SEBKUDO. SEBKNDO) and the distance traveled in possession of the ball (SEPRDPL). and we called it the factor of physical demands and the factor of successful passes in soccer. By

Treću grupu ispitanika (N = 120) činili su nogometaši učesnici Svejtskog prvenstva 2018. godine, gdje je kao i kod dva prethodna prvenstva analizirana situaciona efikasnost. Stuktura je analizirana metodom glavnih komponenti s kosom direkt oblimin transformacijom. Vrijednost KMO i Bartletovog testa je statistički značajna (Sig =,00) i iznosi ,65 (tabela 11). Iz ukupnog prostora varijabli kod nogometa na SP 2018. godine po Keiser-Guttmanovom kriteriju iscrpljeno je ukupno 76,30% zajedničke valjane varijanse koja se može objasniti sa 4 izolovana faktora (tabela 12). Analizom matrice sklopa (tabela 13) i strukture matrice (tabela14) vidimo da su se u prvi faktor izdvojile varijable pređene udaljenosti (SEPRD, SEPRDPP, SEPRDDP, SEPRDBPL) i varijable koje karakterišu niski intenzitet igre (SEVAZ-I, SEVAZ-II, SEVAZ-III), pa je ovaj faktor nazvan faktor fizičkih zahtjeva u nogometu. Drugi izolirani faktor nazvan je faktorom tehničke uspješnosti, jer su se najviše izdvojile varijable koje objašnjavaju distribuciju dodavanja lopte (SEBUDO, SEBNDO, SEBDUDO, SEBNDDO, SEBSUDO, SEBSNDO, SEPUDL). Kod trećeg faktora izdvojile su se sve varijable sprinta (SEBRSP, SEBRSPPP, SEBRSPDP), varijable maksimalne brzine trčanja (SEMAXB, SEMAXBPP, SEMAXBDP) i varijable koje karakterišu visok intenzitet igre (SEVAZ-IV, SEVAZ-V), pa je ovaj faktor nazvan faktor visokog intenziteta igre. Četvrti izolovani faktor je mješoviti faktor sastavljen od projekcija varijabli kratka uspješna i neuspješna dodavanja (SEBKUDO, SEBKNDO) i pređena distanca u posjedu lopte (SEPRDPL), te smo ga nazvali faktor fizičkih zahtjeva i faktor uspješnih dodavanja u nogometu. Korelacijom matrice izoliranih komponenti (ta-

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correlating the matrix of isolated components (table 15). we see that the first factor has the highest correlation with the fourth (.21) isolated factor.

bela 15) vidimo da prvi faktor ima najveću povezanost s četvrtim (,21) izolovanim faktorom.

Table 11. The value of KMO and Bartlett's test at the World Cup 2018

Tabela 11. Vrijednost KMO and Bartlett's testa kod Svjetskog prvenstva 2018. godine

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.654
Bartlett's Test of Sphericity	Approx. Chi-Square	6016.898
	df	300
	Sig.	.000

Table 12. Factor analysis in the area of situational efficiency of the 2018 World Cup

Tabela 12. Faktorska analiza u prostoru situacione efikasnosti Svjetskog prvenstva 2018. godine

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.947	27.789	27.789	6.947	27.789	27.789	6.080
2	6.352	25.409	53.198	6.352	25.409	53.198	6.017
3	3.814	15.255	68.453	3.814	15.255	68.453	4.689
6	1.964	7.856	76.309	1.964	7.856	76.309	4.225

Table 13. Situational efficiency assembly matrix of the 2018 World Cup

Tabela 13. Matrica sklopa situacione efikasnosti Svjetskog prvenstva 2018. godine

Variables / Varijable	Component			
	1	2	3	4
SEPRD (m)	.936	.024	.087	-.094
SEPRDPP (m)	.906	.029	.091	-.045
SEPRDDP (m)	.850	.013	.077	-.136
SEPRDPL (m)	.137	.288	.062	-.628
SEPRDBPL (m)	.698	-.092	.006	.544
SEBRSP (No)	.177	-.262	.662	-.380
SEBRSPPP (No)	.176	-.284	.613	-.307
SEBRSPDP (No)	.151	-.172	.548	-.373
SEMAXB (km/h)	-.114	.169	.929	.239
SEMAXBPP (km/h)	-.057	.022	.729	.022
SEMAXBDP (km/h)	.026	.180	.867	.167
SEVAZ-I (%)	-.968	.008	.090	-.003
SEVAZ-II (%)	.924	.029	-.250	.096
SEVAZ-III (%)	.798	.072	-.003	-.139
SEVAZ-IV (%	.369	-.261	.420	-.385
SEVAZ-V (%)	-.112	-.209	.699	-.038
SEBUDO (No)	.015	.872	-.028	-.352
SEBNDO (No)	.007	.856	.016	-.365
SEBDUDO (No)	.018	.853	.026	.199
SEBNDDO (No)	-.007	.869	.107	.220
SEBSUDO (No)	-.022	.907	-.003	-.156
SEBSNDO (No)	-.018	.895	.012	-.189
SEBKUDO (No)	.096	.178	-.095	-.870
SEBKNDO (No)	.077	.111	-.071	-.893
SEPUDL (%)	.049	.545	-.146	-.068

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Table 14. *Situational Efficiency Structure Matrix of the 2018 World Cup*

Tabela 14. *Matrica strukture situacione efikasnosti Svjetskog prvenstva 2018. godine*

Varijables / Varijable	Component			
	1	2	3	4
SEPRD (m)	.962	-.060	.174	-.313
SEPRDPP (m)	.922	-.059	.168	-.258
SEPRDDP (m)	.885	-.056	.164	-.333
SEPRDPL (m)	.255	.347	.090	-.705
SEPRDBPL (m)	.587	-.223	.016	.404
SEBRSP (No)	.338	-.375	.786	-.469
SEBRSPPP (No)	.318	-.396	.733	-.387
SEBRSPDP (No)	.293	-.258	.648	-.454
SEMAXB (km/h)	-.101	-.064	.850	.120
SEMAXBPP (km/h)	-.001	-.141	.717	-.063
SEMAXBDP (km/h)	.049	-.040	.807	.024
SEVAZ-I (%)	-.961	.067	.006	.195
SEVAZ-II (%)	.880	-.003	-.190	-.077
SEVAZ-III (%)	.822	.027	.067	-.322
SEVAZ-IV (%	.510	-.334	.560	-.485
SEVAZ-V (%)	-.027	-.353	.742	-.077
SEBUDO (No)	.018	.924	-.178	-.469
SEBNDO (No)	.018	.901	-.129	-.484
SEBDUDO (No)	-.093	.819	-.191	.077
SEBNDDO (No)	-.117	.816	-.119	.091
SEBSUDO (No)	-.062	.930	-.189	-.273
SEBSNDO (No)	-.048	.919	-.167	-.307
SEBKUDO (No)	.262	.309	-.014	-.902
SEBKNDO (No)	.256	.241	.027	-.915
SEPUDL (%)	.006	.583	-.256	-.133

Table 15. *Intercorrelation matrix of isolated components of situational efficiency of the 2014 World Cup*

Tabela 15. *Matrica interkorelacije izolovanih komponenti situacione efikasnosti Svjetskog prvenstva 2014. godine*

Component	1	2	3	4
1	1.000	-.082	.085	-.218
2	-.082	1.000	-.226	-.134
3	.085	-.226	1.000	-.130
4	-.218	-.134	-.130	1.000

DISCUSSION

The obtained results can certainly expand our understanding of modern football. its game structure. as well as the direction of training in the training technology of football players. A large number of indicators. 30 of them in this research. which define the situational efficiency of top football players in modern football. were explained by factor analysis and summarized into a smaller number of latent. homogeneous and interdependent factors. The research partially explained the structure of the football elements of the situational performance of the displayed parameters. which

DISKUSIJA

Dobijeni rezultata mogu nam sigurno proširiti shvatanje o savremenom nogometu, njegovoj strukturi igre kao i pravac obučavanja u trenažnoj tehnologiji nogometaša. Veliki broj indikatora, u ovom istraživanju njih 30, koji definišu situacionu efikasnost vrhunskih nogometaša u savremenom nogometu, faktorskom analizom objašnjen je i sažet u manji broj latentnih, homogenih i međusobno zavisnih faktora. Istraživanje je djelomično objasnilo strukturu nogometnih elemenata situacijske izvedbe prikazanih parametara, koje opet možemo

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we can further observe through certain phases. subphases. moments of the game as well as the position of the players in the team. In the structure of football at WC 2010 and WC 2014. 6 latent factors were singled out. and at WC 2018. 4 latent factors were singled out. which are differently saturated with situational indicators. The obtained results show that the explained variance was the highest at WC 2010 (83.52 %). followed by WC 2014 (81.97 %). and the least explained variance (76.30 %) was at WC 2018. Similar research was done by Čolakhodžić. E. (2019) with the aim of determining the structure of football through situational performance indicators at the 2014 World Cup in Brazil. The obtained results show that 83.82% of the total variance was explained and that five significant latent factors were isolated. namely: the factor of football condition (52.61%). the factor of football technical-tactical success (17.11%). the factor of football technical- tactical success in the counterattack (5.24%). ball possession success factor (4.71%). football speed factor 4.12%. Sporiš. G.. Šamija. K.. Vlahović. T.. Milanović. Z.. Barišić. V.. Bonacin. D.. Talović. M. (2012) determined the latent structure of tactical means in the defense and attack phase in football defined 117 tactical means of the football game. the importance of which was assessed on 30 variables that denote the fundamental elements of the football game. Factor analysis under the component model with the Guttman-Kaiser criterion resulted in a total of five significant latent dimensions: the factor of effectiveness of the end of the attack. the factor of success in possession of the ball. the factor of efficiency of counterattacks. the factor of success of combined defense. the factor of interference and "directing" of the preparation of the opponent's attack. The research partially solved the problem of the hypothetical structure of the tactical means of the football game according to the phases and subphases of the game. the positions of the attackers and defenders. and the types (ways) of the game in defense and attack. Barišić. (2007) in his research. applying factor analysis under the component model. along with the Guttman-Kaiser criteria. obtained a total of five significant latent dimensions: the factor of efficiency of the end of the attack. the factor of the efficiency of the end of the attack. the factor of the success of possession of the ball. the success factor of the counterattack. the success factor of the combined defense. the factor of interference. direction and preparation of the opponent's attack. Gomez. M.A.. Gomez. M.. Lago-Penas. C. and Sampaio. J. (2012) analyzed the independent and interactive effects of match venue and match outcome with respect to pitch zones divided by parallel lines in width. Factor analysis was used for data processing. Four factors were obtained: the factor of the lost ball in zone 5.2. crosses in zone 4; factor hits and shots on goal in zone 5.1.

dalje posmatrati kroz određene faze, podfaze, momente igre kao i poziciju igrača u timu. U strukturi nogometa na SP 2010 i SP 2014 izdvojilo se 6 latentnih faktora, a na SP 2018 izdvojila su se 4 latentna faktora, koji su različito zasićeni sutuacionim indikatorima. Dobijeni rezultati govore da je objašnjenost varijanse bila najveća na SP 2010. (83,52 %), zatim na SP 2014. (81,97 %), a najmanje objašnjene varijanse (76,30 %) bilo je na SP 2018. godine. Slično istraživanje uradio je Čolakhodžić, E. (2019) s ciljem da se utvrdi struktura fudbala kroz pokazatelje situacionih performansi na igrama Svjetskog prvenstva 2014. u Brazilu. Dobijeni rezultati pokazuju da je objašnjeno 83,82% ukupne varijance i da se izolovalo pet značajnih latentnih faktora i to: faktor nogometne kondicije (52,61%), faktor nogometne tehničko-taktičke uspješnosti (17,11%), faktor nogometne tehničko-taktičke uspješnosti u kontranapadu (5,24%), faktor uspješnosti posjeda lopte (4,71%), faktor nogometne brzine 4,12 %. Sporiš, G., Šamija, K., Vlahović, T., Milanović, Z., Barišić, V., Bonacin, D., Talović, M. (2012) utvrđivali su latentnu strukturu taktičkih sredstava u fazi obrane i napada u nogometu definirali 117 taktičkih sredstava nogometne igre čija je važnost procijenjena na 30 varijabli koje označavaju temeljne elemente nogometne igre. Faktorskom analizom pod komponentnim modelom uz Guttman-Kaiserov kriterij dobiveno je ukupno pet značajnih latentnih dimenzija: faktor efikasnosti završnice napada, faktor uspješnosti posjeda lopte, faktor efikasnosti kontranapada, faktor uspješnosti kombinirane obrane, faktor ometanja i „usmjeravanja" pripreme protivničkog napada. Istraživanjem je djelomično riješen problem hipotetske strukture taktičkih sredstava nogometne igre prema fazama i podfazama igre, pozicijama napadača i obrambenih igrača te vrstama (načinima) igre u obrani i napadu. Barišić, (2007) u svom istraživanju primjejnujući faktorsku analizu pod komponentnim modelom, uz Guttman-Kaiserov kriterija, dobio je ukupno pet značajnih latentnih dimenzija: faktor efikasnosti završnice napada, faktor efikasnoti završnice napada, faktor uspješnosti posjeda lopte, faktor uspješnosti kontranapada, faktor uspješnosti kombinovane odbrane, faktor ometanja, usmjeravanja i pripreme protivničkog napada. Gomez, M.A., Gomez, M., Lago-Penas, C. i Sampaio, J. (2012) analizirali nezavisne i interaktvine efekte mjesta odigravanja utakmice i ishoda utakmice s obzirom na zone igrališta podijeljene paralelnim linijama po širini. Za obradu podataka je korištena faktorska analiza. Dobivena su četiri faktora: faktor izgubljene lopte u zoni 5.2, centaršutevi u zoni 4; faktor pogoci i udarci prema golu u zoni 5.1, izgubljene lopte u zoni 4 i osvojene lopte u

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lost balls in zone 4 and won balls in zone 2; factor hits and kicks towards the door in zone 5.2; the factor of the lost ball in the zone 5.1. The results of the analysis would enable the formation of a number of guidelines that can be important in the scientific foundation of the football game. and in practical terms can serve football experts in selecting the most effective content of tactical. technical and fitness training (creating training operators that will have a targeted effect on the formation of the most significant motor skills in football).

CONCLUSION

Based on the obtained results. we conclude that changes have occurred in the structure of football over a period of 8 years. which shows us the number and structure of factors that have been fished out. The structure of football has changed in such a way that the number of factors has been reduced from 6 to 4. and the structure of isolated factors clearly defines modern football. These factors that make up the structure of the football game were distinguished as: 1. Physical requirements in football. 2. Factor of technical success. 3. Factor of football speed and high intensity of the game. 4. Factor of successful passing of the ball. The structure obtained in this way clearly determines the basic factors that make up today's football. i.e. the equation of success in it. and based on it it is possible to direct training operators who will especially influence the faster development and creation of the most important abilities and skills in football. Based on the results. the guidelines and standards on which football training should be based can be clearly determined. while using certain training tools. training stimulans and appropriate training loads in order to achieve a high level of physical preparation. a high level of technique in movement. a high rhythm of the game and tactical maturity of football players. The established latent structure of football gives football experts a clearer picture of what defines success in modern football. and which. through the processes of planning and programming training programs. leads to the improvement of individual. group and team abilities and technical-tactical skills.

zoni 2; faktor pogoci i udarci prema vratima u zoni 5.2; faktor izgubljene lopte u zoni 5.1. Rezultati provedene analiza omogućili bi oblikovanje većeg broja smjernica koje mogu biti važni u naučnom utemeljenju nogometne igre, a u praktičnom pogledu mogu poslužiti nogometnim stručnjacima u odabiru najefikasnijih sadržaja taktičke, tehničke i kondicione pripreme (kreiranje trenažnih operatora koji će ciljano uticati na formiranje najznačajnijih motoričkih znanja u nogometu).

ZAKLJUČAK

Na osnovu dobijenih rezultata zaključujemo da su se u vremenskom razdoblju od 8 godina desile promjene u strukturi nogometa, što nam pokazuje broj i struktura izlovanih faktora. Promijenila se struktura nogometa na način da se smanjio broj faktora sa 6 na 4, a struktura izolovanih faktora jasno definiše savremeni nogomet. Ovi faktori koji čine strukturu nogometne igre izdvojili su se kao: 1. Fizički zahtjevi u nogometu, 2. Faktor tehničke uspješnosti, 3. Faktor nogometne brzine i visikog intenziteta igre, 4. Faktor uspješnosti dodavanja lopte. Ovako dobijena struktura nam jasno određuje osnovne faktore koji čine današnji nogomet, odnosno jednačinu uspješnosti u njemu, te je na osnovu nje moguće usmjeriti trenažne operatore koji će posebno utjecati na brže razvijanje i stvaranje najvažnijih sposobnosti i vještina u nogometu. Na osnovu rezultat mogu se jasno odrediti smjernice i standardi na kojima treba da se bazira nogometni trening, pri tom koristeći određena trenažna sredstva, trenažne stimuluse i odgovarajuća trenažna opterećenja kako bi se postigao visok nivo fizičke pripremljenosti, visok nivo tehnike u kretanju, visok ritam igre i taktička zrelost nogometaša. Utvrđena latentna struktura nogometa daje nogometnim stručnjacima jasniju sliku onoga što definiše uspješnost u savremenom nogometu, a što kroz procese planiranja i programiranja trenažnih programa vodi unaprijeđenju individualnih, grupnim i timskih sposobnosti i tehničko-taktičkih vještina.

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THE INFLUENCE OF INDONESIAN SPORT MASSAGE TRAINING ON THE KNOWLEDGE AND SKILLS OF SPECIAL SPORTS THERAPISTS

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Abstract: Athletes are state assets, so they need to be handled appropriately to reduce fatigue. Objective: This study aims to provide knowledge and skills in Indonesian sports massage for sports therapists. therapists specifically for sportsmen where the sample was taken using purposive sampling, namely: 1) already have beginner massage skills and have not yet mastered sports massage therapy; 2) have a sports physiologist certificate; 3) have special experience in sports. The sample in this study consisted of 30 specialist sports therapists. Method: used in this research was an experiment using one group pretest posttest with data collection techniques using a Likert scale questionnaire. The instrument in the research uses a questionnaire that has been validated by experts. Research results: after being given 12 training meetings, knowledge and skills results increased by 4.861 and t table (df 28; 5%) 2.048 with a significance p value of 0.000, so it can be interpreted as significant. This means that the conclusion is that the Indonesian sports massage training can increase the knowledge and skills of specialist sports therapists who will then be able to carry out special treatment for athletes in Indonesia.
Keywords: Indonesian Sport Massage, Knowledge, Expertise

INTRODUCTION

Massage has become a necessity in everyday human life, because massage can make people healthy and strong, both physically and spiritually (Kirwa & Nkomesha, 2023; Kusparlina et al., 2023). Massage can also be used as a means to relieve fatigue, of course hoping to achieve comfort in the body (Ismail & Rofi, 2024). On the other hand, an athlete must carry out various learning models regularly and seriously (Songwathana et al., 2023). Additionally, in research (Kim & Yang, 2023) In the process of gaining knowledge, students must be required to carry out practice where this practice requires good physical condition. Sports massage is a type of rehabilitation that has been modified to suit the conditions in Indonesia.

Sports themselves don't seem to cause fatigue, but if you observe them from a standing position, sitting position and during the learning process, you can really see how tired they are.(Kuna et al., 2023). Monotonous activities and activities that require physical and mental walking have a real impact, one of which is fatigue and tension which hinders athletes' performance (Yachsie, Pranata, et al., 2023). Of the most common types of fatigue in athletes, overuse injuries can arise due to constant physical and mental stress (Pensgaard et al., 2023). Fatigue is often experienced by athletes after training in the form of fatigue, muscle aches, muscle cramps, muscle spasms, sprains, strains (Pensgaard et al., 2023). Doing repetitive exercises makes your physical and mental condition not well maintained. So it is necessary to relax the body for students by providing various types of massage manipulation, including sports massage.

There are many ways you can do when you experience fatigue and to speed up recovery after activities, one of which is the massage method (Gavanda et al., 2023). The treatment that is often carried out is sports massage which aims to reduce muscle tension due to activity (Musat et al., 2023). The muscle tension that occurs is influenced by lactic acid in the blood due to the body's process of releasing energy (Edouard et al., 2023). Sports massage is a massage performed by a massage therapist to help speed up the recovery process by using hand touch and without inserting medication into the body with the aim of alleviating or reducing complaints or symptoms of several types of diseases which are indications for massage (Priyonoadi et al., 2018). The goals of hand manipulation techniques (massage) include muscle relaxation, improvement of flexibility, reduction of pain, and improvement of blood circulation (S. Lee et al., 2023; Liu et al., 2023). Sports massage is a type of massage that is used as an alternative to relieve

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fatigue and tiredness (Edouard et al., 2023; Hussain et al., 2023; S. Lee et al., 2023; Liu et al., 2023; Priyonoadi et al., 2020; Robergs et al., 2023). This is because sports massage is designed to facilitate blood circulation, especially the encouragement of venous blood to the heart, thus helping to restore and process metabolic waste, in addition to providing muscle and nerve relaxation (Mulyadi & Sartono, 2019). In according to (Ayudi et al., 2022) Sports massage mainstay manipulation techniques are Effluerage, Petrissage, Shaking, Tapotement, Friction, Walken, Efflurage, Vibration. Thus, the aim of this research is to find out the results of providing massage training, namely sports massage specifically for sports therapists.

METHOD

The population in this study were therapists specifically for sportsmen, where samples were taken using purposive sampling, namely: 1) already had beginner massage skills and had not yet mastered sports massage therapy; 2) have a sports physiologist certificate; 3) have special experience in sports. The sample obtained in this study was 30 therapists specializing in sports. The method used in this research is an experiment using one group pretest posttest with data collection techniques using a Likert scale questionnaire. The data collection process is by providing sports massage training. The guidelines for implementing treatment (massage treatment) refer to the FITT (Frequency, Intensity, Time and Type) treatment program as follows.

Table 1. Procedure for Implementing Sports Massage

No	Component	Sports Massage
1	Frequency	1x Treatment
2	Intensity	Pressure adjusts the size or thickness of the outer muscles
3	Time	15 Minutes, Each Manipulation 3-8 Repeats
4	Type	Sports massage techniques: Effluerage, Petrissage, Shaking, Tapotement, Friction, Walken, Efflurage, Vibration

Table 2. Instrument Grid

Variable	Factors	indicators	Expert Number				
			Strongly agree	Agree	Enough	Don't agree	Strongly Disagree
Sports Massage	Knowledge	Know the Sports Massage Procedure	5	4	3	2	1
		Know the history of sports massage	5	4	3	2	1
		The movements carried out are sequential	5	4	3	2	1
		Memorize sports massage techniques.	5	4	3	2	1
	Skill	Memorize sports massage techniques	5	4	3	2	1
		Can do it independently.	5	4	3	2	1
		Not sure about the techniques you have mastered	5	4	3	2	1
		Knowing repetition in sports massage manipulation	5	4	3	2	1
Total			**40**	32	24	16	8

However, the initial step in providing the material is by presenting the material, then continuing with the demonstration method, where the demonstration is carried out by providing assistance for 2 weeks. In this activity, intensive guidance and assistance is carried out so that the results of the training will be permanent and participants will contribute fully, with the hope that the implementation of this activity can increase participants' knowledge and skills. This means that the pretest data collection process was carried out before giving this sports massage training and the posttest data collection was taken after carrying out and assisting the demonstration for 2 weeks using a questionnaire on the instrument. In this study, the instrument was taken from research (Ashraf et al., 2024; Hamzehnejadi et al.,

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2024; Hernández-Sánchez et al., 2024) put together and then used as a tool to measure knowledge and skills in the form of a Likert scale questionnaire, of course this questionnaire has been validated by experts and has been proven to be valid and reliable with a score of 8.876. Following is the instrument grid.

Before testing the hypothesis, it is necessary to test the prerequisites. Testing measurement data related to research results aims to help the analysis to be better. For this reason, in this research, normality and homogeneity tests will be tested, then proceed to the t-test.

RESULTS

The data results in this research are in the form of sports massage knowledge and skills. The results of the knowledge and skills data analysis are: The results of the descriptive statistical analysis of sports massage knowledge and skills in Table 3 are as follows:

Table 3. Descriptive statistics on sports massage knowledge and skills

Statistics	Knowledge	Skills
N	15	15
Mean	168.07	188.40
Media	167.00	185.00
Mode	166.00	183.00a
Std, Deviation	8.43	13.83
Minimum	154.00	168.00
Maximum	181.00	218.00
Sum	2521.00	2826.00

When displayed in the form of assessment norms, sports massage knowledge and skills are presented in Table 4 as follows:

Table 4. Norms for assessing the level of knowledge and skills in sports massage

No	Intervals	Category	Knowledge		Skills	
			F	%	F	%
1	80-100	Very good	0	0.00%	0	0.00%
2	50-79	Good	2	13.33%	11	73.33%
3	30-49	Not enough	13	86.67%	4	26.67%
4	10-29	Very less	0	0.00%	0	0.00%
	Amount		15	100%	15	100%

Based on Table 4 above, it shows that the level of knowledge and skills has increased. Based on the average results, it shows that there has been an increase in the knowledge and skills of the training participants. The normality test is intended to determine whether the variables in the study have a normal distribution or not. This normality test calculation uses the Kolmogorov-Smirnov formula. with processing using the SPSS 16 computer program. The results are presented in Table 5 as follows.

Table 5. Summary of normality test results

Fitness	p	sig	Information
Knowledge	0.710	0.05	Normal
Skills	0.062	0.05	Normal

From the results of Table 5 above, it can be seen that the training participants have p (Sig.)> 0.05, so the variable has a normal distribution. The homogeneity test is useful for testing the similarity of samples, namely whether or not the variance of samples taken from the population is uniform. Homogeneity rule if p > 0.05. then the test is

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declared homogeneous, if p < 0.05. then the test is said to be inhomogeneous. The homogeneity test results can be seen in Table 6 as follows:

Table 6. Summary of homogeneity test results

Group	df1	df2	Sig.	Information
Knowledge and Skills	1	28	0.231	Homogeneous

From Table 6 above it can be seen that the two groups have a p value (Sig.) > 0.05 so the data is homogeneous. The hypothesis in this study states "there is a significant influence of sports massage on the knowledge and skills of training participants". The research conclusion is declared significant if the calculated t value > t table (df n-2) and the sig value is smaller than 0.05 (Sig < 0.05). Based on the results of the analysis, the data in Table 7 is as follows.

Table 7. Results of sports massage t-test analysis of the knowledge and skills of training participants

Archery Accuracy	Average	t-test for Equality of means			
		t ht	t tb	Sig.	Difference
Knowledge	168.07	4,861	2,048	0,000	20.33
Skills	188.40				

From the t-test results in Table 9 above, it can be seen that the t count is 4.861 and the t table (df 28; 5%) is 2.048 with a significance p value of 0.000. Because t count is 4.861 > t table 2.048, and the significance value is 0.000 < 0.05, then this result shows that there is a significant difference. Based on the results of this analysis, the alternative hypothesis (Ha) which states "there is a significant influence of sports massage on the knowledge and skills of training participants", is accepted. This means that the sports massage training increases the knowledge and skills of the training participants.

DISCUSSION

Based on the research results, it shows that the influence of providing sports massage socialization in terms of knowledge and skills is a series where these two aspects go hand in hand and this training adds insight to the training participants, which is characterized by them being able to immediately practice and do it alternately. Sports massage itself is a massage with many partners where you need to practice to be memorized and consistent (Sumarjo et al., 2023). In this massage movement, it is always followed by pressure on the targeted muscles, to achieve a relaxed condition for athletes who are tired but does not damage the muscles that have been formed during exercise (Đukić et al., 2019).

Knowledge is an important element in massage conditions where the therapist comes into direct contact with various patients (Yao et al., 2024). So with the new knowledge in the form of sports massage, it is hoped that it will not only be the general public who can be massaged but will look at the suitability aspects of athletes who can also be massaged (Ekradi et al., 2024). This can be interpreted, by looking at the needs of society, where many sportsmen get massages but it actually reduces their performance so that with sports massage it can reduce the public stigma that spas are only for office and public circles but sportsmen can also get massages. Knowledge here according to (Ekradi et al., 2024; Godfrey et al., 2024; Nemati et al., 2024) is always associated with pure science which underlies a person's knowledge where knowledge is the first step to development and innovation, so that with knowledge it is hoped that the therapist will not take it lightly and will still be willing to improve knowledge so that when doing massage the therapist has sufficient knowledge so that he can aspire to a better massage. efficient to be developed and combined with sports massage.

Skill is a condition where the therapist can carry out sports massage correctly and can increase his creativity (Nemati et al., 2024; Thomson-Casey et al., 2024). Apart from physical factors, sports massage is also aimed at improving psychosomatic aspects (factors related to various bodily symptoms that arise due to psychological factors). (Butala et al., 2024). Emotional tension causes various mistakes during massage (Suresh, 2024). A lack of self-confidence often causes skills to decline(Butala et al., 2024). This means that if skills are truly honed and precise, it will lead to high self-confidence so that work will feel easy and reduce stress (H.-M. Lee et al., 2024; Notsu et al., 2024). The implementation of mentoring to improve these skills is carried out intensively 12 times in 2 weeks. So

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that training participants have the ability to adapt the massage skills learning that has been implemented in a coherent and clear manner. Even though this activity has been carried out with a thorough plan, there are still problems experienced where the training participants experience boredom where repetition of massage techniques is directed at not changing the structure and sequence first so that the training participants master it and can do it without assistance.

CONCLUSION

The solution offered by the community service team in this training program is to provide knowledge and skills to training participants so they can prevent and relieve sports injuries through sports massage. The material used for handling sports injuries is through sports massage based on Indonesian national standards. The modules that will be provided will make participants more effective during the training. Apart from that, this training will also provide several materials that the Team can use to increase their knowledge in the future. So that training participants can practice and combine sports massage to increase their skills in the field of SPA.

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Abstract: The rapid development of javelin throwing sport, it is necessary to improve the ability of athletes, this problem is a competitive demand. This study is to determine the effect of a specific training programme in this case is SCP-B-T training on improving the javelin throwing ability of prospective athletes. The sample in this study were prospective athletes at the South Sulawesi Sports Excellence High School specialising in javelin throwing, totalling 24 people. The research design used is true experiment, with purposive sampling technique. The experiment was given treatment for four weeks, consisting of two groups, namely the group given the SCP-B-T training programme and the control group. The SCP-B-T exercise programme treatment group used the Standing Cable Pullover-Bench Press-Torso tool, frequency 3 times per week, intensity 40-60%, reps 10-20, rest 60 seconds. To measure the level of improvement of the treatment given, we conducted a pre-test and post-test on both experimental groups. The study showed that the group given treatment in the form of the SCP-B-T training programme had a significant effect compared to the conventional training programme to improve the javelin throwing ability of prospective athletes. SCP-B-T training is very influential in improving the ability of prospective javelin throwing athletes.

Keyword: Experiment, Jevelin Throwing, SCP-B-T Training program

INTRODUCTION

The sport of javelin throwing has been organised competitively since 1896 and has been part of the Olympic Games since 1908 for men and 1932 for women (IAAF, 2010). The development of javelin throwing sport is so rapid, so it demands an increase in the ability of athletes and becomes a competitive demand. It is a highly technical sport that involves precise sequential movements of lower and upper body segments. The javelin in this case is an aerodynamically designed device controlled by the laws of physics (Gorski, 1982). Javelin release is an important part of throwing technique (Hussain & Bari, 2012). The throwing angle is considered an important feature for travelling the maximum throwing distance, where the lower and upper body parts play an important role in javelin throwing (Krzyszkowski & Kipp, 2019). In the implementation of javelin throwing, there are several movements starting from the head, how to hold and carry the spear, body attitude when throwing a spear, how to throw a spear, and body attitude after throwing a spear. The sequence of movements is a unity of motion that must be trained in accordance with the throwing motion pattern. But so far there is no standardised training to improve javelin throwing, as stated by Guntoro, T.S. (2014) the conventional method is an approach that generally emphasises the use of weight training by trainers. This way of training contributes less to improving the performance of javelin throwing athletes.

To increase the success of javelin throwing, seen from the pattern of motion of the legs to the arms, the muscles that determine the motion of throwing javelins, especially the hip muscles to the arms still need to improve the form of training. One of the efforts to improve javelin throwing ability is physical exercise for athletes. Bafirman & Wahyuri (2018) say physical exercise and sports activities can provide changes in all body system functions. Changes that occur during training are called responses, while changes that occur due to regular and programmed training in accordance with the principles of training are called adaptations. The occurrence of changes in improving physiological abilities due to physical exercise is related to the use of energy by muscles, the form and method and principles of exercise carried out. Good physical condition will go hand in hand with good skills as well. In addition, to improve

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the physical condition of an athlete, training with the circuit training method is needed (Susanto et al., 2021). Physical exercise can also be adjusted with a play approach so that it is not boring (Susanto et al., 2022).

Physical condition is a very important aspect in improving athlete achievement, physical development in factors that need to be resolved and improved without waiting for a better situation. Abou Elmagd, M (2016) explains that when athletes do not carry out regular physical exercise, they certainly cannot perform techniques optimally, to improve physical condition, programming must be done, that the training programme is part of training management that must be compiled and implemented properly and correctly. The basis for making an exercise programme should be based on the physiological and bimechanical aspects of the sport. Therefore, it is very important to make an exercise programme that is in accordance with the movement patterns of the sport to train the anatomy of the body that plays a role when performing these movements, so as to produce maximum ability. Increasing the ability of an athlete must be supported by a good physical component, this condition must be accompanied by structured training, this is in accordance with the opinion of McKinney, J., et al (2019) that an athlete can win the title when he has excellent physical condition in every training and competition.

In biomechanics of motion in javelin throwing sports, the implementation of javelin throwing techniques is a unity of motion from strength (strength), speed (speed), flexibility (flexibility), to produce a long throw influenced by the flexibility of the togok before releasing the javelin, and coordination of muscle work requires strength and speed (explosive power) of the arm in throwing the javelin. In the javelin throwing movement, the element of flexibility is very important because the movement of flexibility when starting the arm before releasing the javelin requires good flexibility so that the flexibility of the togok as a power plant to throw the javelin so that the explosive power of the arm is better. In javelin throwers, adaptation of static and dynamic shoulder flexibility will increase strength in the dominant physique (Edouard, P., et al 2013). The javelin throwing technique, the speed at which the thrower releases the javelin is by far the most important factor. To achieve a high throwing speed, the transfer of mechanical energy through the kinetic chain plays an important role.

Based on the author's interviews with several athletes and javelin throwing coaches, it was found that the problems experienced by athletes are the form of training that is not supported by facilities and infrastructure, related to physical training that does not understand the pattern of motion in accordance with the biomechanics of motion (Bacis, Special, Specific), there is no special training for javelin throwing numbers, the usual training given is training using external loads such as push ups, sit ups and others. In addition, the coach also complained about not understanding the types of muscles that play a role and the physiological function of training adaptations. This problem makes the athlete's performance decrease when competing, this is a factor inhibiting achievement, therefore it is necessary to offer a structured concept to support these achievements.

In addition, considering the nature and characteristics of javelin throwing, which is an explosive action and a series of continuous movements, the training provided should reasonably address these characteristics. Through the analysis of javelin thrower injuries in sports, this study uses biomechanical analysis methods to analyse the data changes in the final exertion stage and related reasons (Wang Wei a, Li Yalong b, 2021). Therefore, the compatibility of physical training with javelin throwing movements has an important role in improving physical fitness to the maximum. Based on this analysis, the author proposes a specific training programme based on the pattern of motion when throwing a javelin.

Problems arising from the observations of researchers, it was found that physical exercise that was not in accordance with the physical components of domonin did not have a good effect on improving javelin throwing ability. The need for weight training that trains muscles that play a role in anatomical physiology so that the results of the exercise have a significant effect. SCP-B-T training is a form of weight training that develops skeletal muscles well and has not been used by several coaches. The novelty of SCP-B-T training is a form of training that combines training (Bacis, Special, Specific) so as to increase the dominant biomotor components in the sport of javelin throwing.

METHODS

The research method used is True Experiment. As explained by Jack R. Fraenkel (2012) that an important element of the True Experiment is that subjects are randomly divided into several groups, where random assignment is a powerful technique for controlling the external influence of subject characteristics on the validity of the research. The random distribution of subjects was divided into two groups, the experimental group which was treated with the SCP-B-T exercise programme and the control group. The control group in this study as a comparison with the group

given treatment. The research design used in this study is The Randomised Pretest-Posttest Control Group Design. In this design, the effect will be seen between the group giving the treatment of the SCP-B-T training programme and the control group given treatment according to the conventional javelin throwing training programme. The division of groups is determined by random means through a lottery, in accordance with the research method used, namely True Experiment. The groups were given a pretest to measure the ability to throw a javelin, then given treatment to each group with a predetermined duration and form of treatment, ending with a posttest by measuring the javelin throwing ability again.   The pre-test is given at the beginning before giving treatment to determine the initial state and changes that occur. The post-test is given at the end (after treatment) to evaluate changes in data during the pretest as well as review the impact of the group given treatment or the control group given treatment according to the training programme provided. Changes that occur can be seen through the difference in O2 - O1 scores in each group, the difference obtained between O2 and O1 will explain the better effect due to the treatment given.

This research was conducted in Makassar City, with the population in this study being athletes at the South Sulawesi Sports Excellence High School specialising in javelin throwing, totalling 24 people. Participants in this study used a sampling approach, namely purposive sampling which is a sample selection based on criteria that are considered by researchers according to research needs. The criteria in this purposive sampling are: (1) Willing to be a sample, (2) Recorded as a student of the South Sulawesi Sports Excellence High School, (3) In good health, (4) Following the training programme properly. Based on these criteria, the number of samples in this study totalled 24 athletes.

RESEARCH INSTRUMENTS

In this study, data collection will be carried out using test and measurement techniques with research instruments in accordance with the reference. Specifically, the instruments used are (1) Microtoice or Anthropometer pipe to measure height. (2) Body weight using instruments: Body weight scales. (3) Strength using the instrument: Push Up. (4) Explosive Power using the instrument: Two hand medicine ball put test (5) Flexibility using the instrument: Forward flexion of trunk test (6) Javelin Throwing Ability using instrument: Javelin throwing ability test.

Treatment

The treatment was carried out after the athletes performed the SCP-B-T training programme with high intensity and had done the pretest. The treatment in this study was given to the SCP-B-T exercise programme treatment group using the Standing Cable Pullover-Bench Press-Torso tool, frequency 3 times per week, intensity 40-60%, reps 10-20, rest 60 seconds for the first group, with the number of meetings based on the significance of the treatment given. The control group was treated with a conventional javelin throwing training programme that did not specialise in the dominant body part when throwing the javelin.

Data Analysis Technique

The effectiveness test used was an experiment with a research design of one group pretest-postest design. Hypothesis testing using the Wilcoxon nonparametric test compares the results of the pretest and posttest of paired groups. The collected data were analysed using the SPSS version 20 application.

RESULTS

Presentation of data analysis results includes descriptive and inferential statistical analysis. Then a discussion of the results of the analysis and its relation to the theory underlying this research to provide interpretation of the results of data analysis. The Effect of SCP-B-T Training on Javelin Throwing Ability in Prospective Javelin Throwing Athletes. Empirical data obtained in the field in the form of SCP-B-T Training on Javelin Throwing Ability, first tabulated the data to facilitate further testing. Data analysis used in this research is analysis with inferential statistical techniques. Furthermore, testing the requirements of the analysis is carried out, namely testing the normality and homogeneity of the data, for hypothesis testing using the t-test to find the effect of SCP-B-T Training on the ability to throw javelins on prospective javelin throwing athletes with the requirement that the data must be normally distributed and homogeneous.

Descriptive data analysis is intended to get an overview of research data. Descriptive data is intended to be able to interpret and give meaning to the Effect of SCP-B-T Training on the Ability to Throw Javelin on Prospective Javelin Throwing Athletes the data is successively as in the following table.

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Table 1. *Summary of the results of the analysis of the Effect of SCP-B-T Training on Javelin Throwing Ability in Prospective Javelin Throwing Athletes*

Variabel	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
Javelin throwing pre test	20	14.50	19.00	33.50	483.24	24.1620	5.08484
Javelin throw post test	20	13.82	23.34	37.16	573.26	28.6630	4.70585

Based on table 1, the data results of the Effect of SCP-B-T Training on the Ability to Throw Javelins on Prospective Javelin Throwing Athletes are obtained as follows: 1) For Pre test data of javelin throwing given SCP-B-T training on prospective javelin throwing athletes obtained a value of N 20, range 14.50, minimum 19.00, maximum 33.50, Sum 483.24, mean 24.1620, Standard Deviation 5.08484. 2) For javelin throwing post test data given SCP-B-T training to prospective javelin throwing athletes obtained a value of N 20, range 13.82, minimum 23.34, maximum 37.16, Sum 573.26, mean 28.6630, Standard Deviation 4.70585.

One of the assumptions that must be met so that parametric statistics can be used is that the data follows a normal distribution if the test turns out that the data is normally distributed, it means that parametric statistical analysis has been fulfilled. To find out whether there is an effect of SCP-B-T training on javelin throwing ability in prospective javelin throwing athletes, testing is carried out with the Kolmogorov-Smirnov test. The results of the data normality test can be seen in the table.

Table 2. *Summary of the results of the normality test of the Effect of SCP-B-T Training on Javelin Throwing Ability in Prospective Javelin Throwing Athletes*

Variabel	N	Absolut	Positif	Negatif	KS-Z	Asymp.Sig (2 tailed)	Ket.
Javelin throwing pre test	20	0.250	0.250	-0.155	1.116	0.165	Normal
Javelin throw post test	20	0.141	0.141	-.0.129	0.631	0.820	Normal

Based on table 2, the variable Effect of SCP-B-T Training on Javelin Throwing Ability in Prospective Javelin Throwing Athletes above, it can be seen that the data normality test is as follows: 1) Pre test data for javelin throwing given SCP-B-T training on prospective javelin throwing athletes obtained a value of N 20, Absolute 0.250 Positive 0.250, Negative -0.155, KZ 1.116, asymp 0.165 (P> 0.005), with a perception equation asymp 0.165> 0.005 then the data on javelin throwing athletes given SCP-B-T training follows a normal distribution or normal distribution. 2) Javelin throwing post test data given SCP-B-T training on prospective javelin throwing athletes obtained the value of N 20, Absolute 0.141 Positive 0.141, Negative -0.129, KZ 0.631, asymp 0.820 (P> 0.005), with the perception equation asymp 0.820> 0.005 then the data on javelin throwing athletes given SCP-B-T training follows a normal distribution or normal distribution. For the sake of hypothesis testing, the average test between the research groups was carried out, namely the group that practised SCP-B-T training on javelin throwing ability in prospective javelin throwing athletes The statistical test technique used is the T test. A summary of the analysis results can be seen in the following table:

Table 3. *Summary of the results of the Effect of SCP-B-T Training on Javelin Throwing Ability in Prospective Javelin Throwing Athletes*

Variabel	N	Mean Value	Sig. Value
Javelin throwing pre test	20	24.1620	0.000
Post test javelin throw	20	28.6630	0.000
Difference	-	4.5010	-

Based on table 3 above, it can be seen that the effect of SCP-B-T training on the ability to throw javelins on prospective javelin throwing athletes as follows: 1) Data on athletes who were given SCP-B-T training on the ability to throw javelins on prospective javelin throwing athletes obtained the results of N 20, mean value 24.1620, value and sig value.0.000. 2) Data of athletes given SCP-B-T training on javelin throwing ability in prospective javelin throwing athletes obtained the results of N 20, mean value 28.6630, value and sig value.0.000. 3) From the data of athletes given SCP-B-T training on the ability to throw javelins at prospective javelin throwing athletes obtained the initial mean of 24.1620, the final mean of 28.6630 and obtained a difference of 4.5010.

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DISCUSSION

Kinetic chains are segments influencing each other during movement (Seroyer et al., 2010). When one segment moves, it creates a chain of events that affects the movement of adjacent joints and segments. The more body segments that contribute to the total force output, the greater the velocity at release (Wilk et al., 2000). Throwing is the dynamic activity of an open-ended kinetic chain of segments acting from proximal (lower limb) to distal (upper limb) sequences (Oliver et al, 2018). The motion of each segment in the chain maintains energy transfer, but also increases energy (Wilk et al., 2000). Wilk and colleagues described a kinetic chain in overhead throws starting with 1) lower extremity, 2) pelvis, 3) spine, 4) shoulder girdle, 5) upper arm, 6) forearm, 7) hand; each segment starts as the adjacent proximal segment reaches its peak velocity (Seroyer et al., 2010).

The muscles of the lower extremities (quadriceps, hamstrings, internal and external rotators of the hip) coordinate together to provide a stable base for the trunk to rotate and flex during throwing (Seroyer et al., 2010). As the lower extremities generate most of the force during the throwing motion, dysfunction in the proximal segments can result in reduced energy transfer and shoulder and elbow (distal segment) weakness (Oliver et al., 2018). Success achieved from an efficient kinetic chain, requires strength, coordinated muscle activation with flexibility, and properly executed biomechanics (Meron & Saint-Phard 2017). According to Seroyer (2010), in support of Kibler and Chandler's previous findings, they found that a 20% decrease in kinetic chain energy delivered from the hip and torso to the arm would require a 34% increase in rotational velocity from the shoulder to achieve the same amount of force to the hand. Efficiency in the kinetic chain reduces the contribution of the shoulder joint, reducing stress and potentially reducing injury to the joint (Seroyer et al., 2010). Seroyer also stated that with greater knowledge of the kinetic chain and key parameters of the throwing motion can greatly improve technique, performance, rehabilitation and injury prevention. According to Weber et al. (2014) the energy generated during throwing should be safely released during deceleration and follow-through to reduce overuse injuries.

This study piloted the SCP-B-T training programme as a method to improve the javelin throwing ability of prospective athletes or novice athletes in throwing. Continuous training can also improve javelin throwing ability (Dumang, F., & Tengah, P. S. 2013). The throwing ability in this case is the javelin throwing technique from the prefix to the follow-through stage. When the prospective athlete is trained, a special training programme is given based on the dominant body organs when the prospective athlete throws. This is in line with what was revealed by Bompa O. Tudor, Buzzichelli A. Carlo. (2019), that the specificity includes: the dominant muscle group trained and the expected motion pattern. The exercises given must be related to the specific skills of a particular sport. This SCP-B-T exercise is a new training programme in the sport of javelin throwing. This study also compared the results of SCP-B-T training with conventional javelin throwing training. It was significantly found that SCP-B-T training was claimed to have more effect on improving javelin throwing ability than conventional javelin throwing training. Where throwing activity is a movement that provides energy to an object (Ambia, F et all., 2023).

In the initial stage of this study, the authors conducted a preliminary study by testing the training programme provided by the trainer at a high intensity. Once the SCP-B-T programme was deemed feasible, the author proceeded to administer the exercise programme to the actual sample. At the first meeting, the author introduced the sample to the programme and let the sample feel the physiological impact on their body after doing the SCP-B-T-based exercise programme. By the second week, the samples were getting used to the exercises and enjoying the exercise process. The SCP-B-T exercises belong to strength training. The author developed the training pattern to increase the strength of certain muscles so that when throwing, they have strength and speed. Strength training has been widely used as an exercise that is considered effective for increasing strength and muscle (Souza et al., 2014). Every week the author takes sample data to see the effect of the training programme that has been given. The increase in javelin throwing ability occurred in week three but the data showed that the increase was not significant. Therefore, the author continued until week four and found that the increase in the sample's javelin throw increased significantly. The results showed that of the two groups given treatment in the form of the SCP-B-T training programme and conventional training, it was found that SCP-B-T training had more influence on improving the javelin throwing ability of prospective athletes.

CONCLUSION

The SCP-B-T training programme has a significant effect compared to the conventional training programme to improve the javelin throwing ability of prospective athletes. This is in line with the research hypothesis based

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on theories that support the principle of specificity of training programmes in related sports. Although the control group also showed an increase in the javelin throwing ability of the sample, when compared to the SCP-B-T training programme, it was found that the SCP-B-T training programme had a more significant effect on the javelin throwing ability of prospective athletes. The results showed the effect of the SCP-B-T training programme had a significant effect on javelin throwing ability, but this study still has several limitations such as, the number of samples that must be more and the duration of research time is too short. Therefore, future researchers are recommended to consider a larger and broader sample size, a longer duration of research and use different methods in order to reveal information that has not been revealed in this study.

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Abstract: This comprehensive review delves into the impact of low-intensity resistance training coupled with blood flow restriction (BFR) on arterial stiffness, evaluated through the ankle-brachial index (ABI). This assessment seeks to discern any discernible alterations in arterial stiffness attributed to this unique training approach. Employing systematic search via PubMed and Google Scholar databases, this review examined research articles focusing on the chronic effects of resistance training with BFR on the ABI. Inclusion criteria encompassed studies assessing this effect across various age groups while concentrating on healthy individuals and publications in the English language. Among the extensive array of studies, a selective inclusion of 5 research articles formed the foundational basis of this analysis. Synthesizing analyses from these studies illuminated the safety of BFR training, particularly at intensities around 20-30% or using elastic bands. Intriguingly, these modalities exhibited no significant impact on alterations in the ABI, notably observed within elderly subjects. However, a notable scarcity in studies focusing on young subjects warrants a more comprehensive investigation into this specific demographic. The findings of this review underscore the safety and efficacy of BFR resistance training methodologies, especially protocols utilizing 20-30% 1RM or incorporating elastic bands of 75-repetition-scheme, showcasing no significant impact on the ankle-brachial index, particularly in the elderly population over intervention periods not exceeding 12 weeks. Encouraging practitioners, these established methodologies offer safe practices for the elderly. However, the evident research gap in young subjects necessitates more expansive investigations.
Keywords: Ankle-brachial index, Blood flow restriction, Resistance training

INTRODUCTION

In recent years, blood flow restriction (BFR) resistance training has gained considerable traction within sports coaching and physiotherapeutic practices for its purported benefits in enhancing training adaptations and aiding rehabilitation (Cuffe et al., 2022). The versatile nature of BFR training is exemplified through its varied applications: coaches harness its potential for athletic performance (Wortman et al., 2021), optimizing muscle hypertrophy (May et al., 2022) and strength gains (Lopes et al., 2022); physiotherapists utilize it as an effective tool for injury rehabilitation (Killinger et al., 2019), aiding in muscle recovery and functional restoration (Cognetti et al., 2022); additionally, it finds utility among elderly individuals who may not tolerate high-load exercises, allowing for enhanced muscle activation and maintenance (Cook et al., 2017).

However, amidst its increasing popularity, concerns have been raised regarding its safety (Nakajima et al., 2006), particularly in relation to the vascular system. This apprehension is centered around the external compression applied to muscles via cuffs (Wortman et al., 2021), potentially impacting vascular function. Notably, the assessment of arterial stiffness through the Ankle-Brachial Index (ABI) serves as a crucial method for evaluating vascular health (Aboyans et al, 2012). The ABI is a simple yet crucial diagnostic tool. It involves measuring and comparing the blood pressure in the ankle to that in the arm. By dividing the ankle systolic pressure by the arm systolic pressure, this index provides a numerical value that reflects the ratio of blood pressure in these two areas. The meta-analysis of 4 studies comprising 922 limbs demonstrated that the test of ABI score of less than or equal to 0.90 could be a non-invasive method to identify the serious peripheral arterial disease, such as peripheral artery disease or atherosclerosis, aiding in the diagnosis and monitoring of vascular conditions (Xu et al. 2013; Casey et al. 2019). The ABI serves as a quick and non-invasive method to evaluate blood flow and arterial health, offering valuable insights into a patient's vascular status.

Given these considerations, this systematic review aims to comprehensively review the available data pertaining to the

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safety aspects of low-intensity resistance training combined with BFR, particularly focusing on the chronic impact on the Ankle-Brachial Index change. By evaluating existing evidence, this review should provide insights into the potential effects and safety profile of this training modality on vascular function, informing future practices in training and rehabilitation.

MATERIALS AND METHODS

Eligibility Criteria

This systematic review incorporated studies that met stringent inclusion criteria: (1) measurement of pre- and post-training Ankle-Brachial Index, (2) implementation of resistance training accompanied by blood flow restriction techniques, (3) emphasis on chronic training effects (over a duration exceeding 4 weeks), and (4) inclusion of participants classified as possessing a healthy status. Solely peer-reviewed publications in English, available in reputable journals, were taken into account. Exclusion criteria encompassed study cohorts characterized by physical ailments such as cancer or diabetes. Furthermore, populations with mental health conditions such as depression, schizophrenia, or dementia were deliberately omitted from this comprehensive analysis.

Search Strategy

The databases such Google Scholar and Pubmed were searched for papers published between 2010 to 2023. The search term consisted of "Blood flow restriction" OR "Blood Flow-restricted" OR "BFR" AND "Low intensity" AND "Resistance training" OR "Resistance exercise" AND "Arterial stiffness" OR "Ankle Brachial Index" AND "Healthy" AND "Older" OR "adult"

Study Selection

The study selection process followed a meticulous approach in adherence to the predefined inclusion and exclusion criteria outlined in section 2.1. Initially, retrieved articles from Google Scholar and PubMed databases, encompassing publications dated between 2010 to 2023, underwent a rigorous screening process. This involved an initial screening of titles and abstracts to identify relevant studies meeting the specified criteria. Subsequently, selected studies underwent a full-text assessment for comprehensive scrutiny against the predetermined eligibility criteria. The final selection included studies meeting all predefined criteria outlined in section 2.1 and aligned with the specific focus of this systematic review on blood flow restriction and its chronic impact on arterial stiffness evaluated through the Ankle-Brachial Index among healthy adult populations.

Quality Assessment

The methodological quality of the studies was evaluated utilizing the Physiotherapy Evidence Database (PEDro) scale, as detailed by Morton et al. (2009). In order minimizing subjectivity and enhancing the objectivity of the quality assessment, the appraisal step underwent an evaluation by independent experts in filed of sport science and sport rehabilitation to mitigate the potential risk of bias and uphold the rigor of the evaluation. This PEDro scale encompasses rigorous assessment criteria including Eligibility criteria, Random allocation, Concealed allocation, Baseline comparability, Blind subjects, Blind therapists, Blind assessors, Adequate follow-up, Intention-to-treat analysis, Between-group comparisons, and Point estimates and variability. Each study was appraised on a scale ranging from 0 to 10, with higher scores indicative of superior methodological quality (Cashin & McAuley, 2020). The PEDro scale serves as a comprehensive tool for evaluating the rigor and reliability of research methodologies employed in the assessed studies.

RESULTS

A total of 5 articles meeting the specified inclusion criteria were identified, involving a combined total of 96 healthy subjects, with 44 individuals allocated to the BFR training group. The resistance training interventions encompassed exercises with an external load ranging from 20% to 30% of the subjects' one-repetition maximum (Clark et al, 2011: Yasuda et al, 2014), and in some cases, incorporated the use of elastic bands (Yasuda et al, 2015; Yasuda et al, 2015; Yasuda et al, 2016). The duration of these interventions varied from 4 to 16 weeks.

Notably, studies focusing on elderly participants uniformly employed a training frequency of two sessions per week (Yasuda et al, 2014; Yasuda et al, 2015; Yasuda et al, 2015; Yasuda et al, 2016). Conversely, one study (Clark

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et al. 2011) involving healthy young participants utilized a training regimen comprising three sessions per week. Regarding the targeted muscle groups, four studies (Clark et al. 2011; Yasuda et al, 2014; Yasuda et al, 2016) concentrated on lower body resistance training, while two studies (Yasuda et al, 2015; Yasuda et al, 2015) centered their interventions on upper body resistance exercises.

Table 1. Effect of blood flow restriction resistance training on ankle-brachial index

Study	Duration and Training Frequency	Subjects	BFR-RT Intensity	Arterial occlusion pressure	Training intervention	Exercises	Primary outcome on Ankle-Brachial Index of BFR-RT
Yasuda et al. 2014	12 weeks 2days /week	19 healthy elder men and women	20-30%1RM 4sets of 75 repetitions scheme (30, 20, 15, and 10 reps)	120-270mmHg	Low intensity BFR RT (n=9) Control (n=10)	1-Leg press 2-Knee extension	There was no significant change from pre to post observed in ABI value from pre 1.13 unit to post intervention 1.15 unit in BFR training group.
Yasuda et al. 2015	12 weeks 2days /week	17 healthy elder women	Elastic bands 4sets of 75 repetitions scheme (30, 15, 15, and 15 repetitions)	180-270mmHg	Low intensity BFR RT (n=9) Control (n=8)	1-Arm Curl 2-Triceps Pressdown	There was no significant change from pre to post observed in ABI value from pre 1.17 unit to post intervention 1.14 unit in BFR training group.
Yasuda et al. 2015	12 weeks 2days /week	14 healthy elder women	Elastic bands 4sets of 75 repetitions scheme (30, 15, 15, and 15 repetitions)	230-270mmHg	Low intensity BFR RT (n=7) Control (n=10)	1-Arm curl 2-Triceps Pressdown	There was no significant change from pre to post observed in ABI value from pre 1.14 unit to post 1.12 unit in BFR training group.
Yasuda et al. 2016	12 weeks 2days /week	30 healthy elder women	Elastic bands 4sets of 75 repetitions scheme (30, 15, 15, and 15 repetitions)	160-200mmHg	Low intensity BFR RT (n=10) High intensity RT (n=10) Control (n=10)	1-Bilateral squat 2-Knee extension	There was no significant change from pre to post observed in ABI value from pre 1.14 to post 1.15 unit in BFR training group.
Clark et al. 2011	4 weeks 3days/week	16 young healthy men and women	30%1RM 3sets x 30-50 repetition to failure 80%1RM 3sets x 8-12repetition	130% above the resting brachial SBP	Low intensity BFR RT (n=9) High intensity RT (n=7)	1-Knee extension	There was no significant change from pre to post observed in ABI value from pre 1.15 to post 1.09 unit in BFR training group.

For a comprehensive overview of the interventions and outcomes of the included studies, refer to Table 1. Additionally, Table 2 provides the individual PEDro scores for each study, offering an assessment of methodological quality. Of 5 studies included, two studies were classified as "good quality" while the rest of three were classified as "fair quality".

Table 2. PEDro scale

		Yasuda et al. 2014	Yasuda et al. 2015	Yasuda et al. 2015	Yasuda et al. 2016	Clark et al. 2011
	Eligibility	Yes	Yes	Yes	Yes	Yes
1	Random allocation	1	0	1	1	1
2	Concealed allocation	1	0	0	1	0
3	Baseline comparability	1	1	1	1	0
4	Blind subjects	0	0	0	0	0
5	Blind therapists	0	0	0	0	0
6	Blind assessors	0	0	0	0	1

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7	Adequate follow-up	1	1	1	1	1
8	Intention-to-treat analysis	1	1	1	1	1
9	Between-group comparisons	1	1	0	0	0
10	Point estimates and variability	0	1	1	1	0
	Scores	6/10	5/10	5/10	6/10	4/10
	Quality	"Good"	"Fair"	"Fair"	"Good"	"Fair"

DISCUSSION

The key outcomes of this comprehensive review underscore several critical points. First, our analysis revealed a lack of evidence indicating a significant impact of low-intensity resistance training with BFR on the ABI score. Second, our findings suggest that in elderly individuals aged over 60, BFR training demonstrates a notable safety profile concerning this vascular index. This safety was particularly evident when utilizing an external load range between 20-30% of 1 repetition maximum in conjunction with 75-repetition schemes. Third, the limited available data, notably from a solitary study involving healthy young subjects over a short duration of 4 weeks, impedes making conclusive statements about the safety of BFR training for this specific demographic. Consequently, establishing robust conclusions about this cohort's safety necessitates further research and deeper investigation.

The arterial occlusion pressure, notably exceeding 200mmHg, emerged as a seemingly safe threshold, even among elderly individuals, warranting consideration and potential adoption in the practice of this technique. Among the four studies that incorporated low-intensity resistance training with BFR, the recorded pressure ranged between 120-270mmHg (Yasuda et al., 2014; Yasuda et al., 2015; Yasuda et al., 2015; Yasuda et al., 2016). Nevertheless, the recent recommendation on the guideline practice of how much pressure to be applied suggested the use of individual arterial occlusion pressure (Rolnick et al., 2020). However, it's pivotal to consider the duration of training as a crucial factor. The studies reviewed this time followed a pattern involving four sets with 75-repetition schemes, with each set interspersed by a mere 30-second rest interval, resulting in a total exercise duration of approximately 10-15 minutes (Yasuda et al., 2015) which is in accordance with the guideline for appropriate time of application of BFR (Patterson et al., 2019). The extension of application time becomes a focal point of concern when contemplating additional sets or exercises for the elderly. Careful consideration is warranted for longer application times, especially when incorporating more sets or exercises, to ensure optimal safety and efficacy among this demographic.

In our analysis, it became evident that resistance training targeting both lower and upper body muscles appears to maintain safety concerning the ABI among the elderly population which is in accordance with the current recommendation (Patterson et al., 2019). Existing studies have implemented isolated exercises like knee extensions alongside compound lower body movements such as squats and leg presses, all of which demonstrated safety in relation to the vascular index. However, it's noteworthy that while lower body exercises have been studied (Yasuda et al., 2014; Yasuda et al., 2016), the impact of compound exercises on the upper body remains unexplored within this context. As such, future research endeavors should prioritize investigating the effects of chronic resistance training with BFR utilizing compound upper body exercises like bench presses or seated rows. This exploration aims to discern whether these exercises might influence the ABI, thus contributing to a more holistic understanding of the implications of such training regimens.

Given the scarcity of studies involving young, healthy individuals, drawing definitive conclusions and formulating precise recommendations for this age group is currently constrained by the presence of only one fair-quality study investigating this specific vascular index. To bridge this gap in our understanding, it is imperative that future research endeavors focus on augmenting this body of knowledge. Expanding the duration of studies beyond the current 4 weeks scope to obtain the insights into the safety profile associated with training modality among this demographic. This extension in study duration stands to enrich our understanding and provide a more nuanced perspective on the implications and safety considerations pertinent to young, healthy subjects engaged in this form of training.

CONCLUSION

This review highlights the lack of evidence on low-intensity resistance training with BFR affecting ABI scores. For the elderly (age >60), BFR training, using 20-30% of 1RM and 75-repetition schemes, appears notably safe. However, limited data, especially for young, healthy individuals, impedes solid conclusions. Further research, extending beyond 4 weeks, is crucial to fully comprehend the safety of BFR training in this demographic. Considering

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arterial occlusion pressures over 200mmHg as seemingly safe, cautious extension of exercise duration is advised, particularly for additional sets or exercises among the elderly. Future studies should explore compound upper body exercises' impact on ABI, complementing the existing focus on lower body movements in BFR training research.

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TRAINING MECHANISMS AND RECOVERY IN SPRINTERS

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Abstract: *Top sprinters have higher body mass index, relaxed upper arm girths, thigh and calf girths, fat free mass, and fat free mass index than the lowest tertile. Eccentric training has significant changes in body composition, while explosive strength training improves running performance. Training mechanisms include progressive overload, specificity, periodization, individualization, technical training, strength and power training, plyometric training, recovery strategies, and tapering. The sprint start is a key factor in sprint results, with biomechanical performance factors. Recovery strategies include foam rolling, active recovery, passive recovery, and contrast water therapy. Proper nutrition and supplementation of vitamins, minerals and anti-oxidants are essential for sprinters to maintain optimal glycogen stores, muscle repair, recovery, and growth. Collaboration between athletes, coaches, and sports nutrition professionals is needed to develop personalized nutrition plans.*

Keywords: *sprint, strength, power, recovery, training*

INTRODUCTION

Despite a large amount of research on sprint training, we still know very little about how to train for a world-class sprint performance and all the aspects that make an athlete better at sprinting, however there are researches conducted that have proved conclusive in defining training mechanisms and methods to improve sprint speed and mechanisms that don't (Haugen et al., 2019). Such as body types and mass measures play a very important role in impacting sprint performance (Barbieri et al., 2017). Performance at the sprint is closely related to measures of strength and power (Smirniotou et al., 2008). Body mass distribution can be impacted for greater sprint results by inculcating eccentric training which in turn prove with higher sprint speed results (Suarez-Arrones et al., 2018). Listing the recovery strategies for short term perceptual recovery and power performance recovery that also affect results (Crowther et al., 2017). Looking at the effects of altitude on the physiologies of athletes and evidences that the effects of altitude training are marginal and not long lasting (Girard et al., 2017). How explosive strength training, sprinting and endurance training, shows no improvement in certain physical parameters (Paavolainen et al., 1999).

The contribution of neuromuscular function to running performance has received a lot of attention lately. In one single training session, Complex Training (CT) alternates between completing strenuous resistance exercises and plyometric workouts, greatly improving neuromuscular adaptation for sprinting (F. Li et al., 2019). Also, studies show the outcome of a race being heavily determined by the block start (Valamatos et al., 2022). To maximize recuperation and enhance sprint performance, the authors advised coaches and practitioners to combine these tactics and come up with the optimal strategy for results (Crowther et al., 2017). Without leaving out the importance of diet and supplementation and how vitamins, antioxidants and protein have positive impacts on better performance (Slater et al., 2019).

The aim of the review paper is to showcase, highlight and investigate the parameters and methods that have the greatest impact on sprint results and encourage professionals to formulate the best possible training program for athletes with all these aspects in consideration.

BODY TYPES

The study of the science of sprint is, even though a large amount, still in the process of new methodical discoveries (Haugen et al., 2019). As comparison to the lowest tertile, top sprinters had a considerably higher body mass index, relaxed, and contracted upper arm girths, thigh and calf girths, fat free mass, and fat free mass index. There was a noticeable increase in strength and power (Barbieri et al., 2017). Several anthropometric characteristics and measures of lean body mass were shown to be substantially associated with personal best times (Barbieri et al., 2017). The body shape, composition, and size vary according to the sped running performance level (Barbieri et al.,

2017). Significant disparities in sprinting performances can be attributed to being less ectomorphic and having a higher fat-free mass and strength (Barbieri et al., 2017). These also have an impact on strength and power parameters (Smirniotou et al., 2008). The study's findings offer a benchmark for sprinter traits that coaches and sport scientists can use to enhance sprinter performance (Barbieri et al., 2017). Eccentric training also has significant measured changes in body composition in professional athletes, with fat tissue being significantly lower in a time period from the beginning of the season to the end of the season (Suarez-Arrones et al., 2018). The muscle mass of arms was also substantially increased at the end of the season in a comparative study conducted on the athletes (Suarez-Arrones et al., 2018). Studies also showcase the fact that explosive strength training, irrespective of load weight used for the explosive exercise, also improves running performance in athletes (Paavolainen et al., 1999). It shows significant changes in neuromuscular characteristics of the athletes as well as considerable increase in overall body mass index (Paavolainen et al., 1999). Evidently, less ectomorphic characteristics, lower fat tissue, higher muscle mass in the arms and legs, a higher muscle explosiveness are all body compositional characteristics that contribute to better performance in sprinting (Paavolainen et al., 1999).

TRAINING METHODS

The most widely used training mechanisms for sprint specific training are Progressive overload, specificity (application of velocity), periodization, individualisation, specific sprint training, technical training, strength and power training, plyometric training, recovery strategies, and tapering (Haugen et al., 2019). However, there is a disconnect between the scientific vs practical information and knowledge about each of these methods (Haugen et al., 2019). Strength and power models and methods have the best agreement and connect between science and practice because they are more objective measures compared to the other methods and models (Haugen et al., 2019). Plyometric training models are also in conjunction with the science (Haugen et al., 2019). Recovery methods used by athletes have little or incomplete science behind them however show effects on application (Haugen et al., 2019). Tapering training methods have high science and practice agreement behind it. (Haugen et al., 2019). Simultaneous explosive strength training, including sprinting and endurance training, showed no change in V˙o2 max or other aerobic performance variables in well-trained endurance athletes over 5,000 miles (Paavolainen et al., 1999).

Compared to most forms of training methods, complex training of 1rep max explosive methods has a more direct effect on neuromuscular function and therefore results in better coordination (chain linking between muscle and brain) (F. Li et al., 2019). Relatively small volume of plyometric training in combination with complex exercises have more prominent effects on sprint performance in comparison to overload training (F. Li et al., 2019). Also, a study concluded that the efficiency factor of athletes was improved by giving attentional focus on sprint movements rather than power (D. Li et al., 2022). However, attentional focus was seen to have more of a significant effect on lower skilled athletes and less significant on higher skilled sprinters (D. Li et al., 2022). Using repeated sprints as a performance measure for athletes is less effective in comparison to measures directed to their specific sport (Charron et al., 2020). Acute hypoxic exposure challenges multiple regulatory systems by increasing cardiorespiratory (higher heart rate, minute ventilation), metabolic (slower muscle re-oxygenation responses), and/or neuromuscular (incomplete muscle activation) requirements during sprinting and subsequent recovery periods (Girard et al., 2017). Acute hypoxic exposure also decreases convective O2 transport (i.e., reduces arterial O2 saturation values) (Girard et al., 2017). The advantages of traditional techniques of altitude/hypoxic training, such as living at altitude, on sprint performance are still up for debate (Girard et al., 2017). This may be because sprint-based disciplines do not heavily rely on haematological adjustments (Girard et al., 2017). Resistance training in hypoxia or repeated-sprint training in hypoxia have recently emerged as innovative "live low-train high" techniques, either alone or in combination with chronic HH/NH exposure, with the idea that up-regulated non-haematological peripheral adaptations (i.e., additional activation of anaerobic and neuromuscular pathways) may further improve performance of multiple sprints compared to similar normoxic interventions (Girard et al., 2017). But in terms of competitive sporting events, these assertions need to be supported further (Girard et al., 2017).

THE BIOMECHANICS OF SPRINTING

The sprint start holds one of the most crucial parts in sprint results and is a defining factor in competition (Valamatos et al., 2022). Generating high acceleration during the initial phase of the race and achieving an optimal body

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position for efficient force production and propulsion is one of the most researched aspects of a sprint race (Valamatos et al., 2022). Through a systematic review of existing research, there are several biomechanical performance factors that significantly influence the sprint start (Valamatos et al., 2022). These include reaction time, block configuration, block force production, step characteristics, and body position during the start. (Valamatos et al., 2022). Optimising the biomechanical factors of strength and power parameters in also is showcased for their importance in determining performance factors in sprinting (Smirniotou et al., 2008). They both play key roles in even the block start, explosivity of the beginning part of the race and the glide of a 100m sprint (Smirniotou et al., 2008). There is a huge importance in evaluating and targeting these parameters in training programs for sprinters, as they can provide valuable insights into an athlete's potential and areas for improvement (Smirniotou et al., 2008).

RECOVERY

Naturally, recovery being a key part in athletic performance would be to say the least. There is a considerable prevalence in delayed onset muscle soreness, which refers to the muscle discomfort and reduced performance experienced after intense or unfamiliar exercise (Pearcey et al., 2015). More and more the need for effective strategies to mitigate DOMS and accelerate recovery, as prompt recovery is essential for maintaining optimal training and performance levels. foam rolling can be an effective strategy for reducing DOMS and enhancing recovery of dynamic performance measures (Pearcey et al., 2015). Findings support the potential benefits of foam rolling in alleviating muscle soreness, improving flexibility, and promoting recovery after intense exercise (Pearcey et al., 2015). Coaches, athletes, and practitioners can consider incorporating foam rolling as part of their overall recovery and performance enhancement strategies (Pearcey et al., 2015). However, not just that, there is also importance in effective recovery strategies in optimizing athletic performance and reducing the risk of overtraining and injury (Crowther et al., 2017). Athletes must employ various recovery methods to expedite the recovery process and enhance their readiness for subsequent training or competition (Crowther et al., 2017). Such as active recovery, passive recovery, and contrast water therapy. Active recovery involves low-intensity exercise or movement, while passive recovery involves complete rest (Crowther et al., 2017). Contrast water therapy alternates between warm and cold-water immersion (Crowther et al., 2017).

DIET AND SUPPLEMENTATION

Proper nutrition and supplementation are essential for sprinters to maintain optimal glycogen stores, muscle repair, recovery, and growth (Spriet, 2014). Nutrients, carbohydrates, electrolytes, and supplements are also important for hydration, muscle function, and overall health (Spriet, 2014). One of the most widely used enhancers for energy is caffeine. It is necessary for athletes and coaches to be aware of the impact of caffeine consumption at moderate to low doses on various aspects of physical performance, including endurance, strength, power, and cognitive function. moderate caffeine consumption can enhance endurance, strength, power, and cognitive function (Spriet, 2014). However, individual variations and considerations should be taken into account, and athletes should be mindful of anti-doping regulations and potential side effects associated with caffeine use (Spriet, 2014). Another supplement that cannot be ignored for its benefits is creatine (Izquierdo et al., 2002). creatine supplementation can enhance maximal strength, power output, muscular endurance, and sprint performance (Izquierdo et al., 2002). Athletes and practitioners can consider incorporating creatine supplementation as part of their training and performance enhancement strategies, particularly for activities that involve high-intensity, explosive efforts.(Izquierdo et al., 2002). L a s t l y and most importantly, diet, beginning with pre-exercise meals rich in carbohydrates can optimize glycogen stores and enhance performance, while post-exercise meals with a combination of carbohydrates and proteins facilitate muscle recovery and adaptation (Slater et al., 2019). Micronutrients such as vitamins and minerals play vital roles in energy production, immune function, and muscle contractions (Slater et al., 2019). Antioxidants help combat oxidative stress and inflammation, which can occur during intense sprinting efforts (Slater et al., 2019). All research suggests stress the importance of individualization in dietary approaches, considering factors such as training load, body composition goals, and personal preferences (Spriet, 2014), (Izquierdo et al., 2002), (Slater et al., 2019). They highlight the need for collaboration between athletes, coaches, and sports nutrition professionals to develop personalized nutrition plan (Slater et al., 2019).

CONCLUSION

This considers the different body types that are genetically predisposed to be better sprinters with training such as higher BMI's, wider thigh and calf girths, wider upper arm girths, etc. Also highlights the various body measures that sprinters develop due to training. It also showcases the effects that different training methods that have been researched upon have on performance like altitude training having no effect, while plyometric training having a significant effect. It showcases how explosivity, muscle mass, strength, power, all are a factor in assisting and enhancing sprint performance. It summarises the main biomechanical aspects of sprinting such as technique, the block start, reaction time, etc. It gives insight into the research done into different recovery strategies for greater performance outputs such as foam rolling, stretching, contrast water therapy. And shows the value and data behind different supplementation approaches as well as dietary approaches. The improvements to this paper would be use and reviews of more literature on the subject, conduct more research on the subject. The limitation is also that this is short and not exploring this topic in detail. However, the strength is that there are many credible citations all based on the subject matter. It can be a help to researchers, sports scientists, coaches, athletes, and anyone interested in the subject.

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Abstract: Every paper must contain the abstract. You should bring basic idea with final results of research to abstract. Paper should be written according the guideline bellow. Abstract may contain up to 250 words.

Keywords: Maximum of five, key words or phrases, separated by commas.

The paper must contain clear introduction, problem statement, method of resolving the problem, results, conclusion, and references. It shoud not contain more than 8 pages of A4 format (21 x 29.7 cm) including figures, tables, references. Paper margins must be: top and bottom 2.5 cm, inside 2.5 cm and outside 2 cm. Pages are not ought to be numbered.

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