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Bulevar Vojvode Petra Bojovića 1A

78000 Banja Luka, Bosna i Hercegovina

Phone/Fax: 00387 051 31 22 80

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RELATIONS OF COACH-ATHLETE RELATIONSHIP' QUALITY AND ATHLETE PSYCHOSOCIAL FUNCTIONING: A SYSTEMATIC REVIEW

Nikolina Kuruzović¹ & Valentina Đorić²

^{1 2} Faculty of sport and psychology, Educons University, Novi Sad, Republic of Serbia

Correspondence: Valentina Đorić,
researcher, assistant, +381643188346,
21000 Novi Sad, Serbia,
valentina.djoric@tims.edu.rs

ABSTRACT

The innate tendency for forming social relations is also reflected in the area of sports. The sport itself represents a significant context for meeting other people, forming and maintaining relationships. This paper is aimed to review and interpret current literature results on coach-athlete relationships quality and its relations to aspects of athlete psychosocial functioning. Following the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) guidelines, the literature search of different electronic databases yielded a total of 56 studies. The findings underline several aspects of athlete psychosocial functioning connected with coach-athlete relationships. Among others, it is revealed that positive relationships with coaches contribute to different aspects of athlete motivation and satisfaction manifested in higher performance and intention to continue with sports activities. It is also detected that better relationships with coaches protect athletes from stress, burnout and negative affect guarding their mental health. Relationships with coaches also shape the way an athlete perceives himself, coach and team. The results highlight the unique contribution of coach-athlete relationships to athlete life and activities which may serve as a useful guide to future research in sports.

Keywords: sports, coach-athlete relationship, athlete psychosocial functioning, PRISMA

INTRODUCTION

The sports environment represents the important context of social relationships (Jowett & Nezlek, 2011). During different forms of learning, training, competition and other sports activities, individuals develop social relationships that can have a high level of trust, closeness, dedication, support, cooperation, friendly affection, respect, etc. (Jowett & Nezlek, 2011). Relationships in sport are a contextually specific type of social relations, where the individuals express and satisfy important psychosocial needs (attachment need, need for support, self-actualization and others), and reach numerous goals (e.g., the development of sport competencies, raising the level of sports success, etc.) (Adie et al., 2008).

In accordance with the interdependence theory, Kelley et al. (1983, p.38) define social relations as “a complex and varied interdependence between two individuals, which lasts for a certain period of time”. If this interpretation is applied to the domain of sport, then the relationships between athletes, coaches, parents and other individuals in the sport community can be observed through different forms of affective, cognitive and behavioral interdependence (Jowett & Nezlek, 2011).

Every relationship in sport has a specific role and function in an athlete's life, considering the fact that they satisfy psychosocial needs of athletes in a different way. Among numerous relations in the sports environment, the relationship between coach and athlete is specified as the most important relation (Jowett & Schanmugam, 2016). In the initial stages of sport, a coach's role is connected with the support towards children so they can gain confidence in the activities which they are doing for the first time. However, in time, they develop a reciprocal relationship. The coach primarily observes and develops the athlete's technical and physical skills, but also has a significant role as an attachment figure (Davis and Jowett, 2010). The coach is becoming a dominant person who has numerous psychosocial functions, which resembles those of the parents (Jowett & Schanmugam, 2016). He is becoming a new authority in the life of an athlete. Among numerous roles, a coach gives the support to an athlete during psychophysical changes, actively listens, takes care of an athlete and gives him support during the training.

It is certain that the type of sport environment, the phase of the athlete's career, age and other individual differences and preferences mold the type and frequency of interactions between athletes

and coaches (Côté, 1999). Therefore, we can expect variations in their quality. Under the term of the quality of social relations, we consider the number of characteristics, including the positive ones (intimacy, affection, help, attachment, trust, etc.) and negative ones (conflicts, rivalry, animosity, aggression, etc.) which are used to describe the relationship in more details (Berndt, 1996). In this way, some coach-athlete relationships can be defined as having high quality, if the positive relational exchange (trust, commitment, respect, etc.) is dominant. Less quality relationships include numerous conflicts, mistrust, lack of understanding and other forms of negative interaction exchange.

A lot of research in the domain of sport is focusing on the relations of the quality of coach-athlete relationships and different athlete's psychological variables, and the variables of different aspects of sport activities. The general conclusion is the high-quality coach-athlete relationship has a positive effect on the individual psychological variables of the athletes (Adie & Jowett, 2010), sport performance (Jowett, 2005), sport achievement of athletes and sport teams (Eys et al., 2019), as well as psychophysical growth and development of young athletes (Ullrich-French & Smith, 2006). However, it is not yet completely clear on which psychosocial aspects of the athlete's functioning influence this relationship the most. In this paper, we systematically review and organize the current literature on coach-athlete relationships. We are eager to identify the most common aspects of athlete psychosocial functioning related to the quality of coach-athlete relationships. We would like to show the most important findings and conclusions concerning this topic, because understanding the nature, functions and importance of coach-athlete relationship can improve coach expertise, training process and overall athlete performance.

METHOD

Design

The review incorporated studies about quality of coach-athlete relationship and different aspects of psychological and social functioning of athletes. The systematic electronic search of available scientific papers was realized on two occasions. The first one took place during 2000. via the platform of the Consortium of Libraries in Serbia (KoBSON), which enables the use of the electronic services for searching scientific journals. The following electronic services for search of scientific journals were used: Wiley online library, Science Direct, Sage Journals, Oxford Journals, Emerald Insight, JSTOR,

EBSCOhost. Second search, during 2022, used 2 electronic libraries: Web of Science and Scopus. During the both searches, the combination of the following keywords is used: quality of coach-athlete relationship.

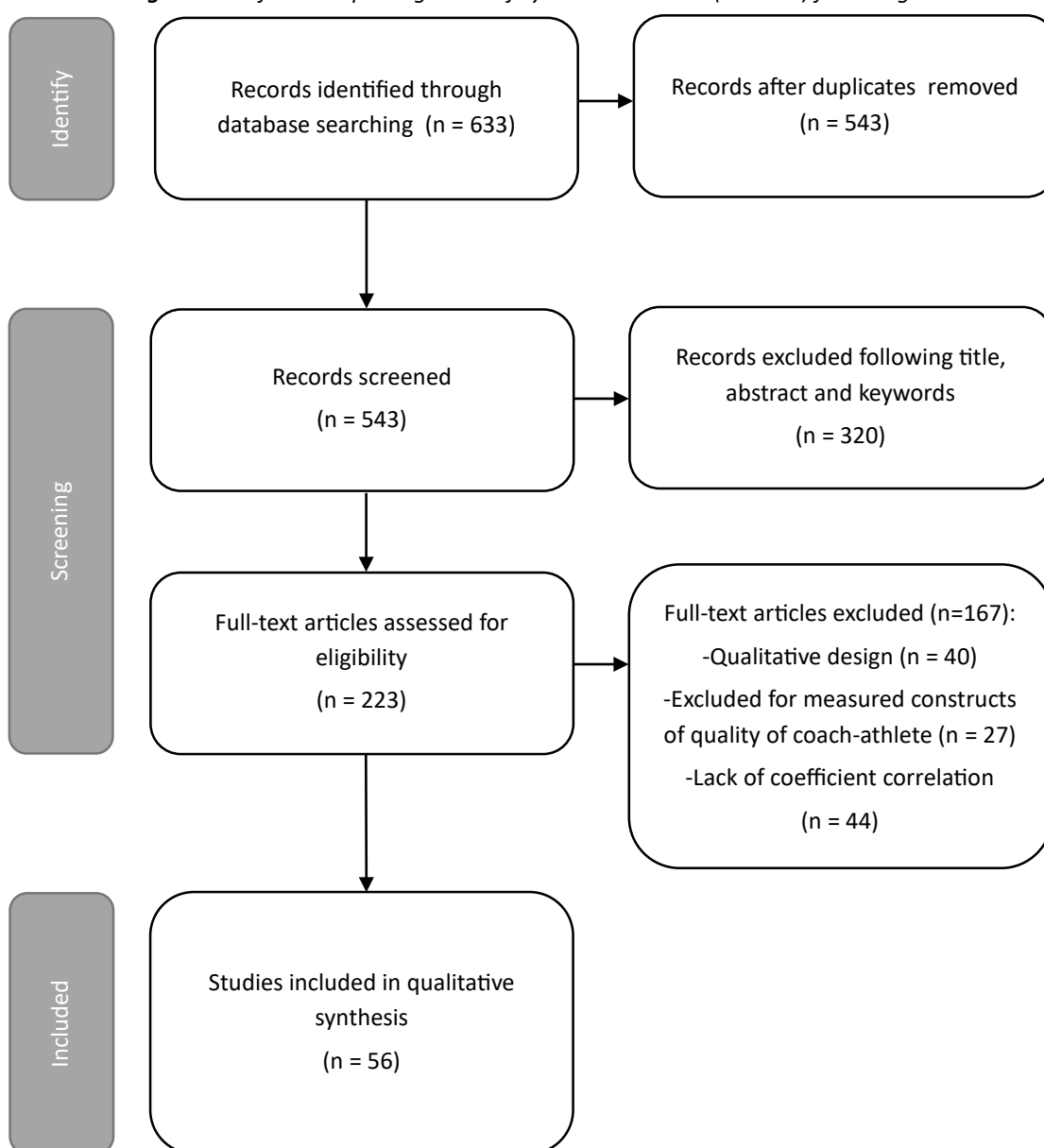
Inclusion criteria

The selection of the studies during the search was based on the following inclusion criteria: a) published original scientific papers in Serbian and English in the period from 2000 to 2023.; b) quantitative type of design; c) papers that question the relations between the quality of coach-athlete relationship and psychosocial aspects of athletes' functioning; d) contain the data about the coefficient of the correlation between aforementioned variables; e) papers are open accessed (full-text). Abstracts and conference reports, books and publications were not included in the selection process. The selection was not limited to the criteria of age, gender, type of sport, length of sports involvement, the level of competition and education.

Selection of studies

The results of the search are presented in Picture 1. via Prism (Preferred reporting items for systematic reviews and meta-analyses) flow diagram. During the identification phase, a total of 633 papers were identified on the topic of quality of coach-athlete relationship (KoBSON = 354; Web of Science = 172; Scopus = 107). During the screening stage, the duplicates were excluded, a total of 90 studies. Two reviewers then screened titles and summaries according to the descriptors, which left a total of 543 studies. In the eligibility stage, reviewers independently checked full-text papers, reaching a level of agreement of over 90%. Disagreements and doubts were solved through discussion and consensus. During the included phase, reviewers agreed upon the final sample of 56 studies included in the qualitative synthesis (KoBSON = 27; Web of Science = 23; Scopus = 6).

Figure 1. Preferred Reporting Items of Systematic Review (PRISMA) flow diagram.



RESULTS

Descriptive characteristics of included studies

The total number of participants (see Table 1) (Section Appendix) in 56 studies is 14304, both males and females. The youngest participant had 9 and the oldest 40 years ($M = 19.29 \pm 4.59$). The studies included all levels of competitions as well as different types of sport, some of which are: individual (athletics, gymnastics, archery, tennis, table tennis, swimming, ice skating, skiing) and team sports (football, basketball, volleyball, baseball, hockey). Certain studies assess only participants who are in individual sports ($N = 8$), while others assess only participants in team sports ($N = 15$), while some include both individual and team sports ($N = 31$). As far as the level of relationship between coach and athlete and psychological aspects are concerned, the lowest coefficient correlation is $r = .07$, and the highest $r = .82$ ($M = .32.67 \pm 14.21$) which indicates that the strength of the connection ranges from low to high.

The quality of interpersonal relationships is operationalized with the achieved score on the questionnaires that assess positive and negative characteristics which describe the relationship. They are subjective assessments of the certain aspects of close relations. The fulfillment of certain psychosocial needs is questioned (e.g. need for closeness, safety, support, etc.) and the forces of interaction between close people (e.g. solving conflicts, telling secrets) (Furman & Buhrmester, 1985). The most frequent are both types of operationalizations: as processes or forms of exchange and interaction as well as gains/provisions that are fulfilled through relations (Ladd, Kochenderfer & Coleman, 1996). The largest number of the included studies for assessment of the quality of relations between coach and athlete used the questionnaire The Coach-Athlete Relationship Questionnaire (CART-Q; Jowett and Ntoumanis, 2004) ($N = 40$), that enables the assessment of the coach-athlete relationship via general measure of the relations that is present in 21 papers. While the dynamics of presence of the separate scales of mentioned questionnaire is the following: Commitment ($N = 27$), Complementarity ($N = 25$) and Closeness ($N = 14$). In the rest of the papers, the following measures of the quality of relationship coach-athlete are present: Support ($N = 6$), Attachment ($N = 4$), Relationship Satisfaction ($N = 3$), Conflict ($N = 2$), Proximity, Relatedness, Depth, Relationship interdependence, Positive influence, Punishment, Dysfunction ($N = 1$).

The aspects of an athlete's psychosocial functioning are operationalized with the achieved score on the questionnaires of self-report. Table 2 (Section Appendix) displays psychosocial aspects that are assessed in 56 included scientific papers.

DISCUSSION

The present review was conducted on a total of 56 studies exploring relations between quality of coach-athlete and different aspects of athlete psychosocial functioning. We were aimed to identify areas of athlete psychosocial functioning connected with the quality of coach-athlete relationship. To the best of our knowledge this is the first systematic review exploring this topic. A review of the studies highlighted that there are several athlete psychosocial areas of functioning connected with the quality of coach-athlete relationship.

These are motivation and satisfaction, variables of athlete mental health, variables of self-perception, perception of coaches and team.

Athlete motivation

It is noticed that numerous studies explore relations among quality of relationship and athlete motivation. This is not a surprise, considering the fact that motivation of athletes is considered to be a significant factor of athletes' success (Jowett et al., 2017). Also, it is noticed that different measures of motivation are used, which creates a more detailed picture of the relations between athletes' social relationships and motivational aspects. It is concluded that athletes who have a higher quality of relationship with coach have a more pronounced sport motivation (Jackson & Beauchamp, 2010), they are more intrinsically motivated (Adie & Jowett, 2010; Jõesaar et al., 2011; Pacewicz et al., 2020), they feel that their basic needs for autonomy, competence and social attachment are satisfied (Choi et al., 2013), they are more goal-oriented toward tasks and skills (Adie & Jowett, 2010), and have more pronounced achievement goals (Isoard-Gauthier et al., 2016; Nicholls et al., 2017), and motivational outcomes such as working hard, enjoying sport and having competencies (Chan et al., 2018). Altogether, this high motivation status is reflected in athletes' intention to exert a high degree of sport effort (Jackson and Beauchamp, 2010) and willingness to continue with sport activities (Gardner et al., 2016).

The relationship of athlete with coach creates a prerequisite for improving or lowering the athlete's motivation. Positive, supportive relationship with a coach can create a social climate where the individual develops their skills, but also strives to achieve their goals, which satisfies their basic psychological needs (Felton & Jowett, 2013). How significant others interpret athletes's behavior and beliefs influences their personal expectations, values and the behavior that leads to achieving goals. If the behavior and the beliefs of the significant others are interpreted as positive, there is a development of a positive self-image and the impression of competence, control, the positive affect and inner motivation (Jowett & Cramer, 2010). The athlete who has satisfied the need for competence, connection and autonomy through relation with the coach, will invest more time and effort into sports. This is different from an athlete who is not in this situation and who can decide to abandon sport because of this (Adie & Jowett, 2010). It is concluded that coaches as significant others have a major impact on the satisfaction of basic psychological needs and the development of autonomous forms of motivation. With their behavior, they can create a social context that is supportive or sabotaging (Joesaar et al., 2011).

Athlete satisfaction

After the motivation, the focus of different research in the context of social relations in sport was the topic of satisfaction of athletes. This represents the positive emotional reaction to sports activities and includes feelings like fun, enjoyment, and love. It is noticed that the high quality coach-athlete relationship leads to higher satisfaction of an athlete with their own performance, training, and coach's instructions and behavior. (Davis & Jowett, 2010; Jowett &

Nezlek, 2011; Yang et al., 2014; Zhang & Chelladurai, 2013), they show bigger enjoyment in sport (Gardner et al., 2016), and a bigger desire and passion to play (Lafreiniere et al., 2008; Güllü, 2019). It is also noticed that these athletes are generally more satisfied, due to spillover mechanisms (Alfermann et al., 2013). Based on the Sport Commitment Model (Scanlan et al., 2003) satisfaction with sport is the strongest predictor of sport dedication. Relationship with coach is presented as one of the most significant source of athlete's satisfaction. Involvement and the support of coaches as well as their satisfaction with the athletes' performance and the achievement are the main sources of athlete satisfaction.

Athlete mental health

A larger number of studies is concerned with relations between quality of coach-athlete relationship and athletes' mental health. Doing sports (especially on the professional level) includes many psychological and physical demands that an athlete has to face (Powers et al., 2000). If an athlete is not ready to adequately and continuously face and deal with the pressure, it can lead to stress, which can lead to burnout and even mental disorders. Positive relations with the coach can have an important protective function in stressful situations. If an athlete, through relation with the coach, receives enough support, understanding, comfort and affection, they will feel protected and secure and will deal easier with stressful situations. It is shown that these athletes are less prone to interpret situations as threatening, but rather as challenging (Nicholls et al., 2016), they use more functional coping strategies such as self and other control and dealing with the problem (Nicholls et al., 2016), use more positive self talk (Ada et al., 2021) and feel much more psychologically safe (Gosai et al., 2021). Social relations with coaches do not only have a protective function, but it is also as we mentioned earlier, a prerequisite to satisfy basic needs, lead to adequate motivation, positive self-image, and mental well-being, which altogether improves the mental health of an athlete. Many research indicate that positive relationship with coach is connected with better psychological well-being (Jowett et al., 2017), the general quality of life (Powers et al., 2020), vitality (Felton & Jowett, 2013), flourishing in life (Gosai et al., 2021), positive affect, happiness and life satisfaction (Lafreiniere et al., 2011; Felton and Jowett, 2015). It is also notices, that athletes with high quality relationship with coach have less indicators of depression (Powers et al., 2020), anxiety and anxiety concentration disruption (Scott et al., 2020; Stephen et al., 2022), negative affect (Felton & Jowett, 2013), stress (Lu et al., 2016; Ullrich-French & Smith, 2006), athlete burnout (Aunolaa et al., 2018; Pacewicz et al., 2020) and eating psychopathology (Shanmugam et al., 2013; Shanmugam et al., 2014).

Athlete self- and other-perceptions

Another important psychological aspect of an athlete functioning is the self-concept which is observed in the context of social relations. Self-concept is the way a person, according to different criteria, observes and assesses himself and it is important for all life's segments. In the context of sport, the self-concept and self-evaluation processes are especially important (Jowett & Cramer, 2010), because they are connected to cognitive, affective and behavioral

mechanisms of sport activities (Mortiz et al., 2000). The results of research suggest that athletes who have a better quality of relations with the coach have a higher degree of both sport confidence (Gencer & Öztürk, 2018) and general confidence (Scott et al., 2020). They have a higher score on the self-concept scales such as bodily, social, sport, physiological, mental self-concept and self-concept of performance and skill (Jowett & Cramer, 2010; Scoffier et al., 2010; Shapiro & Martin, 2014). They also have a more pronounced experience of self-efficacy (Jackson & Beauchamp, 2010), and value their individual sport performances more (Zhang and Chelladurai, 2013; Contreira et al., 2019). In the context of social factors of self-image, many researchers focus on social relations, which are the basic mechanism of developing self-image (Jowett & Cramer, 2010). During an interaction and communication with the coach athletes exchange important messages such as expectation, support, feedback, encouragement, cooperation, compassion etc. This also includes the less positive messages such as control, rejection, punishment etc. These signals are connected to the questions of effort, ability, performance, athlete's achievement, etc. If the quality of the relationship with the coach is positive, the social climate will be positive. This will enable the internalization of a positive self-image, because the individual typically internalizes the standards of significant others if he has a strong positive attachment to them (Jowett & Cramer, 2010). How an athlete observes and assesses things is influenced by how he is observed and assessed by significant others, especially the coach.

Because of the coach's importance, many researchers observed how the coach is viewed by athletes. In team sports, the perception of coaches, their personal characteristics and their behavior is frequently different because of the individual approach that the coach has with each player (Stein et al., 2012). An athlete does not pay so much attention to the coach's relationship with others, but is focused on his own relationship with the coach. This is the reason why the researchers claim that in order to understand the team climate, created by the coach, it is important to take into consideration the personal experience of every individual athlete (Stein et al., 2012). It is shown that the quality of the relationship between an athlete and a coach is connected to how the athlete observes him. If the coach is committed and close to athlete, he will see him as a well-intentioned, competent person with integrity (Zhang & Chelladurai, 2013), more empathetic (Jowett et al., 2012), capable to guide training practice and give adequate instructions, as a person who gives social support and is more democratic towards athletes (Alfermann et al., 2013). In this type of interpersonal climate, athlete satisfaction with relationships is bigger (Davis et al., 2016), the conflict is present in a lower percentage and when it occurs is better handled (Jowett et al., 2012; Jowett et al., 2023). He trusts the coach more and communicates openly (Zhang and Chelladurai, 2013; Jowett et al., 2023) which is noticed among other occasions in willingness to report concussion problems (Milroy et al., 2018).

Coach also represents the team leader who can modify and manage the group dynamics in the desired direction. In this process, the relationship the coach has with individual athletes contributes to the entire team. Positive interaction with the coach helps the athletes to be more integrated into the team (Jowett and Chaundy, 2004), and to have a

higher satisfaction with team and motivation to play, which leads to greater team efficacy (Hampson and Jowett, 2014; Cho et al., 2020). The high degree of mutual trust, respect, dedication and cooperation between coach and athlete has a positive impact on the feeling of togetherness. If athletes believe and feel that the coach is close to them, that he has long term plans with the players, that the players can trust the trainer and rely on him, they will start to work harder, be more efficient and achieve more.

Although study provides an important insight in the importance of coach-athlete relationship for athlete's psychosocial functioning, the definite generalization is still constrained by several limitations. The most important one is of methodological nature, and it concerns the lack of external control of the data collection process. The inclusion of independent and external researcher/s in the process of control of the data collection would be much more methodologically justified. Another limitation is conceptual, when it comes to the phenomenon of quality of coach-athlete relationship. We were particularly concerned about including in the study works that conceptualize this term in a similar way. However, we believe that in this part as well, external controllers would play a key role. Closely related to this issue is the use of various measuring instruments used in the studies. Although we narrowed down our choices in this matter, the question remains how successful we have been. It was noticed that for some aspects of the psychosocial functioning of athletes, the number of studies (and sample size) is too small to draw final conclusions.

Therefore, we propose that further research establishes a shared and reliable theoretical and methodological framework for the concept of coach-athlete relationship. External control of the data collection and analysis process is required too. It is also recommended to explore this topic in relation to age, the length of sports engagement, gender, the type of sport, the level of competition and numerous other factors that potentially moderate relation of athlete relationships and psychosocial functioning. It would be also interesting to assess, by longitudinal research design, how these relationships affect athlete psychosocial functioning as the time progresses.

CONCLUSION

With the literature overview on the topic of the quality of coach-athlete relationship in sport, we wanted to focus on the psychosocial functioning of athletes. We wanted to determine which aspects of the psychosocial functioning of athletes are connected with this social relation. The relationship with the coach is presented as the most important relationship, which has a significant influence on the psychological and social aspects. When psychological aspects of an athlete's functioning is concerned, the topics of motivation, satisfaction, self-concept and mental health variables are in the focus. Athlete perceptions of coach and team are also related to coach-athlete relationships.

Researchers conclude that it is completely justified to consider coach-athlete relationships as an important factor that contributes to the different athlete's motivational aspects. Athletes which have quality relations with the coach, also have motivational benefits such as higher dedication, involvement, goal orientation, etc. which results in higher sport

efficacy. If the sport activity is supported by high quality coach-athlete relationship, athletes have an emotional benefit such as higher satisfaction and enjoyment, as well as a desire to play, which is the prerequisite of continuous sport activity. This relationship is also one of the sources of athlete positive self-image as well as self-efficacy and significantly participates in maintaining an athlete's mental health. It is also emphasized that quality relationships with coaches guide the athletes toward the positive perception of the coach and team, which can influence the team efficacy and relationships in the team.

Based on the presented research results on the topic of quality of coach-athlete relationship in sports, it can be concluded that these relations have a unique and significant role in the life of an athlete. It would be useful to bear in mind this notion while directing and creating a sports career. The main conclusions of this study could be implemented in the sports environment by building high quality relationships, in a systematic way. In this way, we can set conditions for improvement of psychosocial functioning of athletes which leads to better sports performance and results.

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APPENDIX

Table 1.

No.	Author	Year	N	Sport	Age/Range	Quality of coach-athlete relationship scale	Athlete psychosocial variable					
	Jowett and Chaundy	2004	111	Team	21.08		Team cohesion (social)		Team cohesion (task)			
						Commitment		.36		.50		
						Closeness		.31		.48		
						Complemen.		.29		.48		
	Amorosea and Butcherb	2007	581	Individual Team	17.50	Relatedness			Sport motivation			
									.45			
	Rutten at al.	2007	260	Team	14.80	Relationship quality	Moral reasoning	Moral atmosphere	Antisocial behavior	Prosocial behavior		
							.21	.45	.38	.26		
	Lafreiner et al.	2008	157	Team	20.23		Harmonious passion		Obsessive passion			
						Commitment		.28		.22		
						Closeness		.35		.22		
						Complementarity		.38		-		
	Olympiou et al.	2008	591	Team	16-36		Motivational climate:					
							Punishment	Unequal recognition	Important role	Cooperative learning	Effort/Improvement	
						Commitment	-.15	-.22	.42	.44	.49	
						Closeness	-	-.19	.42	.39	.47	
						Complementarity	-.16	-.17	.39	.42	.46	
	Jowett	2008	138	Individual Team	18-31	Relation satisfaction			Intrinsic motivation			
									.27			
	Jowett	2007	303	Individual Team	12-18	Relationship quality			Physical self concept			
									.63			
	Adie and Jowett	2010	194	Individual	21.50		Mastery approach		Performance avoidance		Intrinsic motivation	
						Relationship quality		.35	-.24		.26	
						Commitment		.22	-.20		.29	
						Closeness		.39	-.25		.29	
						Complementarity		.35	-.21		-	
	Davis and Jowett	2010	309	Individual Team	19.90	Attachment:	Satisfaction (performance)		Satisfaction (training)		Satisfaction (treatment)	
						Avoidant		.45	-.39		-.48	
						Anxious		-.28	-.16		-.22	
						Relation satisfaction		.46	.61		.67	
	Jowett and Cramer	2010	173	Individual	17.55		Self concept -Skill	Self concept -Body	Self concept -Physiology	Self concept -Mental	Self concept -Perform.	
						Support		.34	.29	.28	.37	.38
						Depth		.43	.36	.33	.44	.47

Jackson and Beauchamp	2010	58	Individual	15.52		Self efficacy		Coach efficacy		Effort
					Commitment	-		.46		.73
					Satisfaction	.42		.60		.41
Lafreniere et al.	2011	104	Individual Team	22.04	Relationship quality			Athlete` happiness		
					Closeness			.33		
					Commitment			.38		
					Complementarity			.52		
								.52		
Jowett and Nezek	2011	138	Individual	18-40	Relationship interdependence	Satisfaction (performance)		Sat. (training, instructions)		Sat.(treatment)
						.67		.34		.82
Rutten et al.	2011	439	Individual Team	13.72	Relational support	Moral	Antisocial behavior	Prosocial behavior	Fairplay	Moral atmosphere
					Attach.rel. support	.20	-.55	.46	.23	.65
						-	-	.36	.29	.44
Jowett et al.	2012	178	Individual Team	20.40	Relationship quality	Satisfaction with training and instruction			Coach empathy	
						.63			.78	
Jowett et al.	2012	103	Individual Team	22.04	Relationship quality	Harmonious passion		Obsessive passion		Conflict with coach
						.55		.26		-.55
Jowet and Shanmugam	2012	150	Team	20.07	Commitment			Collective efficacy		
					Closeness			.37		
					Complementarity			.33		
								.29		
Shanmugam et al.	2013	411	Individual Team	20.95	Support	Person Perfectionism	Self-critic perfectionism	Self esteem	Depression	Eating psychopathology
					Conflict	.13	-.08	.12	-.13	.62
						.16	.22	-.20	.23	
Davis et al.	2013	107	Individual Team	20.60	Relationship quality			Relationship satisfaction		
								.34		
Felton and Jowett	2013	300	Individual Team	20.40	Relationship quality	Need satisfaction	Need satisfaction	Need satisfaction	Vitality	Self concept
						Autonomy	Competence	Relatedness	.19	(skill)
						.52	.61	.60		(performance)
									.18	.16
Zhang and Chelladurai	2013	215	/	20.00	Commitment	Performance	Perception of justice	Perception of bene.	Perception of integrity	Perception of comp.
					Cooperation	.46	.42	.40	.39	.43
						.44	.44	.44	.47	.40
										.58
Choi and Huh	2013	328	Individual Team	20.00	Commitment	Need satisfaction: Autonomy		Need satisfaction: Competence		Need satisfaction: Relatedness
					Closeness	.19		-		.13
					Complementarity	.32		.31		.39
						.30		.39		.38
Alfermann et al.	2013	173	Individual	13.20	Support	Training and instruction	Positive feedback	Mastery climate	Performance climate	Athlete satisfaction
					Closeness	.48	.47	.64	.22	.33
						.56	.43	.51	-.27	.61

RELATIONS OF COACH-ATHLETE RELATIONSHIP' QUALITY AND ATHLETE PSYCHOSOCIAL FUNCTIONING: A SYSTEMATIC REVIEW

[Review article]

Davis and Jowett	2014	192	Individual Team	16-32	Attachment: Avoidant Ambivalent	Need satis. -.14 -	Vitality -.24 -.17	Self-esteem -.16 -.16	Neg.affect .21 .38	Posit.affect -.21 -.10	Skil self.conc. -.14 -	Perform.self conc. -.17 -
Shanmugam et al.	2014	411	Individual Team	20.95	Support Conflict	Pers.perfecionism. .13 .16	Self-critical perf. -.08 .22	Self-esteem .12 -.20	Depression -.13 .23			Eat.psychopath. -.13 .12
Hampson and Jowett	2014	150	Team	20.07	Commitment Closeness Complementarity				Collective efficacy .37 .33 .29			
Yang et al.	2014	350	Individual team	21.00	Relationship quality				Satisfaction (training) .70			
Felton and Jowett	2015	241	Individual team	20.74	Attachment: Avoidant Anxious Secure	Performance satisfaction -.21 - .13	Life satisfaction -.21 - .18		Depression .28 .27 -.21			Negative affect .18 .17 -.13
Gardner et al.	2016	393	Individual Team	13.03	Relationship quality		Enjoyment .47				Intention to continue .33	
Isoard-Gauthier et al.	2016	360	Individual Team	21.00	Commitment Closeness Complementarity	Reduc.accompl. -.14 -.16 -.18	Athlete burnout: Exhaustion - -.19 -.18	Sport.devaluat. -.23 -.24 -.28		Mastery approach .31 .26 .32		Master avoidance .21 - .12
Lu et al.	2016	218	Individual Team	20.04	Emotionional support		Life stress -.32				Athlete burnout -.23	
Nicholls et al.	2016	274	Individual Team	21.59			Stress appraisal: Threat Challenge Centrality				Coping with stress Uncontroll. Task Disengagement	
Nicholls et al.	2017	104	Team	9-20	Relationship quality Commitment Closeness Complementarity						Achievement-mastery .33 .27 .24 .39	
Jowett et al.	2017	756	Individual Team	14-27	Relationship quality		Overall need satisfaction .73		Self determinated sport motivation .52			Mental well-being .46
Chan et al.	2018	904	Individual Team	9-18	Positive influence Punishment Dysfunction		Motiv. Outcome: Competence .30 -.07 -.08		Motiv. Outcome: Effort .40 - -.21			Motiv. Outcome: Enjoyment .41 -.09 .14

Gencer and Ozturk	2018	198	Individual	15-25	Closeness Commitment Complementarity	Sport confidence						
						.38 .37 .30						
Avci et al.	2018	96	Team	19.97	Closeness Commitment Complementarity	Motivational climate (mastery)						
						.27 .33 .33						
Davis et al.	2018	82	Team	19.87	Relationship quality Commitment Closeness Complementarity	Athlete burnout (exhaustion)						
						-.33 -.26 -.37 -.22						
Milroy et al.	2018	268	/	19.16	Attachment: Avoidant Anxious Secure	Concussion reporting to coach						
						- .13 -.15						
Davis et al.	2019	210	Individual Team	18.00	Relationship quality	Athlete burnout:		Reduced accomplishment		Sport devaluation		
						Emot.and phys exhaustion		-0.26		-.25		
Davis et al.	2019	182	Individual Team	21.10	Relationship quality	Satisfaction (performance)		Satisfaction (training)		Satisfaction (treatment)		
						.60		.59		.55		
Gullu	2019	200	Team	20-30	Relationship quality Closeness Commitment Complementarity	Harmonious passion			Obsessive passion			
						.38 .33 .46 .33			.27 .36 .32 .18			
Contreira et al.	2019	182	Individual Team	16.24	Closeness Commitment Complementarity	Basic psychological needs:			Athlete satisfaction:			
						Competence	Autonomy	Relatedness	Train. and instruction	Ind.Perform.	Personal treatment	
						.19	.27	.32	.42	.24	.45	
						.27	.34	.32	.42	.36	.50	
						.30	.33	.23	.45	.29	.52	
Robert et al.	2019	185	Individual Team	17.27	Complementary Closeness Commitment	Perception of collective efficacy:				Goals orientation		
						Ability	Effort	Persistence	Union	Preparation	Task	Ego
						.32	.37	.23	.23	.34	.44	-
						.41	.40	.26	.28	.39	.38	-
						.30	.32	.24	.19	.37	.40	.53
Powers et al.	2020	79	Individual Team	19.50	Commitment Closeness Complementarity	Quality of life		Depression		Anxiety		
						.38 .37 .36		-.36 -.44 -.41		- -.26 -		

Cho et al.	2020	254	Team	16.45														Team efficacy						
					Relationship quality													.73						
Choi et al.	2020	302	Individual Team	21.63														Athlete burnout						
					Relationship quality													-.60						
Nascimento et al.	2020	335	Team	16.02														Motivation:						
						Amotivation	Introjected regulation	Identified regulation	Integrated regulation	Intrinsic regulation														
					Proximity	-.16	.11	.21	.19	.21														
					Commitment	-.21	.18	.31	.29	.28														
					Complementarity	-.12	.21	.26	.23	.25														
Gosai et al.	2021	166	Team	20.86														Psychological safety	Flourishing in sport and life	Positive affect	Individual performance	Team performance		
					Commitment	.28	.27	.36	.57	.51														
					Closeness	.24	.24	.25	.48	.51														
					Complementarity	.26	.26	.37	.48	.47														
De Silva et al.	2021	23	Team	18.04															Stress					
					Commitment														-.52					
					Complementarity														-.42					
Wekesser et al.	2021	148	Team	13.83															Intentions to continue					
					Commitment														.23					
					Closeness														.18					
					Complementarity														.25					
Ada et al.	2021	477	Individual Team	19.24															Negative self talk:	Positive self talk:				
						Worry	Disengage.	Som.fatigue	Psych-up	Anx.control	Confidence	Instruction												
					Closeness	-.11	-.23	-.14	.28	.16	.29	26.												
					Commitment	-.12	-.19	-.14	.26	.17	.27	.25												
					Complementarity	-.13	-.21	-.13	.27	.16	.29	.26												
Stephen et al.	2022	142	Individual	26.59															Self efficacy	Anxiety concentration disruption				
					Closeness														.67					
					Commitment														.56					
					Complementarity														.52					
Fan et al.	2022	272	Individual	19.95															Basic psychological needs satisfaction	Athlete burnout				
					Relationship quality														.56					
Davis et al.	2023	350	Individual Team	19.18															Basic psychological need satisfaction:					
					Relationship quality														Autonomy	Competence	Relatedness			
						.53													.35					
Jowett et al.	2023	379	Individual Team	21.36															Communication: Conflict management	Communication: Openess	Psychological safety			
					Commitment														.19					
					Closeness														.28					
					Complementarity														.36					
																				.43				
																				.29				
																				.29				
																				.35				

Table 2. Psychosocial aspects of athlete's functioning

<p>Motivation:</p> <ul style="list-style-type: none"> • Sport motivation; • Intrinsic motivation; • Goal orientation (ego, task, skill; avoidance); • Motivational outcome; • Self-determined motivation; • Basic need satisfaction (autonomy, competence, relatedness); • Intention to continue; • Effort; <p>Athlete mental health:</p> <ul style="list-style-type: none"> • Mental well-being; • Quality of life; • Happiness; • Life satisfaction; • Flourishing in life; • Vitality; • Sport burnout; • Stress; • Stress appraisal; • Coping with stress; • Psychological safety; • Positive and negative affect; • Depression; • Eating psychopathology; • Anxiety; • Anxiety concentration disruption; • Positive and negative self-talk. 	<p>Athlete self-perception:</p> <ul style="list-style-type: none"> • Self-concept (skill, performance, physical, body, physiology, mental, sport competence); • Sport self-esteem; • General self-esteem; • Self-efficacy; • Perfectionism (personal, self-critical); • Moral reasoning; • Antisocial and prosocial behavior; • Fair-play attitude. • Individual performance. <p>Athlete satisfaction:</p> <ul style="list-style-type: none"> • Satisfaction (performance, training, instruction, treatment); • General athlete satisfaction; • Passion (harmonious, obsessive); • Enjoyment. <p>Athlete satisfaction:</p> <ul style="list-style-type: none"> • Satisfaction (performance, training, instruction, treatment); • General athlete satisfaction; • Passion (harmonious, obsessive); • Enjoyment. 	<p>Athlete perception of team characteristics:</p> <ul style="list-style-type: none"> • Collective efficacy; • Team cohesion (social, task); • Motivational climate (ego, performance, punishment, unequal recognition, important role, cooperative learning, effort/improvement i skills); • Team performance. <p>Athlete perception of coach:</p> <ul style="list-style-type: none"> • Coach characteristics (fairness, integrity, instruction, training, competence, support, democratic behavior, positive feedback, benevolence); • Conflict; • Trust; • Coach efficacy; • Coach empathy; • Communication with coach; • Satisfaction with relationship; • Concussion reporting.
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EVALUATION OF PEDAGOGICAL COMPETENCES AND MOTIVATION OF TAEKWONDO COACHES FOR PERMANENT EDUCATION

Jovana Njegovan¹ & Draženko Jorgić²

¹Taekwondo club „Prnjavor“ Prnjavor Bosnia and Herzegovina

²University of Banja Luka, Faculty of Philosophy, Bosnia and Herzegovina

Correspondence: Jovana Njegovan, MA

Taekwondo club „Prnjavor“, Prnjavor 78430, Bosnia and Herzegovina

Tel.: +387 66 954 909; E-mail: njegovan.j@gmail.com

SUMMARY

The goal of this research was to examine the degree of agreement between athletes and taekwondo coaches in their assessments of pedagogical competence and motivation of taekwondo coaches for permanent education. The research sample consisted of 10 coaches of the Taekwondo Association of Bosnia and Herzegovina and 265 taekwondo athletes. For this purpose, a quantitative-qualitative research was conducted. By defining and specifying the research goal, nine causally elaborated research tasks were defined. The defined research tasks represent the fundamental segments of the problem and research subject. Through the realization of the quantitative part of the research and the application of a five-level scale intended for athletes, their assessment of the pedagogical competencies and motivation of taekwondo coaches for permanent education was determined. In contrast to the assessment of athletes, the self-assessment of taekwondo coaches for permanent education was determined through the logical analysis of the answers received during the interview and through the analysis of the record of the participation of coaches of the Taekwondo Association of Bosnia and Herzegovina in international seminars. With the help of a five-level scale intended for coaches, a self-assessment of the coaches' pedagogical competences was carried out. The obtained results indicate that there is no significant difference between athletes and taekwondo coaches regarding their assessment of pedagogical competence and motivation for permanent education. Athletes believe that their coaches demonstrate high pedagogical competence for the training process and high motivation for permanent education. The coaches are of the same opinion in their personal self-assessment. The only significant difference relates to the tendency of taekwondo coaches towards physical and psychological violence against athletes.

Keywords: lifelong learning, coach's motivation for progress, sports pedagogues

INTRODUCTION

The coach often serves as a role model and a model for children to learn from. Dimec and Kajtna (2009) define the coach as a key person and the most important factor in the development of a sports career. Coaches should consciously strive to have a positive influence on young athletes. The development of coaching competence relates to the ability to organize sports activities and understand the needs of children. Every child should be motivated and encouraged to work and achieve psycho-physical progress (Fraser – Thomas et al., 2005). Early childhood experiences contribute to the formation of personality and, in the future, the formation of attitudes in adulthood (Markovic et al., 2022). Based on the aforementioned, coaches should act as conscientious individuals who are achievement-oriented, decisive, persistent, disciplined, reliable, and responsible in their work with children (McCrae and Costa, 1999). Through positive influence, healthy social relationships, a warm and pleasant atmosphere within the sports collective, there will be a sense of connection and closeness. Closeness is reflected in mutual trust, acceptance, and support (Lepir, 2021).

The results of a research study conducted to assess the level and structure of self-assessment of pedagogical competence of coaches and their attitudes toward pedagogical training and improvement, involving 102 coaches from 17 different sports, indicate that coaches have a positive attitude toward pedagogical training and improvement. Furthermore, a strong positive correlation was found between coaches' subjective perception of pedagogical competence and their attitude toward pedagogical training (Cokorilo and Grk, 2010). Pedagogical competences refer to various types of abilities that a coach must possess in their work with children (Kostovic–Vranjes and Ljubetic, 2008). Additionally, sports competitive results depend on a good plan and program, appropriate training content, training format, and alignment with periodization and competition calendar (Savic et al., 2013).

Research regarding the need for pedagogical education suggests that coaches expect society's support in their professional development. In the educational process, understanding is crucial, rather than simply acquiring a large amount of information (Orlovic - Lovren, 2012). Support and assistance from society further motivate coaches to engage in forms of continuous education. Intrinsic motivation and the motivation for sports achievement, along with adequately defined goals, can be one of the assumptions for the connection between motivation and success in sports (Vujanovic, 2015). Intrinsic motivation is described as an innate tendency to engage in personal interests and practice one's abilities, resulting in a sense of satisfaction. In contrast to intrinsic motivation, there is extrinsic motivation, which involves various rewards, recognition, and social status (Reeve, 2010). Sports clubs play a key role in the development of sports within each community, and the motivation of coaches and support from the local community can influence the popularization and development of sports within the same community (Mitrovic et al., 2019).

To the best of our knowledge, no previous study has examined the level of congruence between athletes and taekwondo coaches regarding the assessment of pedagogical competences and the motivation of coaches for continuous education. The aim of this research

was to examine the level of congruence between athletes and taekwondo coaches in the assessment of pedagogical competence and motivation for permanent education.

METHOD

Participant Sample

The sample for this research was selected from the population of taekwondo coaches and taekwondo athletes in Bosnia and Herzegovina. The sample consisted of a total of 10 male coaches out of 155 licensed taekwondo coaches and 265 athletes from a population of approximately 2,500 taekwondo athletes. The athletes were of cadet age (8 to 13 years) and junior age (14 to 17 years). The coaching experience ranged from 6 to 30 years. During the quantitative analysis, coaches were divided into less experienced (less than 15 years of coaching experience) and more experienced (more than 15 years of coaching experience) coaches. This is presented in Table 4. The average age of the coaches was 41 years.

Procedures

Quantitative and qualitative research, along with field data collection, was conducted in April and May 2022 in Prnjavor, Bosnia and Herzegovina, and Porec, Croatia. Prior to distributing and completing the research instruments, taekwondo coaches and athletes were provided with necessary instructions, guidance, and information about the research. The instruments were filled out before the start of training sessions, when the participants were rested and focused on the task. All participants were informed that the research was anonymous, and their identities would not be disclosed.

INSTRUMENTS

For the purpose of this research, the following instruments were created: 1. Scale of self-assessment of taekwondo coaches' personal pedagogical competencies (STLPK), 2. Scale of athletes' attitudes towards coaches' pedagogical competencies and motivation for continuous education (SSPKMTT), 3. Questionnaire for coaches (APT). Collaboration with Dr. Miroslav Hrzenjak and Prof. Dr. Ksenija Bosnar was established in structuring these scales. With the permission of the mentioned authors, certain statements were adapted from a previously published doctoral thesis entitled "The correlation between athletes' motivational factors and coaches' evaluations of their characteristics" (Hrzenjak and Bosnar, 2017).

The first instrument, "STLPK," consists of 50 statements. Coaches used this instrument to self-assess their pedagogical competencies. The reliability was established with a sample of 10 coaches from the Taekwondo Association of Bosnia and Herzegovina, resulting in an r-value of 0.93.

The second instrument, "SSPKMTT," consists of 60 statements. The first 50 statements are identical to those in the coach scale, with the statements and their meanings adapted to the age of the athletes. Through these 50 statements, athletes assess the coach's pedagogical competencies by indicating their level of agreement with each statement. The last 10

statements (from 51 to 60) relate to the athletes' indirect assessment of the coach's motivation for improvement and continuous education.

Both created scales use a five-point Likert scale on which taekwondo coaches and athletes express their level of agreement or disagreement. For each statement, athletes and coaches circled a number indicating their level of agreement on a scale from 1 to 5. The numbers represent the following: 1 - Strongly disagree, 2 - Agree, 3 - Uncertain, 4 - Mostly agree, and 5 - Strongly agree. This scoring method ensures the objectivity of the assessment scale.

For negative statements, the scoring direction is reversed during data processing (scores are reversed). The re-coding is done as follows: 1 becomes 5, 2 becomes 4, 3 remains 3, 4 becomes 2, and 5 becomes 1. This ensures that the final result indicates a positive attitude of taekwondo coaches and athletes towards pedagogical competencies and motivation for permanent education. The validity of the instruments was established through expert analysis for methodological relevance of the instruments and factor analysis. Varimax rotation extracted seven almost equal factors that explained 54% of the variance of the attitude towards pedagogical competence variable.

The questionnaire for coaches (APT) was used as part of the survey technique and consists of 6 open-ended questions. The questionnaire is anonymous to encourage coaches to provide honest responses. The data obtained is of both objective and subjective nature.

ANALYSIS OF DATA

The entire statistical analysis of the data was performed using the "SPSS" software package (SPSS 20.0 for Windows) and the statistical program "JASP" (JASP 0.16). In the process of data analysis and application of descriptive statistics, the following parameters were obtained: mean (M), significance (p), and sum (Σ). Comparative results were obtained using the Mann-Whitney test (MW).

RESULTS

One of the research tasks was to examine whether there is a significant difference between the assessment of athletes and the self-assessment of taekwondo coaches regarding their inclination towards physical and psychological violence. This factor is reflected through the behavior, comments, and verbal communication of coaches that emotionally disturb athletes, as well as the physical punishment of athletes by taekwondo coaches. One possible reason for how athletes perceive the coach's behavior as aggressive may be the coach's training style. Czajkowski distinguishes between a dictatorial and a friendly coaching style. Coaches with a dictatorial coaching style do not explain their training methods and expect athletes to follow their orders (Czajkowski, 2010). The dictatorial or autocratic leadership style refers to the aggressiveness of the leader, their dominance, and complete control over other group members (Markovic et al., 2004).

Table 1 The inclination of taekwondo coaches towards physical and psychological violence;;

Self-assessment of coaches	Σt	15	15	15	15	15	15	15	15	14	13
	Ms	14.62	13.20	12.90	12.82	14	13.35	14.11	14.23	13.72	14.06
Assessment of athletes	Ns	40	30	20	35	15	20	35	30	25	15
	$\Sigma t - Ms$	0.38	1.80	2.10	2.18	1	1.65	0.89	0.77	0.28	-1.06

Σt (Sum of self-assessment of coaches); Ms (Mean of athletes' assessment.); ns (Sample size of athletes); $\Sigma t - Ms$ (Difference between the sum of self-assessment of coaches and the arithmetic mean of athletes' assessment).

The differences between the self-assessment of coaches and the assessment by athletes are small. The average difference between athletes' assessment and coaches' self-assessment of their inclination towards physical and psychological violence towards athletes is 0.99. Based on the number of determined statements related to this factor and the theoretical range, it can be concluded that there is a positive assessment by athletes and coaches regarding their inclination towards physical and psychological violence. The inclination towards physical and psychological violence is closely related to the emotional competence of the taekwondo coaches. Emotional competence refers to an individual's ability to be aware of their own emotions as well as the emotions of others and to react accordingly (Arnold, 2008). Coaches do not fully adhere to the principles of social competence either. Social competence involves kindness, tolerance, acceptance of rules, respect, and resolving conflicts through healthy communication (Juricic, 2014).

Individual assessment and self-assessment scores of taekwondo coaches are higher than 9. Higher individual scores indicate a lower inclination of taekwondo coaches towards physical and psychological violence. Violence in sports is a social anomaly that encompasses aggression and bullying behavior towards athletes. It occurs in all categories of sports, from amateur to elite level. It includes inappropriate criticism of athletes, punishments, aggression towards athletes, referees, and others (Bozovic, 2007).

Table 2 The differences in the assessment of taekwondo coaches regarding physical and psychological violence

Group	n	M	W	P
Coaches	10	14.70	1782.50	0.047
Athletes	265	13.73		

n (sample); M (mean); W (Mann – Whitney test); p (significance level).

The hypothesis has conditionally been rejected ($p=0.047$). There is a difference between the assessment of athletes and the self-assessment of taekwondo coaches regarding their propensity for physical and psychological violence. The obtained significance level is at the threshold of $p=0.05$. Some taekwondo coaches give significantly higher values to themselves compared to what athletes attribute to them. This means that coaches, based on their self-assessment, believe they use significantly less physical and psychological violence than what athletes perceive.

Speaking about continuous education, the author Vekic (2015) emphasizes that in the modern world, it represents the right of all individuals to have access to education and continuous capacity development. To achieve this, a certain level of motivation is necessary. Starting from the meaning of motivation itself, as the driving force behind people's task performance (Pintrich & Schunk, 2002), it was important to examine the assessment of athletes and the self-assessment of taekwondo coaches regarding their motivation for continuous education. The most significant results are presented in Table 3 and Table 4.

Table 3 Assessment of athletes, by clubs, on the motivation of their taekwondo coaches for continuous education;

T/BSP	Mt51	Mt52	Mt53	Mt54	Mt55	Mt56	Mt57	Mt58	Mt59	Mt60	M(VM)
1(40)	4.67	4.27	4.07	4.47	4.32	4.75	4.57	4.77	4.25	3.40	4.35
2(30)	4.06	4.06	3.66	4.13	4.06	4.23	4.16	4.60	3.46	2.40	3.88
3(20)	3.85	4.00	3.80	4.20	4.50	4.85	4.80	3.75	3.50	2.90	4.01
4(35)	3.57	4.00	3.85	4.08	4.22	4.20	3.88	3.77	3.85	2.57	3.80
5(15)	3.60	4.06	4.26	4.33	4.60	4.53	4.40	4.46	4.53	2.26	4.10
6(20)	3.60	3.50	3.15	3.25	3.55	4.05	4.10	3.85	3.40	2.15	3.46
7(35)	4.34	4.08	4.02	4.25	4.08	4.25	3.42	4.40	4.02	3.37	4.02
8(30)	4.06	4.33	4.00	4.36	4.40	4.30	3.50	4.23	3.90	2.80	3.99
9(25)	4.32	4.08	4.12	4.32	4.08	3.96	3.72	4.40	3.88	3.04	3.99
10(15)	4.13	4.00	3.73	4.13	3.53	2.20	2.60	4.60	3.93	3.06	3.59

T/BSP ((coaches and number of athletes per clubs); Mt (mean of athletes' assessment for items 51-60 on the motivation of their coaches for continuous education); M(VM) (mean of the variable motivation).

The study involved 265 athletes. Among them, the sample size for coach 1 was 40 athletes, coach 2 had 30 athletes, coach 3 had 20 athletes, coach 4 had 35 athletes, coach 5 had 15 athletes, coach 6 had 20 athletes, coach 7 had 35 athletes, coach 8 had 30 athletes, coach 9 had 25 athletes, and coach 10 had 15 athletes. Descriptive statistics were used to determine the mean values for each item, numbered from Mt51 to Mt60 in Table 3, and the overall mean M(VM) of the variable motivation.

Based on the obtained results, it can be concluded that, according to athletes' assessments, coach 1 is the most motivated (M(VM) is 4.35) in terms of permanent education. Goals related to intrinsic motives lead to individual well-being and progress (Randjelovic and Smederevac, 2011). According to athletes' assessments and the results presented in Table 3, coach 6 is the least motivated (M(VM) is 3.46). Therefore, this result is in line with the findings of Ersari and Naktiyok (2012), suggesting that a lack of motivation for improvement certainly affects productivity and work quality.

Table 4 presents the results related to the analysis and self-assessment of motivation among the taekwondo coaches for permanent education.

Table 4 Presentation of self-assessment of motivation among taekwondo coaches for permanent education based on the data obtained from the Taekwondo Association of Bosnia and Herzegovina;

Trener	Godine trenerskog rada	Iskustvo	Br. gradova	Br. seminara (učešća)	Ms	Trener
1	30	More experienced	17	39(2)	4.35(1)	
7	20	More experienced	11	22(5)	4.02(3)	M5TI
8	19	More experienced	15	29(3)	3.99(5)	3.99
9	28	More experienced	10	27(4)	3.99(5)	
10	17	More experienced	7	21(6)	3.59(9)	
2	15	Less experienced	26	68(1)	3.88(7)	
3	12	Less experienced	5	12(8)	4.01(4)	M5TMI
4	9	Less experienced	7	16(7)	3.80(8)	3.85
5	6	Less experienced	5	10(9)	4.10(2)	
6	8	Less experienced	4	8(10)	3.46(10)	

Ms (mean score of athletes' assessment of coaches' motivation for continuous education); M5TI (mean score of the five more experienced coaches); M5TMI (mean score of the five less experienced coaches).

The coaches were ranked from more experienced to less experienced. Taekwondo coaches with less than 15 years of coaching experience were categorized as less experienced, while coaches with over 15 years of coaching experience were categorized as more experienced coaches.

Based on the logical analysis and the data presented in Table 4, the following conclusions can be drawn: by categorizing the experience of taekwondo coaches, 5 coaches were classified as more experienced, while the remaining 5 coaches were categorized as less experienced taekwondo coaches. By comparing the results obtained from the arithmetic means of athletes' assessment of the motivation of taekwondo coaches for continuous education and the logical analysis, it can be concluded that there is no statistically significant difference in the motivation between more experienced and less experienced taekwondo coaches. Due to the nature of the data (variables), the Mann-Whitney test is not reliable for the application and comparison of the mentioned data. It is important to note that coaches should act through responsible organizational behavior that is not directly or explicitly recognized by the formal reward system in the organization but supports the efficient functioning of the organization (Mirkovic et al., 2017).

Regarding the analysis of the records of taekwondo coaches' participation in official seminars, it can be concluded that in most cases, more experienced coaches with over 15 years of coaching experience have higher attendance at seminars. This can be expected considering their long involvement in the sport. Sports organizations are subject to continuous changes, so they must plan their work properly and systematically in the future. The progress of sports organizations is reflected in the coach's readiness for self-improvement and continuous work on themselves and the development of the sports organization (Rodríguez, 2019). Due to the nature of the data (variables), the Mann-Whitney test is not reliable for the application and comparison of the data, so a logical analysis was used in the process of comparing the results.

Based on the presented results and logical analysis, it can be concluded that the hypothesis has been confirmed. There is no significant difference in the assessment of athletes and the self-assessment of taekwondo coaches regarding motivation for permanent education. The results of athletes' assessment and coaches' self-assessment are positive. Coaches are motivated for various forms of permanent education.

DISCUSSION

The aim of this research was to examine the level of agreement between athletes and taekwondo coaches in assessing pedagogical competence and motivation for permanent education. A quantitative-qualitative study was conducted for this purpose. The results indicate that there is no significant difference between athletes and taekwondo coaches in their assessment of pedagogical competence and motivation for permanent education. It is important to note that a good coach is one who is familiar with and takes into account the characteristics of their team and develops a positive atmosphere without violence in the sports collective (Rhind and Jowett, 2010). Athletes believe that their coaches demonstrate high pedagogical competence in the training process and high motivation for continuous education. The same opinion is held by taekwondo coaches in their self-assessment. Coaches should act by publicly announcing planned sports activities, goals, and athletes' achievements. This should be done in order to provide continuous feedback, support, and motivation for athletes to invest effort in achieving the set goal (Simic and Vardo, 2018). A noteworthy finding of this research relates to the inclination of taekwondo coaches toward physical and psychological violence against athletes. A coach should provide calm and continuous feedback to their athletes while correcting their mistakes (Hrzenjak and Bosnar, 2017). The lack of timely feedback and the absence of empathy and behavioral rules lead to bullying behavior (Bozovic, 2007). Although individual results obtained in this research are positive and indicate no inclination of coaches toward physical and psychological violence, certain differences and discrepancies have been detected. Taekwondo coaches achieve significantly higher scores for themselves and completely deny any inclination toward psychological and physical violence. In contrast, athletes believe that some coaches exhibit a certain degree of sports anomaly, aggression, inappropriate, and non-empathetic behavior.

Differentiation and concretization of the research goal defined nine causally elaborated research tasks. They represent key segments of the problem and research subject. The research tasks are related to pedagogical competencies, within which factor analysis defined seven separate factors. These factors and research tasks are as follows: 1. Affirmative presentation of taekwondo coaches, 2. Professionalism of taekwondo coaches, 3. Influence of taekwondo coaches on athletes, 4. Coaching abilities and the ability to transmit positive life values, 5. Reliability in coaches, 6. Responsibility and self-confidence of coaches, 7. Coaches' inclination towards physical and psychological violence. The eighth task is related to the assessment of athletes and self-assessment of taekwondo coaches regarding motivation for continuous education. The last, ninth task is qualitative in nature and pertains to the examination of coaches' opinions and attitudes about coaching work, pedagogical

competence, and motivation for continuous education. Significant attention is given to the seventh separate factor within coaches' pedagogical competencies. In other mentioned factors of pedagogical competence, there is a positive assessment from athletes and positive self-assessment from taekwondo coaches, and there is no significant difference in the assessment and self-assessment of determined pedagogical competencies. The only significant difference is in the assessment from athletes and self-assessment of coaches' inclination towards physical and psychological violence by athletes. That is why the importance of the obtained results of the seventh factor of coaches' pedagogical competence is emphasized in the paper.

The analysis of the research results indicates that the hypothesis was confirmed. There is congruence between athletes and taekwondo coaches in the assessment of pedagogical competence and motivation of taekwondo coaches for permanent education. Comparing the results of this research with similar studies conducted in the past, it can be observed that there are certain agreements and similarities. The research results are mostly of a positive nature. To assess the level and structure of coaches' self-assessment of pedagogical competence in 17 different sports and their attitude towards pedagogical improvement, Cokorilo and Grk (2010) conducted a study with a sample of 102 coaches. The results indicate that coaches have a positive attitude towards pedagogical training and improvement (Cokorilo and Grk, 2010). Determining the educational needs of adults is a fundamental question for evaluation, correction, and improvement of personal work (Jorgic, 2016). Taekwondo coaches generally have a positive attitude towards personal progress and developing pedagogical competencies. In their professional development, coaches are motivated by both internal and external factors. A conducted study on the need for pedagogical education indicates that coaches expect society's assistance in their professional development. Society's support further motivates coaches for various forms of continuous education and advancement (Vujanovic, 2015). A coach must be aware that their attitude and relationship with the team are more important than the attitude of any individual. Their main function is teaching and leading the team (Novic and Cancarevic, 2015). Additionally, through the obtained results, Nash and Sproule (2009) conclude that a coach must develop their professional and pedagogical competencies to become better in their job, enabling personal and team progress.

When it comes to analyzing the records of taekwondo coaches' participation in official seminars, it can be concluded that in most cases, more experienced coaches with over 15 years of coaching experience have higher attendance at seminars. Through logical data analysis, it was determined that one of the coaches who falls into the category of less experienced taekwondo coaches has the highest number of seminar participations (68 seminars in 26 different cities). This particular coach is on the verge of gaining more experience, having exactly 15 years of coaching experience. An interesting fact is that the arithmetic mean of athletes' assessment of the motivation of this coach for continuous education is 3.88. This result is one of the lowest ratings given by athletes regarding the motivation of coaches for continuous education. It can be concluded that this coach attributes significantly higher results

and a higher level of pedagogical competence and motivation for continuous education to themselves than perceived by the athletes.

One limitation of this research is the small sample size of taekwondo coaches. However, considering that the research was a combined (quantitative-qualitative) type, the sample of coaches in this case could not be larger. The combination of quantitative and qualitative research approaches is precisely one of the strengths of this study. The obtained statistical data could be compared with the opinions and attitudes of taekwondo coaches, which enabled a better understanding of the research topic and the problem itself. A limitation of the research could also be the indirect examination of the degree of coaches' motivation for permanent education. The research did not involve direct participation in training activities or involvement in groups and firsthand observation of the training situation.

In future research, efforts should be made to include a larger sample of coaches to obtain more comprehensive data and a broader picture of the assessment of pedagogical competence and motivation of coaches for permanent education. Additionally, it would be beneficial to apply the method of observing taekwondo training and expert observation of coaches' abilities during training and competitions. Expert observation would be conducted with the aim of identifying the main shortcomings in the work of taekwondo coaches with children. Coaches should be aware that learning occurs when individuals are in the mood for training and when their positive emotions encourage them (Chabot and Chabot, 2009). This is developed through empathy, which involves understanding the emotions and feelings of others and the ability to imagine oneself in the position of others (Novosel, 2012). It would be valuable, in collaboration with sports psychologists, to design an instrument specifically aimed at directly examining and assessing the degree of coaches' motivation for continuous education. Based on the data obtained, appropriate programs could be developed to improve and enhance the pedagogical competence of taekwondo coaches. This is particularly important considering that most of these coaches have not received education in pedagogical, psychological, and methodological subjects as part of their initial education, which would provide them with a foundation for later advancement through various professional development programs. It is crucial to place special focus on futuristic orientations in terms of the directions of development and further research on this issue (expanding research to a larger sample, including taekwondo coaches in the region, building a network of experts...).

CONCLUSION

Athletes of the Taekwondo Association of Bosnia and Herzegovina believe that their coaches demonstrate high pedagogical competencies during the training process and have motivation for permanent education, which is also reflected in the self-assessment of the Taekwondo coaches themselves. The success of sports coaches is not only about teaching young athletes proper Taekwondo techniques. Success is also achieved when coaches are able to instill genuine life values and ideals of Taekwondo in children. The ideals of Taekwondo include kindness, honesty, perseverance, self-control, and indomitable spirit (Vrekic, 2014). Due to the significant influence coaches have on young athletes, it is necessary for them to

continuously improve their sports and pedagogical knowledge. Through various professional development programs, they should work on mechanisms for reducing or overcoming different forms of physical and psychological violence towards participants in this sport. It is also essential for coaches to develop a democratic, open, and flexible leadership style instead of a dictatorial style of command. Building on such foundations, athletes with open minds and strategic orientations will be developed, rather than rigid, strict individuals focused on martial arts skills, without considering their social and emotional competence.

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MODEL OF ORGANIZATION AND MANAGEMENT IN SKI SCHOOLS

Zvezdan Savić¹, Nikola Stojanović¹, Toplica Stojanović², Đorđe Savić³, Vlado Stijepović⁴

¹Fakultet sporta i fizičkog vaspitanja, Univerzitet u Nišu, Srbija

²Fakultet za sport i fizičko vaspitanje, Univerzitet u Prištini-Kosovska Mitrovica, Leposavić, Srbija

³Fakultet sporta i fizičkog vaspitanja, Univerzitet u Beogradu, Srbija

⁴SASI, Srpsko udruženje učitelja i trenera sportova na snegu, Beograd, Srbija

Correspondence: prof. dr Zvezdan Savić,
Faculty of sport and physical education,
University of Niš, Serbia. +381 69 1166332;
zvezdansavic@yahoo.com

SUMMARY

Alpine skiing is classified as a poly-structured sport on snowy and icy terrains yearly. It mainly attracts skiers during winter, including beginners of various ages and genders. This paper addresses Ski Schools' organization and management model, aiming to guide instructing beginners in skiing considering their gender, age, needs, and interests. Ski schools are envisioned as open and innovative organizations with well-defined goals, tasks, and work programs. The primary objective of ski schools is to impart rational skiing techniques (descent down slopes) while considering the quality of equipment, slope conditions, and the competence of sports instructors and teachers working within ski schools. This study delves into the specific problem of theoretical representation of organization and management in ski schools, which operate as intricate systems within our ski resorts. The paper presents original research outcomes, offering a fresh perspective on previously explored questions and issues related to organization (manifestations) and management in ski schools. A clear and content-rich presentation of the problems, organization, and management in ski schools characterizes the paper's structure. Rather than concluding, the practical focus should be on well-organized and managed ski schools led by competent management and staff to ensure appropriately trained and safe skiers on the slopes.

Keywords: alpine skiing, training, beginners, management

Introduction

Since ancient times, humans have needed to improve themselves and their surroundings, aiming to accomplish tasks with minimal energy, time, and materials. Consequently, there has been a growing research interest in how individuals interact with their environment, organize their work based on new knowledge, and manage it efficiently (Živanović et al, 2003). In everyday practice, without theoretical consideration, i.e., the theoretical foundation of the issue, there is no practical elaboration of the phenomenon of organization and management in ski schools ("there is no practice without theory").

Contemporary sports exhibit all the characteristics of a societal phenomenon that receives considerable attention and involves numerous scientific and political factors. In the current sports practice in our context, the principles and values of modern management, i.e., organization and management in organizations, are still insufficiently affirmed. That is particularly pronounced in small sports organizations, where work is primarily based on routine (Nešić, 2007).

Curiosity, motivation, and personal affinity (interest) of the authors have driven them to acquaint future and current skiing and snowboarding instructors and coaches, as well as all those interested, with models of organization and management (management) in ski and snowboard schools. This work aims to provide a closer explanation of existing knowledge and to adopt new knowledge about the issue of organization and management, i.e., leadership in ski schools. The researched topic is current but, to some extent, insufficiently explored, which is why this work systematically organizes existing knowledge and the facts we have arrived at through theoretical consideration (Miltojević, 2008). Stijepović and colleagues (2017) presented ski and snowboard schools in Serbian ski centers in their professional work. The work addresses the historical development of skiing in four ski centers and the model of human resource engagement without explaining other factors of organization and management in sports institutions. They further emphasize that through the analysis of the past, ski and snowboard schools are vital drivers of tourism and the leading promoters of winter ski centers. Proper organization of ski and snowboard schools enhances the quality of the center itself and the development of free lifestyle styles. The organization of schools in centers is different and depends on the geographical, tourist, hospitality, and ambient position of a ski center.

Bartoluci and Škorić (2009) state that direct economic effects are realized in tourist or sports enterprises based on the sale of sports and recreational services, which is also the case with Ski Schools. They are realized as the difference between income and costs of sports services and are measurable in every tourist or sports organization.

Through theoretical and applied analysis, we have determined various directions in the methodology of teaching skiing in ski schools, that include., recreational, competitive, and combined. Sometimes, the ski school is considered an "open system" where the methodology is adapted to the participant's abilities, motivations, and desires. The work program should encompass basic pedagogical and didactic postulates and be oriented towards achieving

maximum success for talented individuals and those who require more time and attempts to achieve maximum results (Ropert, 2022).

The authors of this work possess significant creative potential and undoubtedly have professional competence and years of experience in teaching beginners in skiing and also theoretical knowledge. The definition of this topic is undoubtedly the result of a deep understanding of the problem in practice and the authors' desire to recognize and emphasize what is essential. The existing author's notes and direct experience in working on the mentioned topic have significantly contributed to forming this work's immediate goal and outcome. Furthermore, practical contribution of this work serves as a foundation for future research and discussions in the professional community, i.e., for those with a clear vision and the desire to realize it.

Definition of the Concept and Problem Statement

The objective of defining the functioning by various authors was to arrive at common attributes for a more precise definition of organization. The term "organization" originates from the Latin word "organisatio" signifying the integration of individual parts (organs) into a whole, making the entity capable of functioning. In a broader sense, organization entails human collaboration to fulfill specific tasks or duties. Vilotijević et al. (2018:20) defines an organization as the "science of principles for achieving optimal results in the realization of set goals and tasks, i.e., an organized entity of various elements". Therefore, an organization molds individuals to meet their needs and adapt to their environment. Thus, this definition can be fully incorporated into the management of ski schools.

Ski school is a sports organization registered to provide instructional services for skiing. It is established as a legal entity or entrepreneur, e.g., Ltd. (Law on Public Ski Resorts, 2006).

An individual who instructs beginners in skiing is a Ski Instructor or Teacher (levels I, II, III, and IV). They are certified to work in ski schools and possess a qualification certificate and a valid work permit (Savić & Stijepović, 2018).

In the cybernetic sense, management involves transitioning a system from one state to another (from one level to another), i.e., control actions to achieve higher, optimal outcomes. Management essentially revolves around the circulation of information. Management is realized through decision-making that executes predetermined school objectives (adapted from Vilotijević et al., 2018:24,25).

Consequently, Ski Schools can be regarded as open systems subject to changes in organization and management. They fall under the category of simple organizations with a specific mission and objectives, where a single individual, a manager or director, maintains direct contact with all staff (Tomić, 2006). Together, they constitute a team that should function positively in practice, specifically within registered ski centers.

The problem addressed in this paper focuses on presenting and explaining organizational forms of management and administration (management) in ski schools. As such, the program of a ski school should be cohesive and aligned with the National Ski School,

encompassing instructions, turning techniques, methodological bases for training, corrective exercises, and professional terminology.

Objective and Outcomes

This professional paper aims to present the principal elements of organization (manifestations and models) and management in registered Ski Schools. Additionally, the objective can be focused on the immediate practical application of this theoretical exploration, acquainting professionals with managerial concepts in the realm of ski school management, along with proposing measures for improving management and organization in future work.

The set objectives of this paper will fully address the defined thematic scope and provide the fundamental guidelines and signposts for the potential organization and implementation of ski schools in day-to-day practice within ski centers.

The outcomes of this paper are seen in the necessity of such theoretical investigations, primarily due to the need for a proper approach to effective theoretical and practical training of beginners on the terrain, considering their outcomes and impacts in immediate practice. Moreover, such theoretical works aid in discerning the positive and negative aspects of the proposed organizational procedures (models and manifestations) and management in ski schools. The ultimate outcome of this theoretical exploration can also be perceived as a type of professional assistance and guidance for all individuals employed and users in ski school.

Thus, a well-examined, respected, and analyzed historical perspective of ski school operations undeniably allows us to make fewer errors in future professional endeavors.

Therefore, the practical value framework of this theoretical research is reflected in several spheres: social, media, marketing, health and tourism. Individually, each of them promotes an upgrades skiing and accompanying ski industry, that means in practice is very hard to define which of them is the most important. That is why it is necessary to look at them in an interdisciplinary way, because it is only when they are given that they make their full contribution.

Organization and Management in Ski Schools

In everyday practice, we encounter three manifestations of a simple organizational structure, among which ski schools fall ("divisional" and "combined") (Tomić, 2006). These are 1) organizations where possibilities and objectives are consciously limited by organizational plans - ski schools; 2) sports organizations - ski schools, where the owner's or founder's decision involves appropriate organizational structure design; and 3) an autocratic management approach (abuse of authority) and management by organization managers. Besides organizational structure, one must familiarize oneself with practical work models.

Based on years of professional experience and personal motivation, the authors propose, elaborate on, and present a working model with five factors in the organization and functioning of ski schools. These are: 1) the mission, goals, and tasks of the Ski School, 2) the

Ski School structure, 3) human resources in the Ski School, 4) Ski School processes, and 5) Ski School management (Tomić, 2006).

Mission, goals, and tasks: The mission of a ski school pertains to its fundamental purpose of existence, which involves establishing a quality school tailored to the participants, and their environment, where all learn and progress. The ski school program should facilitate individual advancement aligned with abilities, interests, and possibilities. Alongside the educational aspect, the program also includes an educative dimension, aiming to create a safe, pleasant, and stimulating environment. The program is stimulating, offering freedom of movement and adaptation and continuous professional development for instructors and trainers (Ropret, 2022:145). The school's objective is an individual or group-oriented target: securing ample participants, employing instructors, positive financial transactions (material gain), marketing activities, quality service provision, and ski equipment rental. Hence, the ultimate goal of the ski school is thriving and secure training. The school's task also involves promoting educational components, addressing the need for new knowledge, and continuous employee professional development (Savić & Stijepović, 2018).

Structure: The structure of a ski and snowboarding school pertains to its internal organization and relationships along vertical and horizontal lines, i.e., division of labor and responsibilities within the school, all aimed at achieving personal and collective tasks and objectives. The school's structure also concerns organizational methods, employee competencies, the school's program, and organizational and production technical conditions. It involves the division of tasks and responsibilities, mainly expressed through specialization of tasks and coordination of all employees (Tomić, 2006).

Human resources: These constitute subjects and objects of action and work. Subjects include all individuals employed in the ski school. It is important to emphasize that only ski instructors engaged by the ski school can conduct skiing instruction on the ski slopes. A skiing instructor is a person engaged in teaching skiing and specialized winter sports, holding the appropriate qualifications of a skiing instructor, teacher, or coach per the law governing the sports field. They also possess a valid license the relevant sports association issued, i.e., a "work permit" (Torlaković et al., 2014). They must adhere to high standards organizationally, technically, and methodologically. In the collaborative work with ski school participants, a skiing instructor applies a proper methodological approach in selecting the best methodical exercises that aid in acquiring elements of skiing technique. Additionally, they promptly identify and correct observed errors in the execution of assigned exercises and elements (Kačer et al., 2014).

Apart from instructors, human resources within schools also include employees in management (director, finance sector), marketing personnel (PR), individuals involved in scheduling instructor hours, and animators responsible for promotion, diploma awarding, and the enjoyable aspect of school activities.

Processes: In the context of a ski school, processes pertain to directing activities and tasks toward goal achievement. Primary processes in a ski school relate to its core activity, i.e.,

participant training (individual, group, full-day ski school). Primary objectives include clearly defined school goals and tasks ("risk management" and addressing operational "bottlenecks"). Risk management is commonly defined in practice as the fundamental function of management, involving assessing and monitoring risks and preparing the organization for potential impacts and opportunities to prevent them. Process management in ski schools is entrusted to managers, other professionals, and experts from various fields. The ski school must contract with Ski Resorts to provide skiing training services. To use ski resorts, it must adhere to stipulated conditions and procedures outlined in the contract. According to the contract, it also bears specific responsibilities it must uphold during its operations. Secondary processes concern activities supporting the core activity, organization, and management, including marketing, finance (financial transactions), administration (administrative structure - secretarial tasks), facility functions, obligations towards partners, and the ski school's environmental basis.

Ski School Management: This relates to activities for effective and successful ski school management. It involves the actions of managers (directors, managers) with the aim of the organization's, i.e., ski school's, efficient functioning. In practice, these are the responsibilities of the ski school owner (school director) and their deputies for specific areas: teaching, scheduling instructors, ski and equipment servicing, on-slope instructor work, and other tasks. The ski school director is directly responsible for implementing the annual work plan and exercising complete control over the ski school. They advocate for teamwork, demonstrate understanding towards the employees, and possess the ability to motivate them effectively. They are resolute and confident in decision-making and have a deep understanding of their staff, serving as the captain of their team. School directors must possess a certain level of authority among their employees, expressed through their knowledge and capabilities (status in the management hierarchy). Ski school management is closely connected to the marketing function, which is monetized through results and service provision in the skiing market. The outcome of management is the realization of the "membership function," directly related to increasing the number of participants and ski school members. Market and competition analysis are also part of ski school management duties.

We emphasize that ski schools constitute a social group existing to fulfill the needs of participants, the school's users (Nešić, 2007). Thus, the direct functioning of the ski school is realized through adherence to "safety organizational training rules" and implementation of the "National Ski School" program, as well as rules applicable in ski centers (Ropert, 2018). The ski school's program must encompass fundamental didactic-methodological teaching principles, with content that is tailored and adapted to the school's participants.

Conclusion

The necessity of such theoretical explorations fundamentally arises from the need to approach the successful theoretical and practical training of beginners on the field correctly, considering its outcomes and effects in immediate practice. Additionally, professional articles of this nature aid us in practice to better discern what aspects of the ski school's organized

procedures and management have been positive or negative. The requirement for this work also partly stems from clarifying prior theoretical ambiguities. Hence, the significance of this work is implemented in presenting and explaining procedures for organizing, managing, and directing ski schools. From the perspective of sports organization activities, i.e., ski schools, they should develop their "market strategy," aligning their activities with user needs.

Ski schools should function as autonomous and creative organizations with clearly defined goals, tasks, and work programs. They should function as well-organized teams, with a competent and quality school director-manager at the helm, possessing authority as an organizational subject. This director-manager indirectly advances positive business obligations, creates a favorable work atmosphere, motivates employees, fosters genuine camaraderie and friendly relationships between employees and participants – the ski school's clients – and displays creativity in their work. The accurate measure of a ski school director's or owner's performance is their ability to make correct, financially justified management decisions. When choosing and defining their operational strategy, schools should also consider "environmental analysis" (a dynamic environment – other schools and sports organizations at the ski resort). Therefore, ski school management must take the initiative and action to achieve set objectives.

Particular attention should be paid to general management procedures, i.e., safety measures and potential risks in conducting business operations (preserving assets and individuals). Thus, ski schools should use ski slopes for skiing instruction only under conditions that ensure safety for participants and other skiers, as stipulated by ski resort regulations. To attain high levels of skiing skill instruction, ski instructors and trainers should adhere to the "Code of Ethics and Conduct Rules" and consistently work on their improvement (in the realm of ski equipment, modern techniques, and methodology). Ski schools should consistently operate under the Law on Sport and its accompanying regulations and protocols.

Clearly defined goals and tasks of ski schools as complex profit-oriented entities are essential for achieving positive outcomes. When defining objectives, their "hierarchy" must be unequivocally established, ranking them by importance and realization timeline. Such organizational and management practices will undoubtedly yield practical results. The analysis of this research has substantiated the validity of such investigations.

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DIFFERENCE IN BALANCE AND SUCCESS IN PERFORMING BASIC GYMNASTICS ELEMENTS BETWEEN 7-8 YEARS OLD BOYS AND GIRLS

Saša Jovanović^{1, 2}, Aleksandra Ilić³, Marko Zec⁴, Raluca A. Tanasa⁵, Tijana Purenović-Ivanović⁶

1 Faculty of Physical Education and Sports, University of Banja Luka, Banja Luka, Bosnia and Herzegovina

2 Faculty of sport, University of Ljubljana, Ljubljana, Slovenia

3 Faculty of Sports and Physical Education, University of Novi Sad, Novi Sad, Serbia

4 UOŠ Branko Radičević, Banja Luka, Republika Srpska, Bosnia and Herzegovina

5 Faculty of Physical Education and Sport, University of Alexandru Ioan Cuza of Iasi, Iasi, Romania

6 Faculty of Sport and Physical education, University of Niš, Niš, Serbia

Correspondence: prof. dr Saša JOVANOVIĆ, University of Banja Luka,

Faculty of Physical Education and Sport, V.P.Bojovića 1a, 78000 Banja Luka, Bosnia and Herzegovina

Phone: +38765799581,

E-mail : sasa.jovanovic@ffvis.unibl.org

SUMMARY

This study aimed to determine the status of motor skill of balance and possible differences between girls and boys, of younger school age, in predicting the performance of selected gymnastic elements on the floor (shoulder stand, headstand, handstand). Eighty-four young participants were divided into two groups participating in the study (Group Males: n=42; Group Females: n=42). The participants had to perform four tests to evaluate motor ability of balance that have the necessary metric characteristics: standing on one leg with eyes open transversely on a balance bench - MBAP, standing on two legs longitudinally on a balance bench with eyes closed - MBAU2Z, standing on two legs longitudinally on balance benches with eyes open - MBAU2O and Flamingo test - FLAM. The success of the execution of the selected gymnastics elements was evaluated by the commission, which consisted of five licensed judges of the Gymnastics Federation of the Republic of Srpska, with marks from 0 to 10. Minor differences were found in the motor ability of balance and the results of predictable values for these gymnastic elements ($p=0.05$). Girls had lower results in the motor tests but better scores in the performance of the gymnastic elements, but it is no significant differences. The average results of all respondents in this research are lower than in previous research. The relatively low scores of the motor ability test results indicate the need to introduce additional pre-exercises to improve results in performing essential gymnastic elements.

Keywords: lesson organization, success, teaching physical education.

INTRODUCTION

Motor movement, represented by various movements and motions, can be observed and expressed through the realization of motor skills and abilities. Motor skills themselves can be divided into primary and specific. The balance represents one of the basic skills expressed in the static and dynamic maintenance of the body's position in space (Lubans et al., 2010). Achievement in gymnastic element training has long left behind an approach in which strength is dominant. Over time, the importance of motor skills and their influence on the performance of gymnastic elements has been differentiated. Introduction to gymnastics takes place in preschool and younger school age to provide optimal conditions for individual development. In the local community, most children of younger school age are introduced to gymnastics in regular physical education classes (Novak et al., 2008; Zivcic, 2007). Here, the teacher faces another challenge: the motor skill of balance could be statistically different ($p = .05$) for girls and boys as they mature (Aleksic-Veljkovic et al., 2014), which could influence the choice and application of methodological means in the implementation of the gymnastics lesson. Few studies have investigated the balance of gymnasts concerning non-athletes (Asseman, Caron & Crémieux, 2008), Carrick, F. R., Oggero, E., Pagnacco, G., Brock, J. B., & Arikan, T., 2007; and other athletes (Bressel, Yonker, Kras & Heat, 2007) with the conclusion that balance is not a primary motoric skill for establishing more significant differences between these groups. In contrast to that findings, few studies have considered balance as a potentially important motor skill that could have a significant influence on the execution of gymnastics elements (Jovanović et al., 2021; Miletić, 1998; Prassas et al., 2006; Sleeper et al., 2016, Von Cagno A. et al., 2008;). Attention should be focused on these details at the beginning of training at a young age. Balance as a motor skill can be significantly affected at this age because it depends on the maturation of the functions of the vestibular, kinesthetic, tactile, and visual analyzers (Massion, 1998). Shoulder stand, headstand, and handstand (in a static position) are the most commonly performed elements of floor gymnastics at the beginner level. This study was conducted under the assumption that there is a gender difference in predicting the quality of their performance, using balance as the criterion variable. This study aimed to determine the status of motor skill of balance and possible differences between girls and boys, of younger school age, in predicting the performance of selected gymnastic elements on the floor (shoulder stand, headstand, handstand).

METHODS

The sample consisted of 84 participants aged 7-8 years (42 girls and 42 boys) with no previous gymnastics experience. During gymnastics training in physical education classes, all participants were healthy and able to participate in class. This project was approved by the Institutional Review Board of the Faculty of Physical Education and sport, University of Banja Luka. All experiments were conducted according to the latest version of the Declaration of Helsinki (World Medical Association, 2002). The predictor variable was tested using four tests of motor balance ability (Metikoš, Prot, Hoffman, Pintar, Oreb, 1989): standing on one leg crosswise on a balance beam with eyes open (MBAP); standing on two legs lengthwise on a

balance beam with eyes closed (MBAU2O); standing on two legs lengthwise on a balance beam with eyes open (MBAU2Z) and a flamingo test (FLAM).

Standing on one leg crosswise on a balance beam with eyes open (MBAP)

Starting position: Barefoot, the examinee stands with one foot crosswise on the partition of the balance bench while the other touches the ground. The palms are pressed against the thighs. The choice of the leg is left to the examinee. Performance of the task: The examinee's task is to raise the leg sat la and remain balanced on one leg with the hands on the thighs for as long as possible. The task is repeated six times with breaks between repetitions. Completion of the task: The task is terminated if the examinee: moves any hand away from the body, touches the bench or the ground with a foot in the air, moves the foot of the landing leg, or stands in a balanced position for more than 180 seconds.

Standing on two legs lengthwise on a balance beam with eyes open (MBAU2O)

Starting position: While keeping one hand on the wall, the examinee steps barefoot with both feet along the vertical balance bench. The feet are one behind the other. The palm of the free hand is next to the body. The examinee keeps his eyes open. Performance of the task: When the examinee has established a balanced position, he moves his hand away from the wall and brings it closer to his body. Both hands are held close to the thighs during the task. The task is to stay in as long as possible in a balanced position. The task is repeated six times with a break between repetitions.

Completion of the task: The task is interrupted if the examinee moves any hand away from the body, moves any foot, and stands in a balanced position for more than 90 seconds.

Standing on two legs lengthwise on a balance beam with eyes closed (MBAU2Z)

Starting position: While keeping one hand on the wall, the examinee steps barefoot with both feet along the vertical balance bench. The feet are one behind the other. The palm of the free hand is next to the body. The examinee keeps his eyes open until he starts; before the start of the task examinee closes his eyes. Performance of the task: When the examinee has established a balanced position, he moves his hand away from the wall and brings it closer to his body. He closes his eyes. Both hands are held close to the thighs during the task. The task is to stay in as long as possible in a balanced position. The task is repeated six times with a break between repetitions. Completion of the task: The task is interrupted if the examinee moves any hand away from the body, moves any foot, and stands in a balanced position for more than 90 seconds.

Flamingo test (FLAM)

Starting position: The examinee stands on a small bench with his wanted leg while the other leans on the ground. Performance of the task: The examinee balances as long as possible on the longitudinal axis while standing on the leg he wants. He bends the free leg backward with the same hand, holding it by the upper part of the foot, standing like a flamingo. The

other hand is in renunciation; at the beginning, it holds the measuring stick. The test begins when the tester withdraws his hand. Completion of the task: Testing is terminated each time the examinee loses balance (i.e., lowers the free leg he is holding) or touches any part of the body. The test is repeated three times, and the better time is counted.

The criterion variable was formed by the evaluated success in performing selected gymnastic elements: shoulder stand, headstand, and handstand. The performance was evaluated by three licensed judges of the Gymnastics Federation of the Republic of Srpska with scores from 0 to 10 (Table 1).

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

SCORE	DESCRIPTION
0	Unsatisfying technique and amplitude
1	Satisfying technique, small amplitude
2	Satisfying technique, large amplitude
3	Good technique, small amplitude
4	Good technique, large amplitude
5	Very good technique, small amplitude
6	Very good technique, large amplitude
7	Great technique, small amplitude
8	Great technique, large amplitude
9	Excellent technique, small amplitude
10	Excellent technique, large amplitude

Scoring was based on a predetermined set of values, given in tens of points for each exercise, according to the set penalties, resulting in a final score 10.00. Scoring followed the FIG Rules and Regulations for Scoring and Activities of Referee Panel "B" regarding deducting performance points and scoring for compulsory exercises - GAY-GASMN Rules and Regulations (Petković et al., 2004). Tests were performed before the beginning and at the end of the training program. The testing procedure lasted two days. On the first day, the respondents were tested for the performance of motor tests for balance, while on the second day, they performed selected gymnastic elements. The physical education teacher performed Motor tests in the school hall after an adequate warm-up. Statistical analysis was performed using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL). In addition to basic descriptive statistical parameters for all variables (mean value (Mean), standard deviation (SD), and standard error (Std. Error)), multiple regression analysis was performed to determine the presence of relationships with $p=0.05$ level of significance.

RESULTS

The values of the intraclass correlation coefficients (Table 2), used to determine the agreement of the different judges in the evaluation of the performance of the acrobatic elements. All the coefficients obtained were above 0.90, confirming the measurement's very high objectivity.

Table 2. Intraclass correlation coefficients

shoulder stand	0.991
head stand	0.986
hand stand	0.985

Table 3 shows the values of the arithmetic mean for the balance tests and the evaluation of the performance of each gymnastics element, where the obtained results indicate the highest values for the execution of the shoulder stand (for B: 5.27 and G: 5.76) and the test FLAM for the girls and the MBAU20 test for the boys.

Table 3. Mean and standard deviation for all scores in motorically and gymnastic tests

	P	M	SD	SEM
MBAP	Boys	2.61	1.73	.26
	Girls	1.63	.88	.13
MBAU20	Boys	2.85	1.81	.28
	Girls	2.43	2.06	.31
MBAU2Z	Boys	1.71	.78	.12
	Girls	1.24	.54	.08
FLAM	Boys	2.66	1.32	.20
	Girls	2.46	.92	.14
Shoulder stand	Boys	5.27	3.71	.57
	Girls	5.76	3.50	.54
Head stand	Boys	2.63	2.74	.42
	Girls	3.92	3.23	.49
Hand stand	Boys	2.84	2.65	.41
	Girls	3.29	2.68	.41

Legend: G-gender (B-boys, G-Girls), M-Mean, SD-standard deviation, SEM-standard error mean, MBAP-standing on one leg crosswise on a balance beam with eyes open, MBAU20- standing on two legs lengthwise on a balance beam with eyes open, MBAU2Z- standing on two legs lengthwise on a balance beam with eyes closed, FLAM- Flamingo test

Table 4 presents a plot of the results' normal distribution, verified by statistical processing with the KS test. The values obtained for the variables used are at the lower limit of the normal distribution.

Table 4. Results of the Kolmogorov-Smirnov test

	Stat. val.	Sig.
MBAP	0.112	.200
FLAM	0.089	.200
MBAU20	0.122	.200
MBAU2Z	0.098	.200

Legend: Stat. val. - statistical value, Sig. - statistical significance, MBAP-standing on one leg crosswise on a balance beam with eyes open, MBAU20- standing on two legs lengthwise on a balance beam with eyes open, MBAU2Z- standing on two legs lengthwise on a balance beam with eyes closed, FLAM- Flamingo test

Table 5 shows the regression analysis results for the performance of all three gymnastic elements. The determined value of coefficient of determination for the value of the results of the performance of the shoulder stand is 0.345 and 0.394 for the boys and girls, respectively. This means that the predictive model used explains 34.5% and 39.4% of the variance. These results are followed by the values for the performance of the headstand (0.489) and the value

of the results for the variable of the handstand (0.474), which was obtained only for the girls' results. This means that the predictive model used explains a total of 48.9% and 47.4% of the variance of these gymnastic elements. The results obtained in the prediction of the used model showed statistical significance in the performance of all three gymnastic elements at the level of $p = .005$.

Table 5. Results of regression analysis for all criterion variables

	P	R	R ²	F	Znač.
shoulder stand	Boys	.587	.345	4.873	.003
	Girls	.628	.394	6.022	.001
head stand	Boys	.355	.126	1.332	.276
	Girls	.699	.489	8.860	.000
hand stand	Boys	.357	.128	1.352	.269
	Girls	.688	.474	8.319	.000

Legend: G-gender (B-boys, G-Girls), R- the share of variance in the dependent variable, R²- coefficient of determination, Sig. - statistical significance

The presented values of beta coefficients (Table 6) show that the highest BETA coefficient in predicting the results of performing the gymnastic elements is based on the test results of FLAM (4/6). The highest predictive value of this individual criterion variable was obtained in the execution of a head position by girls (0.514), with a statistically significant contribution (0.000). Similarly, in the execution of the shoulder stand (stand for boys and girls), a statistically significant predictive result (0.003) and (0.004) was obtained with the values of beta coefficients 0.458 and 0.455, respectively. The values of the BETA coefficient for girls' performance in handstand showed the highest value in the MBAU2Z test (0.435), followed by the values for the FLAM (0.314) and MBAP (0.255) tests, with all three variables making a statistically significant contribution in the regression model (0.003; 0.025; 0.046).

Table 6. Selected significant predictor coefficients for all variables

criterion variables	predictor variable	Stand. B. Coef.	Sig.
head stand - girls	FLAM	.514	.000
shoulder stand- girls	FLAM	.458	.003
shoulder stand- dječaci	FLAM	.455	.004
hand stand- girls	MBAU2Z	.435	.003
hand stand- girls	FLAM	.314	.025
hand stand- girls	MBAP	.255	.046

Legend: Stand.B coef. - standardized Beta coefficient, Sig. - statistical significance, MBAP-standing on one leg crosswise on a balance beam with eyes open, MBAU2Z- standing on two legs lengthwise on a balance beam with eyes closed, FLAM- Flamingo test

DISCUSSION

This research focuses on determining the level of motor ability of balance, and determining differences in the prediction of the performance of selected gymnastic elements between boys and girls of younger school age, using balance as a criterion variable. Looking at the results of the motor balance tests, the boys performed slightly better in all tests. The slightest difference was in the results of the FLAM test, while the most significant difference was in the MBAP test. However, it should be noted that these are much worse results than the results obtained on a similar sample in the research of Tanas, Dumitru, and Budac (2020) and Veljković et al. (2014). On the other hand, the performance results of all gymnastic elements show that the girls had better performance scores on average. The slightest difference in the obtained results is in the execution of the handstand, while the most significant difference in the obtained results is in the execution of the headstand. The obtained results are similar to those of Donti O, Bogdanis GC, Kritikou M, Donti A & Theodorakou K., (2016), and Radanovic (2013) in which the girls had lower results in the motor tests but better scores in the performance of the gymnastic elements. It should also be noted that the average results of all respondents in this research are lower than in the previous research. The relatively low scores of the motor ability test results indicate the need to introduce additional pre-exercises that would lead to improved results (Gavojdea, A.M., 2016, Tanasa et al., 2020,). In order to obtain information about the possibility of predicting success in the performance of selected gymnastic elements, we have used a statistical regression method. The obtained results showed that based on the selected set of motor balance tests, it is possible to predict the success of performing the stance on the shoulder blades in all subjects. Regarding predicting the success of performing the headstand and handstand, obtained results show statistical significance ($p < .001$) only in girls. Girls at this age show greater seriousness than boys, which is shown by paying attention to the performance of the aesthetic components of the elements. They showed more attention and interest during the training, which is also shown by their assessment of the performance of gymnastic elements. The results of predicting the performance of selected gymnastic elements using individual tests indicate that the FLAM test stands out. The FLAM test can predict the success of performing all three selected gymnastic elements in girls and the performance of shoulder blade position in boys. As for the other tests, the results indicate the possibility of using individual tests MBAU2Z and MBAP when performing head posture in girls. Research by Popović et al., (2009), Radanovic et al., (2013), Radanović, D. et al. (2016), and Madić et al., (2011) suggest that it is possible that the difference in flexibility, primarily in the part of the hip flexors, enabled the girls to perform the test itself better, in contrast to boys, who have a slightly lower level of flexibility, girls reached more optimal positions of criterion and predictor variables in their performances. Although the results showed relatively satisfactory levels of predictive values in this sample, the research should be repeated with the application of a more comprehensive prediction system and on a larger sample to be able to generalize the results.

CONCLUSIONS

Based on the results obtained, there is a need to apply a more significant number of different exercises that would contribute to developing the motor ability of balance. In this way, the obtained predictive results would be improved and more credible in evaluating the performance of selected gymnastic elements. Based on a relatively small number of tests of the motor ability of balance (on a similar sample), it would be possible to predict the success of the selected gymnastic elements. In this way, the quality of work and monitoring of subjects at the beginning of the training of gymnastic elements would be improved, which would undoubtedly lead to better results and better performance of the selected elements. Observing the development of skills is essential because, in this period, significant changes occur in children of younger school age, which can lead to greater efficiency in applying classical teaching models. On the other hand, the inadequacy of physical education resources prevents more detailed and extensive testing on a more significant number of students without the need for additional staff and time, which is challenging to fit into students' schedules. The selected balance tests, at this age, can be used to determine part of the examinee's motoric status and the realization of teaching units in gymnastics.

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RELATIONSHIPS BETWEEN ANTHROPOMETRIC AND BODY COMPOSITION MEASURES TO ARMY PHYSICAL FITNESS TEST PERFORMANCE AMONG MALE AND FEMALE ROTC CADETS

Megan B. Thompson¹, Jordan Jeffers¹, Filip Kukić², Robert G. Lockie³, Robin M. Orr⁴, J. Jay Dawes¹

¹School of Kinesiology, Applied Health and Recreation, Oklahoma State University, Stillwater, OK, USA

²Faculty of Physical Education and Sports, University of Banja Luka, Banja Luka 78000, Bosnia and Herzegovina

³Department of Kinesiology, California State University, Fullerton, Fullerton, CA, USA

⁴Tactical Research Unit, Bond University, Robina, QLD, Australia

Correspondence: Megan B. Thompson,
Department of Health and Human Performance,
Oklahoma State University, Stillwater, OK, USA
Email: megan.mcguire@okstate.edu

SUMMARY

The purpose of this study was to determine the relationships between body composition measures and Army Physical Fitness Test (APFT) performance between male and female Reserve Officers' Training Corps (ROTC) cadets prior to enlistment. Retrospective APFT test performance and body composition data were provided for 57 male and 17 female university ROTC cadets. Descriptive statistics were derived for all variables and separated by sex. A MANOVA model was used to determine differences between sexes in all anthropometric and fitness variables. A Pearson's moment correlation was used to determine significant relationships between body composition and APFT measures separated by sex. Significant differences between male and female cadets for height, body mass, body fat percentage, and APFT events were found ($p = 0.001-0.03$). No significant differences were found between sexes for BMI ($p = 0.887$). Additionally, no significant relationships between anthropometric measures and fitness performance were observed among male or female cadets.

Ključne reči: military; soldiers; push-ups; sit-ups; aerobic fitness

INTRODUCTION

Army Reserve Officers' Training Corps (ROTC) is a college program designed to educate, train, and prepare college students to become officers within the United States Army (Mele, 2020). Physical fitness is emphasized within these programs to prepare cadets for the physical demands of essential job tasks they will encounter once they commission into active duty. Some of the most common demands include weight loaded marching, running, overcoming obstacles, crawling, jumping, and hand-to-hand combat (Oliver et al., 2017). For these reasons, cadets are required to meet a minimum physical fitness standard prior to graduating and becoming commissioned soldiers to ensure they can withstand the rigors of training, and to ensure they are able to complete Army-specific tasks.

The Army Physical Fitness Test (APFT) was the standard fitness evaluation used by the U.S. Army since 1985 to determine physical readiness and health of both active-duty soldiers and cadets (Army, 2012; Leiting, 2014). The APFT included three assessments: the 2-minute timed push-up and sit-up tests to assess muscular endurance, and a 2-mile run for time to assess aerobic fitness. While the APFT is no longer widely utilized, having been replaced by the Army Combat Fitness Test (Army, 2019), the measures included in the APFT can still be used to determine information relating to the general health and fitness of cadets and soldiers (i.e., muscular endurance and aerobic fitness) (Steed et al., 2016).

Body composition can have a significant impact on a soldier's occupational and physical performance (Crawford et al., 2011; Crombie et al., 2012). It has been suggested that an individual's body fat percentage (BF%) may be important in determining muscular endurance and aerobic performance among ROTC cadets (Crawford et al., 2011; Steed et al., 2016). This importance is highlighted by research showing that 34% of males and 38% of females in the military are considered overweight or obese (Crombie et al., 2012). Additionally, attaining and maintaining a certain level of fat-free mass may also be necessary for injury mitigation purposes among soldiers (Friedl, 2012). In a study by Crawford et al., soldiers that had higher BF% performed significantly worse on selected fitness tests than those with lower BF% and similar fat-free mass (Crawford et al., 2011). These findings suggest that higher fat mass may not only negatively impact an ROTC cadet's fitness performance, but also their general health and well-being. Therefore, achieving healthy body composition levels prior to commissioning into an active-duty role should receive dedicated attention within cadet populations.

Previous research has indicated that there are differences in the levels of physical fitness between male and female cadets and enlisted soldiers in measures of muscular endurance and aerobic fitness (B. M. Roberts et al., 2023; Steed et al., 2016). These differences may be related to a number of factors, including the propensity for males, in general, to possess greater physical stature, larger lungs, and more muscle mass compared to females (D. Roberts et al., 2016; Yanovich et al., 2008). Additionally, females, in general, tend to carry a larger amount of relative fat mass compared to males, which may increase the physiological burden of performing certain soldiering tasks (Sudom & Hachey, 2011). However, the relationships between fitness and body composition have not been thoroughly explored in the

context of ROTC cadets prior to enlistment. A greater understanding of these relationships may help inform decisions related to strength and conditioning considerations within this population.

The purpose of this study was to investigate relationships between select body composition measures and measures of muscular endurance and aerobic fitness among male and female ROTC cadets. It was hypothesized that body composition would be significantly related to all measures of physical fitness for both sexes. These findings may be used to help direct physical training programs aimed at improving overall health and fitness within these populations.

METHODS AND MATERIALS

To examine the relationship between select anthropometric measures and APFT performance, previously collected data was voluntarily provided by the university's ROTC cadre. Sex related differences in body composition and fitness performance were also assessed.

Subjects

Retrospective data were provided for 74 Army ROTC cadets from a Midwestern university, including 57 males (height: 180.36 ± 7.29 centimeters [cm]; body mass: 76.81 ± 9.81 kilograms [kg]; BMI: 23.53 ± 2.43 m/kg²) and 17 females (height: 164.81 ± 4.73 cm; body mass: 66.56 ± 13.77 kg; BMI: 23.00 ± 2.23 m/kg²). Age data was not included in the data set provided to the researchers, and therefore was not included in analysis (Farina et al., 2022). This data was collected as part of the ROTC program's yearly fitness assessment via the APFT. All research was conducted with approval from the university's institutional review board (IRB # ED-19-146-STW), and informed consent was obtained from each participant prior to data collection (Navalta et al., 2019). The study followed the recommendations of the Declaration of Helsinki ("World Medical Association Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects.," 2001).

Protocols

Data were collected by a senior ROTC cadre in support to a Midwestern university's program using procedures outlined by the U.S. Army for conducting the APFT (Army, 2012). Data collection for the APFT events took place at an outdoor football training facility on university grounds. For all measurements, cadets were instructed to wear standard issue PT gear for the U.S. Army (t-shirt, shorts, athletic shoes). Cadre collected anthropometric measurements for cadets prior to any physical fitness assessments. The APFT was performed in the following order for all cadets.

All cadets followed standard U.S. Army protocol for the 2-minute maximal push-up assessment (Army, 2012). Cadets were instructed to begin in the front-leaning rest position with feet no more than 30 cm apart for the duration of the assessment. On the verbal command of "Go" from their cadre, cadets would lower their body by flexing their elbows

while maintaining a consistent line from their shoulders to feet. Repetitions were considered successful if cadets were able to lower their upper arms to be parallel with the ground, and return to the front-leaning rest position (Army, 2012). The only acceptable rest position for cadets within the 120 seconds was with their arms fully extended in the front-leaning rest. If a cadet's technique deviated from these guidelines, repetitions were not counted towards their total. The assessment was terminated when the time limit was complete, the cadets reached volitional fatigue, or proper technique was unable to be maintained. The absolute number of successful repetitions were included in data analysis.

The 2-minute maximal sit-up assessment was graded by cadre according to U.S. Army standards (Army, 2012). Cadets were instructed to complete as many repetitions as possible in 120 seconds while keeping proper form, described as maintaining a 90-degree angle at the knees with feet no more than 30-cm apart flat on the ground, with fingers interlocked on the back of the head for the duration of the assessment. Another cadet was permitted to stabilize the testing cadet's ankles using their hands if requested, but no other bracing techniques were allowed. Repetitions were considered successful if a cadet was able to bring their torso to or beyond vertical (defined by the base of the neck above the base of the spine), and return to the start position (Army, 2012). This upper position was the only authorized rest position for cadets for the duration of the assessment. Repetitions were not counted towards the total if the cadet did not maintain proper form at any point. This assessment was terminated when the cadet reached volitional fatigue, when proper technique was not able to be maintained for three consecutive repetitions, or the time had elapsed. The total number of successful sit-up repetitions were included in data analysis.

The 2-mile run test was conducted outdoors on a predetermined course on university grounds. The course was not to exceed a 3% grade as outlined by APFT protocol (Army, 2012). Cadets would begin the assessment on the command of "Go" from their cadre, at which time the stopwatches would begin, and would attempt to complete the course as fast as possible. Cadre would record the completion time of each cadet to the closest second.

Anthropometric measurements (height, body mass, BMI and BF%) were measured and collected by a senior ROTC cadre one week after performing the APFT using an InBody 270 (Biospace, California, USA) device and portable stadiometer. Although this device measures a number of other body composition variables, the researchers were only provided information for BMI and BF%. For their height measurement, cadets were instructed to stand barefoot with their heels touching the back of the stadiometer, and cadre recorded the result to the closest half-centimeter. For body composition measurements, cadets were instructed to remove their shoes and socks prior to standing on the InBody 270.

Statistical Analysis

All analyses were performed using IBM statistical package for the social sciences (SPSS) (Version 24.0; IBM Corporation, New York, USA). Descriptive statistics (i.e., mean, standard deviation, minimum and maximum scores) were derived for all variables and separated by sex. A MANOVA model was used to determine differences between sexes in all anthropometric and

fitness variables. Means and standard deviations were derived for all variables included in analysis. In addition, a Pearson’s moment correlation was performed to determine the relationships between body composition and measures of muscular endurance and aerobic fitness and was separated by sex among ROTC cadets. The level of significance was set at $p < 0.05$ for all the statistical analyses. The correlation coefficient strength described as per Hopkins included an ‘r’ value that ranged from weak (≤ 0.39), moderate (0.40–0.69) or strong (≥ 0.70) relationships (Mukaka, 2012). Partial eta squared was utilized as a measure of effect size, and included an ‘ η^2 ’ value that ranged from small (≤ 0.05), medium (0.06-0.14), or large (≥ 0.15) (Stevens, 2012).

RESULTS

Descriptive statistics and MANOVA results for anthropometric measurements and fitness performance results for all male and female cadets are presented in Table 1. There were significant differences between male and female cadets for height, body mass, BF%, push-ups, sit-ups, and 2-mile run. On average, males were taller, heavier, and performed better on the fitness tests than female cadets. No statistically significant differences were found between sexes for BMI.

Table 1. Descriptive statistics and MANOVA results by sex in ROTC cadets

Measure	Male ROTC Cadets	Female ROTC Cadets	Measure	Male ROTC Cadets
HT (cm)	180.36 ± 7.29	164.34 ± 4.95 **	0.467	0.001
BM (kg)	76.81 ± 9.84	63.49 ± 6.94 **	0.248	0.001
BF% (%)	18.43 ± 6.52	25.59 ± 6.50 **	0.164	0.001
BMI (m/kg ²)	23.53 ± 2.42	23.43 ± 2.10	0.000	0.887
Push-ups (reps)	57.89 ± 15.01	35.50 ± 13.98 *	0.271	0.001
Sit-ups (reps)	59.72 ± 14.49	50.07 ± 17.89 *	0.062	0.037
2-mile run (seconds)	969.07 ± 142.65	1187.93 ± 124.09 **	0.289	0.000

*= $p \leq 0.05$, **= $p \leq 0.01$

The relationships between the measured anthropometric variables and fitness assessments for male ROTC cadets are displayed in Table 2. The results revealed no significant relationships between any anthropometric measures and fitness performance among male cadets.

Table 2. Correlations between anthropometric variables and fitness assessments in male ROTC cadets.

Variable		HT	BM	BF%	BMI
Push-ups (reps)	r	-0.195	-0.153	-0.081	-0.027
	p	0.147	0.257	0.551	0.842
Sit-ups (reps)	r	-0.141	-0.148	-0.162	-0.047
	p	0.294	0.271	0.228	0.731
2-mile run (sec.)	r	0.179	0.232	0.139	0.137
	p	0.184	0.082	0.304	0.309

The correlations between the measured anthropometric variables and fitness assessments for female ROTC cadets is shown in Table 3. Similar to the male cadets, no significant relationships were discovered between anthropometrics and fitness performance.

Table 3. Correlations between anthropometric variables and fitness assessments in female ROTC cadets.

Variable		HT	BM	BF%	BMI
Push-ups (reps)	r	-0.210	-0.283	0.053	-0.219
	p	0.418	0.271	0.840	0.399
Sit-ups (reps)	r	-0.183	-0.213	0.116	-0.158
	p	0.482	0.412	0.659	0.546
2-mile run (sec.)	r	-0.235	-0.091	0.062	0.275
	p	0.418	0.756	0.833	0.342

DISCUSSION

The purpose of this study was to determine if significant relationships existed between body composition and general fitness as measured by the APFT among male and female ROTC cadets. While significant differences in performance were observed between sexes, no significant relationships were found between anthropometric measurements and physical fitness performance for male or female cadets. These findings support those of previous research, in which BF% and BMI were not significantly correlated to APFT performance (Pierce et al., 2017; B. M. Roberts et al., 2023).

Sex-based differences in performance among ROTC cadets have been observed in several investigations with male cadets, in general, tending to achieve higher raw test scores when compared to female cadets (B. M. Roberts et al., 2023; D. Roberts et al., 2016). Similarly, significant differences in fitness test performance by sex were observed in this investigation, favoring male cadets on all measures, although the standard deviations suggest that fitter female cadets would outperform less fit male cadets. While previous research agrees with the findings of this research (Steed et al., 2016), whereby male ROTC cadets typically performed better in both the push-up and 2-mile run assessments when compared to female cadets, they do differ in regards to sit-up performance. There were no significant between-sex differences found in sit-up repetitions. This lack of a significant finding for the sit-ups has been found in tactical populations (B. M. Roberts et al., 2023; Yanovich et al., 2008) with research suggesting little difference between males and females in trunk endurance (Dawes et al., 2017).

Male cadets were, on average, taller, heavier, and had lower BF% in this study compared to their female counterparts. Furthermore, female cadets tended to have lower absolute upper body muscular endurance compared to males, which may partially explain the lower scores observed among females in push-up performance (Dada et al., 2017; B. M. Roberts et al., 2023). As such, females considering military service as a career path should physically prepare prior to enlistment or joining an ROTC program to reduce any sex-related differences. Additionally, ROTC programs should consider implementing ability-based training programs to capture and improve the fitness of all cadets, rather than using a “one-size fits-all” technique (Orr et al., 2016).

Previous research has reported significant positive relationships between BF% and 2-mile run time (i.e., lower BF% relating to faster run times), and significant negative correlations between BF% and push-up repetitions performed (i.e., lower BF% relating to more push-up repetitions) (Steed et al., 2016). However, as previously mentioned, no significant relationships between BF% and performance were observed in this cohort. It should be noted however, that 27% of cadets in this study were categorized as overweight or obese based on their BF% (Weir & Jan, 2019), and 23% of the cadets in this study were categorized as overweight or obese when using BMI measures. These findings are concerning, as greater BF% and BMI have been linked to an increased risk of injury within military populations (Anderson et al., 2015). Indeed, it is important that ROTC cadets as well as active-duty soldiers strive to attain and maintain healthy levels of body composition prior to commissioning to increase their overall health, well-being, and extend their occupational lifespan.

While the results of this study provide valuable insights into the impact of body composition on the physical fitness and general health of ROTC cadets, several limitations should be noted. First, this investigation was limited to one University located in the Midwest U.S. Compared to other regions; there is a higher indication of physical inactivity in the Midwest (Centers for Disease Control and Prevention, 2020). As such, research among similar populations from different geographic regions would be useful in determining the generalizability of these results. Second, while significant differences in performance were not observed based on body composition, it is unknown if cadets with greater BF% experienced greater levels of musculoskeletal and cardiovascular strain to complete these tasks in relation to their leaner counterparts. Since excess body fat creates extra physiological burden (Crawford et al., 2011), it stands to reason that cadets with greater relative amounts of non-functional mass may be required to work harder to compete the same task and potentially be at an increased risk of injury (Scott et al., 2015). Finally, in comparison to the male cadets in this study, there was a relatively low sample of female cadets. While this is reflective of the norm within the U.S. military population (Pierce et al., 2017), a larger sample of female cadets may further strengthen the relationships discovered in this investigation.

CONCLUSIONS

The purpose of this research was to investigate relationships between select body composition measures and measures of muscular endurance and aerobic fitness among male and female ROTC cadets as measured by the APFT. While significant differences in performance were observed between sexes, no significant relationships were found between anthropometric measurements and physical fitness performance for male or female cadets. ROTC programs should consider implementing ability-based training programs to capture and improve the fitness of all cadets, rather than using a “one-size fits-all” technique. It is important that ROTC cadets as well as active-duty soldiers strive to attain and maintain healthy levels of body composition prior to commissioning to increase their overall health, well-being, and extend their occupational lifespan.

PRACTICAL APPLICATIONS

Although the findings in this study do not indicate a significant relationship between body composition and fitness performance in the push-up, sit-up and 2-mile run (Steed et al., 2016; Thomas et al., n.d.), poor body composition and low levels of physical fitness could still have negative effects on long-term health and injury status. Therefore, it is important that ROTC cadets, as well as the general population that intends to enlist into service, strive to attain and maintain healthy levels of body composition prior to commissioning to increase their overall health, well-being, and extend their occupational lifespan. The significant differences in fitness between male and female cadets supports the use of ability-based training in pre-enlistment programs to account for these sex-related differences and minimize injury risk. Additionally, females considering military service as a career path should physically prepare prior to enlistment or joining an ROTC program to reduce any sex-related differences.

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EFFECTS OF ADAPTED PHYSICAL EXERCISE ON CHILDREN AND ADOLESCENTS WITH OVERWEIGHT OR OBESITY

Ina Marković¹, Ivana Delibašić¹, Slavka Durlević¹, Jovan Cvejić¹

¹Faculty of Sport and Physical Education, University of Novi Sad

Correspondence: Ina Marković,
master professor of physical education and sports,
University of Novi Sad, Faculty of Sports
and Physical Education, Novi Sad, Serbia.
E-mail: inamarkovic997@gmail.com

SUMMARY

Obesity or adiposity represents an excessive accumulation of fat in the body and an increase in mass by 10% or more compared to the ideal body mass. Today in the world, and in our country, obesity is one of the most common chronic diseases of children and adolescents. One of the main causes of obesity is reduced physical activity, and energy intake is significantly increased in relation to reduced activity. Accordingly, the goal of this research was a systematic review of previously published research that dealt with the effects of adapted physical exercise on children and adolescents with excessive body weight or obesity. When collecting previous research, the internet search engines "Google Scholar", "PubMed" and the academic network "ResearchGate" were used. Positive changes in the morphological status of children and adolescents can be caused by the equal action of adapted physical exercise and controlled nutrition. Due to its enormous importance, physical activity is a proven preventive measure in the fight against obesity and accompanying diseases, which is necessary and must be present in sufficient quantity in all ages, especially in children and adolescents. Physical activity and exercise as well as proper nutrition during childhood and adolescence, along with taking professional preventive measures to reduce obesity, is essential for the future of the population.

Key words: influence, adiposity, adapted physical activities, younger age.

INTRODUCTION

The human body is built for activity, not rest. Physical activity is one of the basic human movements and the most important health determinant related to lifestyle. The World Health Organization (WHO) defines physical activity as any voluntary activation of the body that is caused by the skeletal muscles during which a certain amount of energy is consumed (World Health Organization, 2020).

Over the years the human body has evolved and evolved into a complex organism capable of performing a vast number of motor tasks. In the last few decades, there have been marked changes in the way of life around the world and in all age categories of the population. The modern way of life has resulted in reduced physical activity and increased energy intake (Ignjatović and Cvecka, 2017). An inevitable consequence of the modern way of life and work in an industrialized society creates serious consequences for the health of all age categories of the population (Berentzen et al., 2014). The three most common causes of the occurrence of numerous diseases, which are the most common causes of death today, and which are increasingly affecting young people, are stress, lack of movement and poor nutrition (Suwarsi and Elizabeth, 2023). Today's civilization, and what is increasingly present in the younger population, is characterized by hypokinesia and overweight, which are mutually correlated (Miles, 2007; Carbone et al., 2019). When talking about the younger population, it gains special weight. The free time of young people and children is increasingly used for activities that require almost no muscular effort, which has led to a lack of movement and an unhealthy lifestyle (Friedenreich et al., 2021). Also, like other countries, Serbia, unfortunately, cannot boast of the quality of life and health, since it ranks first in Europe in terms of mortality from diseases of the cardiovascular system. A particularly disturbing fact about such data is that health vulnerability begins at the youngest ages (Đokić et al., 2011; Knežević and Jandrić-Kočić, 2023). According to research data conducted by the Institute for Public Health "Dr. Milan Jovanović" (2006), almost one fifth of children and youth aged seven to 19 in Serbia (18%) are moderately overweight and obese. The increase in the number of obese children in Serbia is a consequence of bad eating habits and insufficient physical activity. This problem does not occur only in Serbia, but also in other countries. At the global level, there is a justified concern that the younger population is increasingly living a sedentary lifestyle, that they are increasingly obese and that they are adopting more and more bad habits that endanger their health (Carson et al., 2010; World Health Organization, 2013; Southcombe, 2023).

Obesity or adiposity is an excessive accumulation of fat in the body and an increase in body weight by 10% or more compared to the ideal body weight (Haslam, 2007; Barton, 2012; Ng et al., 2014; Malenica and Meseldžić, 2022; Southcombe, 2023).). By definition, it is a pathological condition (when the possibility of increased bone and muscle mass and edema of different etiology is excluded), caused as a result of caloric imbalance (Barton, 2012; Lešović et al., 2018; Daniels et al., 2005; Abiri, 2023) . Adiposity is one of the most common chronic diseases of children and adolescents. The trend of increasing prevalence of obesity in children leads to an increase in the risk of associated endocrinological, metabolic, cardiovascular,

respiratory and other health disorders, a decrease in the quality of life and the expected average length of life in the following generations of adults (Lešović et al., 2018). Children's obesity is mainly related to eating habits: irregular eating and skipping meals, choice of foods and excessive intake of certain foods (snacks, dough, sweets, carbonated drinks), volume and frequency of physical activity, factors from parents and the influence of educational institutions (Faik et al., 2017; Rose et al., 2021). As the lack of regular physical activity in children's nutrition is always second in importance, it is clear why regular physical activity is insisted on from an early age. The level of physical activity among children depends on individual influences, as well as on the influence of parents and the environment, and there are gender differences (boys are generally more physically active than girls), as well as age differences (children are more active than adolescents) (Bauman , 2012). The level of physical activity is also influenced to a certain extent by economic conditions, proximity to places for play and recreation, parental support, socio-economic status and education of parents and other factors (Zdravković et al., 2009). Regular physical activity prevents a sudden increase in body weight and the onset of obesity-related diseases (Suwarsi and Elizabeth, 2023). The combination of a dietary program of nutrition and physical activity can significantly influence the reduction of body weight and the change in metabolism, that is, the mechanism of fat deposition in the body (Mitić, 2011; Sente, 2020). Therefore, the goal of this research was a systematic review of previously published research that dealt with the effects of adapted physical exercise on children and adolescents with excess body weight or obesity.

RESEARCH METHODS

In this paper, the following methods were used: selection, systematic, theoretical analysis and comparison of the content of previous scientific and professional literature. All procedures relevant to the identification of papers were carried out in accordance with the Preferred Reporting Items for Systematic Reviews (PRISMA) statement (Page et al., 2021).

Inclusion criteria

The following inclusion criteria were defined for the selection of works to be included in the final analysis: (1) original scientific works; (2) works not older than 2000; (3) papers written in English and Serbian; (4) sample of respondents - obese younger age category (10-18 years).

Exclusion criteria

Based on the following criteria, papers were excluded from further analysis: (1) papers older than 2000; (2) works that are not written in English or Serbian; (3) inadequate sample of respondents; (4) works in which the results are not adequately presented or the parameters required for further analysis are missing.

Paper search strategy

When collecting previous research, the internet search engines "Google Scholar", "PubMed" and the academic network "ResearchGate" were used. The following keywords were searched in English individually or in combination: effect, adapted physical exercise, obesity, younger age, and keywords in Serbian individually or in combination: effect, adapted physical exercise, obesity, younger age. In the phase of collecting previous research on adapted physical exercise for obese people in the age category of 10-18 years, the initial database of research papers was made up of 37 papers that met the basic search criteria by title content. A further selection of works was carried out, where, after reading and analyzing the abstracts, 22 works were eliminated, and 15 works were singled out that meet narrower search criteria (Figure 1).

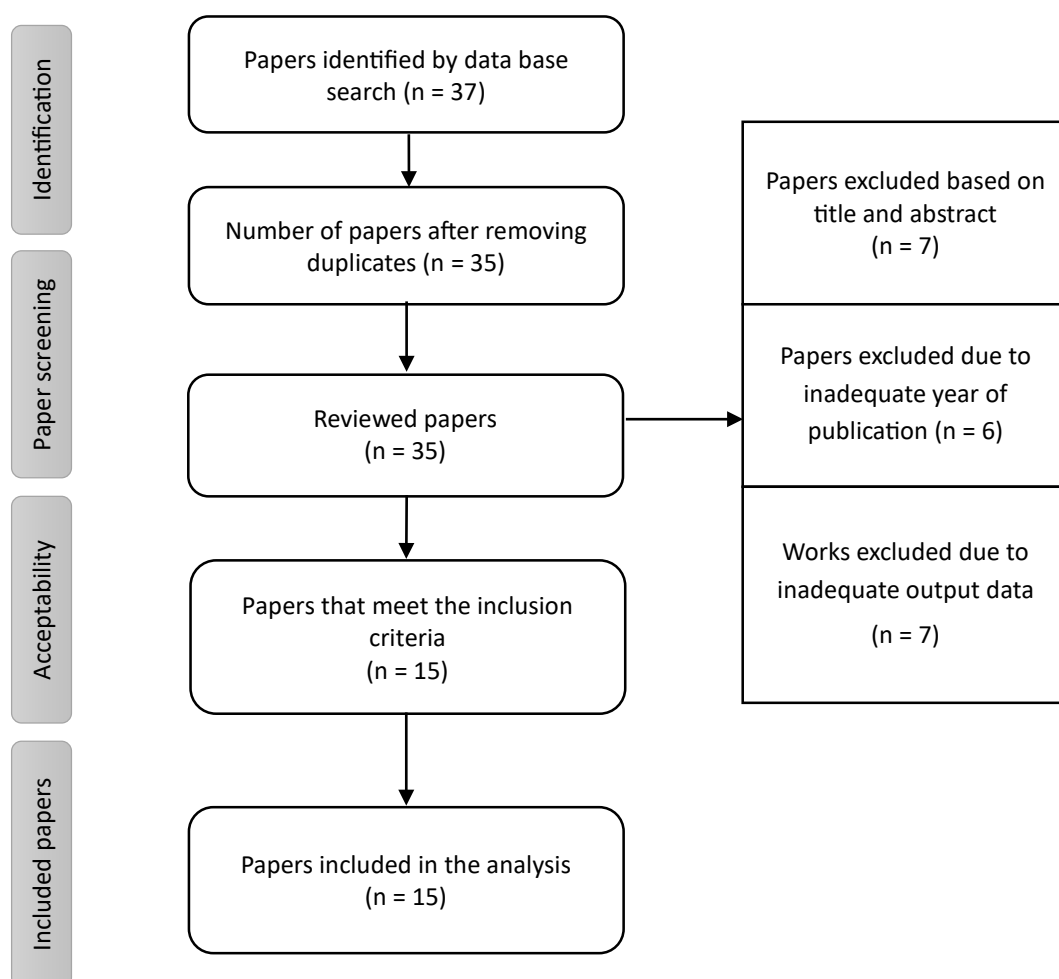


Figure 1. Schematic representation of the selection of collected works

RESULTS

The final analysis included 15 papers that were compiled and analyzed based on the above-mentioned methods. The results of the systematic review of the previous literature are shown in Table 1.

DISCUSSION

In the last three decades, there has been an increase in the prevalence of obesity in all age categories of the population, but not only in Serbia, but it is widespread throughout the world. Obesity is recognized as one of the most important public health problems and challenges in the 21st century. For this reason, numerous studies deal with problems related to obesity, hypokinesia, as well as their origin. Also, in addition to the basic problem of today, a considerable number of research aims to examine which factors and to what extent they influence the increased number of obese people, but also deal with obesity prevention. Certain studies have determined that children whose parents are both obese have a higher risk of obesity than those whose parents are not obese (Magarey et al., 2003; Fábryová, 2015; Knežević and Jandrić, 2023). In addition to hereditary factors, lifestyle changes that have occurred in the last few decades are one of the most significant factors affecting the increased number of obese people. Hypokinesia is caused by bad lifestyle habits and fast food (Ferreira et al., 2016; Nikolić, 2019). Obesity in younger ages, children and adolescents in the modern era is taking on the character of an epidemic, with which a large number of researchers agree (Suwarsi and Elizabeth, 2023; Pinho et al., 2022; Radovanović, 2017; Berentzen et al., 2014). The primary public health problem is the obesity epidemic, and thus the increased risk of many diseases (Zalewska et al., 2022). Diseases associated with excess body weight, which were previously associated only with adults, are now also present in younger categories of the population (Peco-Antić, 2009; Pelicic et al., 2021). The most common consequences of obesity in childhood and adolescence are the cardiovascular system (hypertension, dyslipidemia), the endocrine system (insulin resistance, impaired glucose tolerance, irregular menstruation), mental health (depression), but are increasingly present in respiratory diseases. (Pelicic et al., 2021; Jocić Stojanović et al., 2015; Jović et al., 2018; Jandric-Kočić, 2020; Mayer et al., 2006; Ferreira et al., 2014). Obesity as a phenomenon is easily noticeable and easily diagnosed clinically. Obesity occurs as a result of an imbalance of energy consumption and energy intake (Stojanović et al., 2016).

Research conducted by Mitić (2011) and Al-Ghamdi (2013) showed that watching TV is an important and significant risk factor for obesity in school-aged children. To similar results, in their research Berentzen et al. (2014) indicate that watching TV, with excessive and frequent consumption of sweets and snacks, is one of the most significant risk factors for obesity.

Also, in research conducted by Mitić (2011) and Robinson (2001), in addition to watching TV as one of the causes of obesity, he found that obese children go to bed later and get up earlier in order to have more time to watch TV and playing games. Nikolić and Pandurević (2018) in their sample of 70 respondents, as many as one third were inadequately fed, and one fifth of the sample of respondents was overweight. In addition to free time spent in front of the TV, computer, and poor diet, there is another risk factor for obesity, which is reduced physical activity (Reinehr et al., 2010). Also, Reinehr et al. (2010) in their research point out that children's physical activity has significantly decreased in recent years, energy intake has significantly increased in relation to reduced activities. A considerable amount of

research deals with the effects of adapted physical exercise on overweight people. Mayer et al. (2006) conducted an experimental study lasting six months. Regular physical exercise in overweight individuals restores the function of the cardiovascular system and improves anthropological status (Mayer et al., 2006; Sente et al., 2012). Similar results were achieved in a one-year experimental study by Blüher et al. (2014). Children and adolescents who are more active, around 45-55 minutes have a normal body weight, while children who spend less time on physical activities (>18 minutes per day) become obese (Mitić, 2011; Ferreira et al., 2016). A more recent study by Malićević (2022) found that the prevalence of overnutrition is significantly lower in children who regularly play sports, compared to children without any organized physical activities. Twelve-week recreational adapted indoor soccer programs improved strength and anaerobic capacity in obese boys (Pinho et al., 2022). Research conducted by Sente et al. (2012), Carson (2015) and Malićević (2022) show that adapted physical exercise in combination with a dietary diet led to a reduction primarily of total body mass. In his research, Radovanović (2017) determined that strength training is an effective way of exercising to achieve a healthier body composition of overweight children and adolescents, but with an adapted exercise program, because overweight children and adolescents often experience aerobic physical activities as an inconvenience or discomfort. In their research, Suwari and Elizabeth (2023) did not find that there is a statistically significant difference between the level of physical activity and quality of life in overweight adolescents.

Numerous studies followed the official announcements of the world's leading professional and health organizations indicating that if performed correctly and dosed, strength training can have a positive effect on children and adolescents who are overweight (Behm et al., 2008; Faigenbaum et al., 2009). All previous research points to the importance and positive effects of adapted physical exercise with a controlled diet in reducing body weight in obese people.

CONCLUSION

The prevalence of childhood obesity is increasing worldwide, especially in developed industrialized countries, but also in many developing countries. Physical activity and exercise are an integral and irreplaceable part of non-drug obesity therapy. It should be emphasized that adapted physical activity is not the only process that leads to a rapid reduction of body weight in children and adolescents, but in combination with proper nutrition, it facilitates the achievement and maintenance of the achieved therapeutic effect. Positive changes in the morphological status of children and adolescents, body composition can be caused by the equal action of adapted physical exercise and controlled nutrition. Due to its enormous importance, physical activity is a proven preventive measure in the fight against obesity and accompanying diseases, which is necessary and must be present in sufficient measure in all ages, especially in children and adolescents. Physical activity and exercise as well as proper nutrition during childhood and adolescence, along with taking professional preventive measures to reduce obesity, is essential for the future of the population. Regular physical activity and exercise for children, adolescents and adults should be an integral part of everyday

life in combination with a proper and healthy diet, which represents an effective investment for future generations.

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TABLES

Table 1. Overview of previous literature included in the analysis.

Num.	References	Sample			Num. Of groups	Research objective	Experimental treatment		Results and conclusions
		No.	Year	Sex			Exercise program, measuring instrument, duration and frequency		
1.	Meyer et al. (2006)	67	14±0,7			This study aimed to evaluate the effect of a 6-month exercise program in obese children.	The experimental treatment lasted 6 months.	This study documented increased IMT, impaired endothelial function, and various elevated cardiovascular RFs in young obese individuals. Regular exercises restore function.	
2.	Reinehr et al. (2010)	663	4-16			The aim was to identify predictors of long-term changes in body mass index (BMI) following a lifestyle intervention.	Changes in BMI during the five-year program were analyzed.	Younger age was associated with the best long-term outcome after participation in a lifestyle intervention, supporting the need for early intervention in childhood obesity. Children aged 8 to 10 may need a modified intervention, as BMI-SDS increased more in older children in the long term.	
3.	Đokić et al. (2011)	810	9-12±0,5	404 w 406 w		Comparison of obesity between third and sixth graders.	Method of comparison.	Overnutrition and obesity in boys in the third and sixth grades is represented to the same extent, while there are noticeable deviations in girls in overnutrition in older grades.	
4.	Mitić (2011)	4511	7-9 ±0,5	2237w 2274 m	2	The aim of one study was to examine whether there are differences in the lifestyle of obese children compared to those who are not obese.	A questionnaire about how physically active children are was filled out by parents and anthropometric measurements were taken. BMI was measured and based on that, the children were divided into two groups: obese and normally well-nourished. Variables used to examine lifestyle were: time spent watching TV, computer, playing, studying, and time of getting up and going to bed were recorded.	The results showed that obese children go to bed later and wake up earlier, and spend more time watching TV, using the computer and studying, and less time playing.	
5.	Sente et al. (2012)	136	13±0,6	76 w 60 m		Determining and quantifying the effects of reduction therapy in obesity.	Study lasting 3 months. The 12-week training program was specially designed by the researchers.	The results of the applied univariate and multivariate analyzes in the final compared to the initial measurement in the examined group of obese children show that the application of the program of physical exercise and controlled diet resulted in a significant reduction of all anthropometric parameters, as well as anthropological indicators of the state of nutrition.	
6.	Al-Ghamdi (2013)	397	10-14			The aim of the study is to examine the association between TV viewing and obesity in school-age children in Saudi Arabia.	The study was conducted in the period from February to April, the instrument used was a 20-item questionnaire.	The results obtained from the research showed that watching TV is an important significant risk factor for obesity in school-age children.	

7.	Ferreira et al. (2014)	133	5-17		The aim of the study was to determine whether obesity is associated with poor physical fitness and impaired lung function in children and adolescents, as well as to correlate lung function with the results of the six-minute walk test.		In this study, the obese group walked shorter distances and showed lower values in some lung function markers. However, there is no relationship between their physical condition and these test results. Therefore, we cannot say with certainty that poor physical performance is the result of impaired lung function.	
8.	Blüher et al. (2014)	64	7-18		The aim was to analyze their relationship with weight status and metabolic risk.	The effect of exercise and lifestyle intervention during one year on irisin, adipokines (leptin, adiponectin, resistin) and inflammatory markers (C-reactive protein (CRP), soluble tumor necrosis factor receptor II (sTNFR-II),	A one-year lifestyle intervention program is associated with an improvement in anthropometric and metabolic parameters and leads to an increase in irisin levels in obese children.	
9.	Berentzen et al. (2014)	1447	11-14		The aim of the research was to examine the association between television viewing and snacking with adiposity.	Instruments that were used: blood pressure, cholesterol, glucose.	Watching television with snacks has a significant impact on adolescent overweight.	
10.	Radovanović (2017)				A systematic review of previously published research that dealt with the effects of strength training on body composition, muscle strength and psychosocial status of overweight or obese children and adolescents.	Original and review papers, as well as meta-analyses, from the most important electronic databases (MEDLINE, Web of Science, Embase, Scopus, SPORTDiscus, ProQuest, Cochrane library) were searched and included in the review.	Strength training is an effective way of exercising to achieve a healthier body composition in children and adolescents with excessive body mass or obesity, through an increase in lean body mass and a decrease in the percentage of fat tissue, with potentially positive effects on their psychosocial status.	
11.	Nikolić & Pandurević (2018)	70	10	38 w 32 m	The aim of this paper is to determine the nutritional status of school-aged children aged 10 years in relation to their level of physical activity.	Body mass was measured with a medical digital scale with an accuracy of 0.1 kg. A standard questionnaire was used to assess physical activity, socioeconomic parameters and eating habits. The questionnaire was composed of questions based on which data were obtained about the time spent in some physical activity during seven days with the answers: never, occasionally, often and always.	The results obtained from this research lead to the conclusion that one third of the examined sample of children is inadequately fed, and that as many as 20% of children are overweight and obese.	
12.	Sente (2020)		11-14±0,5		In order to check the effects of multidisciplinary treatment, all investigated parameters were measured at three time points.	The study lasts 3 months.	Descriptive results in all three groups of investigated parameters show statistically significant changes in all subjects in all three time periods, as well as the results of one-factor univariate analysis of variance for repeated measurements for sig.<0.05.	
13.	Malićević (2022)	7880	9-15	2893 FA 4987 FN	2	The main goal of this study was to investigate the prevalence of excessive nutrition in representative samples of children who regularly play sports (more than 2 years and more than 3 hours per	Examined the differences between the prevalence of nutritional levels in the studied groups obtained by applying the definitions of the World Health Organization, the Centers for Disease Control and Prevention of the United	It was found that the prevalence of overnutrition is significantly lower in children who regularly play sports, compared to children without any organized physical activities.

				<p>week) and children without any organized physical activity, aged 9 to 15 years.</p>	<p>States of America, as well as the criteria of the International Working Group on Obesity.</p>	
14.	Pinho et al. (2022)	13	8-12	<p>The purpose was to measure the effects of a 12-week recreational indoor soccer program on cardiometabolic risk and individual responses to cardiometabolic risk factors in obese younger individuals.</p>	<p>Anthropometric characteristics, cardiorespiratory fitness, metabolic profile, individual responses to maximal oxygen intake (VO₂peak), maximal exercise (V_{max}), blood glucose, insulin, HOMA-IR, LDL-C, HDL-C, TC and TG were measured.</p>	<p>Twelve-week recreational indoor soccer programs were able to improve maximal strength and anaerobic capacity and maintain cardiometabolic risk factor levels in obese younger individuals.</p>

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111 YEARS FOR 1 SECOND

Dragan Ž. Perišić¹, Voja M. Milosavljević¹ & Željko M. Rajković²

1 College for Football Coaching and Sport Management Football Academy Belgrade, Department for Football Coaches, Belgrade, Serbia.

2 University of Belgrade, Faculty of Sport and Physical Education, Department for Individual Sports, Belgrade, Serbia.

Correspondence: Ass prof PhD Željko Rajković,
University of Belgrade, Faculty of Sport and Physical Education.

Blagoja Parovića 156, 11030, Beograd, Srbija.
+381 65 2009 026; rajkoviczeljko@yahoo.com.

SUMMARY

The most attractive of all athletic disciplines is the 100m sprint for men. This discipline has its long development, while the world record has been recorded by International Amateur Athletic Federation only just for 111 years. During this period, the World Record was broken 67 times, and Donald Lippincott's record from 1912 (10.6s) was improved by "only" one second and now stands at 9.58s (Usaine Bolt, 2009). This article analyzes the progression of the World Record at 100m, from the moment when records were officially kept, until today, but also gives a prediction about its further development and importance. For easier interpretation of the results, the progression of the 100m world record for men was considered in three time periods: The first period - from 1912 to 1945, the second period - from 1946 to 1983, and the third period - from 1983 to 2023. Effect of recording of the world's best 100m sprint times for men is significant and multifaceted, while including all segments of athletics in a multifaceted connection, it also has mutually opposing prognostic qualities. In the near future, due to sports expert analysis, it is not expected to break the world record in the discipline of 100m sprint for men. On the contrary, a deeper philosophical analysis provides a projection of rule changes, multiple mitigations, as well as aggressive changes to the human body in order to enable new records and indirectly, propagandistically extend the age of modern society and hide the twilight of civilization that is ahead of us.

Key words: athletics, sprint, 100m, world record, World Championships, Olympic Games

INTRODUCTION

The word athletics is of ancient Greek origin and means to compete, fight in strength, speed, etc. It includes natural forms of movement: walking, running, throwing, jumping and their combinations in the form of heptathlon and decathlon. Athletic disciplines can be performed everywhere, on each, or on specially arranged arenas and halls. Athletics is also the main part of the program at the Olympic Games (Jotov, et al., 2022), but also an important part of the physical education program at all levels of education (Stefanović, 1992a). Of the aforementioned movements, walking and running represent the simplest and most natural forms of movement (Despot, 1951).

Already in the tribal community 3100 years before Christ, tribal competitions were known in Kyrgyzstan and Turkmenistan, while a large number of evidences of the initial forms of athletics were left by the Phoenicians. (Stefanović, 1992a). After the Egyptians, who left traces of athletics on the pyramids, the ancient Greeks left a specific mark through numerous individual competitions, but also at several types of games (at the Homeric, Pythian, Isthmian, Nemean and Olympic Games) dedicated to fallen heroes or gods. At the First Olympic Games, held in 776 BC, the only sprinting discipline on the program was a one-stadium race 192.27m (Ćirić, 1996). The military origin of sprinting disciplines, but also their application, can be linked to the actions of archers during warfare, where a short assault of infantry was applied after a platoon of arrows from the opposing army, in order to open the battle and disable the enemy's action at a distance. The next development leap of sprinting disciplines takes place in England with the movement of modern sports and the formation of the International Amateur Athletic Federation (IAAF) (Ilić, Mijatović, 2006).

The simplest translation of the English word "record" would mean note or inscription (Grujić, 1972). A somewhat deeper interpretation includes a thing that is evidence of the past, especially a record kept in writing or some other permanent form (Grujić, 1972). Something closer to the sports interpretation is the definition that makes up the sum of the past achievements or performance of a person, organization or thing (Vujaklija, 1980). A world record is usually the best global and most important performance ever recorded and officially verified in a particular skill, sport or other type of activity.

The goal of the research is to analyze the progression of the men's 100m world record, from the moment when records were officially kept, until today, but also to prognosticate its further development and importance.

METHODS

The article used the method of theoretical analysis of the content of scientific and professional literature, and the causal method, with the systematization of the author's professional experience in the field of physical education, sports and recreation, with the application of logical inductive and deductive reasoning.

RESULTS

At the beginning of the 19th century, the measurement of time in athletics begins, where the victory of a certain Berkeley in 1803 on the 440-yard track is recorded in a time of 56.0 seconds (Stefanović, 1992a). Timing in athletics was made possible by the invention of George Graham, who in 1721 added a third needle so that they could count the seconds (Britten, 1894). The first measured races, however, were not athletic events, but horse races in England in 1731 (Larrosa, 2016). Human races first began to be timed at Oxford University in 1850, taking times with a resolution of a $\frac{1}{2}$ second, using the chronometer model invented by Abraham-Louis Breguet (<https://www.breguet.com/>). Races would not be timed with resolutions as high as $\frac{1}{5}$ of a second until 1862 (Larrosa, 2016). The first electronic timekeeping models that counted hundredths of a second appeared in 1902. It was Heuer in 1916 that patented a chronometer with an accuracy of $\frac{1}{50}$ of a second (<https://www.tagheuer.com>). Heuer's hegemony over race timing at the Olympic Games ended in 1928, when Longines manufactured a pocket stopwatch that could measure with a precision of $\frac{1}{100}$ of a second. In several disciplines a little later, the same time was recorded for both first and second place. At this point photographic cameras (photo finish) placed at the finish line began being used to record race results (<https://timingsense.com/en/>).

Thus, the parallel development of sports and technology enables a new asset of modern society, such as timing in various sports, as well as setting world records. The world record (WR) fascinates both the competitors and the audience. It represents the limit of human possibilities to which elite athletes strive the most. Throughout the history of athletics there has always been something unique and magical about setting a world record. Measuring results and "breaking through" the limits of human capabilities are of great importance for the development of athletics (Perišić, et al., 2022).

The 100m race is the most popular and prestigious sprint race in outdoor athletics. The 100m sprint is often an indicator of speed of movement, and the world record holder is labeled as the fastest man in the world (Stefanović, 1992b). In sprint running for men, at the World Championships in Berlin in 2009, Usain Bolt, breaking two world records, moved the "dream limit", which is still unattainable, at 100 and 200m. After those two fantastic world records (9.58s on 100m and 19.19s on 200m) many asked the question of human limits in sports. Based on an analysis of thousands of sprint races between 1920 and 2007, biologist Mark Denn, from Stanford University in California, found that the result 9.48s, final limit in men's 100m sprint (Perišić, 2011).

After the race in Beijing, Glenn Mills, Bolt's coach, stated that Bolt could achieve a time of 9.52s that he didn't start rejoicing before crossing the finish line and thus slowed down the speed of movement he achieved until the 60th meter of the race (Perišić, 2011). Bolt told the Belgian media that his goal is to lower the world record in the 100m from the current one 9.58 to 9.40 seconds. He believed that it was the ultimate limit, which could no longer be broken (Perišić, 2011). Fourteen years have passed since this statement by Bolt, which is the longest time since the installation of an WR. Have we already reached the limit in this hard-to-beat

athletic discipline? French biomechanics and sports researchers who studied human psychophysical abilities believe that athletes in most athletic disciplines have "used up" as much as 99% of human potential, and in some, even 99.7% (Perišić, 2011).

In a period of 111 years (1912-2023), 67 WRs were achieved, and Donald Lippincott's record from 1912 (10.6s) it was improved by "only" one second (table 1) and now it is 9.58s (Usain Bolt). There are also unofficial world record records as far back as 1891 to 1912 with 19 record holders from 8 countries moving the record from 10.8s to 10.5s. This article analyzes the progression of the men's 100m WR, from the moment when the IAAF officially keeps records, until today with the intention of "tearing out of oblivion" the fastest people in the world. For easier interpretation of the results, the progression of the 100m WR for men was considered in three time periods: The first period - from 1912 to 1945, the second period - from 1946 to 1983, and the third period - from 1983 to 2023 (Perišić, 2011). The first period lasts from the creation of the IAAF, i.e. from when world records were officially kept until the end of the Second World War, (with a break in the organization of competitions in a large part of the world) also with a turning point in the development of technology, training, and sports results. The second period is marked by the expansion of athletics in the world with the organized Olympic Games and continental championships and ends with the year of organization of the first World Championship in Athletics. The third period was marked by the significant influence of the organization of the World Championships in Athletics, which is very important for the development of results because, in addition to the Olympic Games, it represents the most important sports competition for athletic disciplines.

First period – from 1912 to 1945

It is the period since the creation of the IAAF, i.e. from when world records were officially kept until the end of World War II (a period that lasted 33 years).

The first WR in the 100m in men's competition, which was recognized by the IAAF, was achieved by Donald Lippincott (USA) at the Olympic Games (OG) in Stockholm in 1912 by time 10.6s. The first record was followed by a period of eight years without WR (due to war events during the First World War), so that Jackson Scholz (USA) equaled it at the international meeting in Stockholm in 1920, and in 1921 Charley Paddock (USA) improved WR for 0.2s (10.4s). A new period of eight years without WR followed, until 1929, when Eddie Tolan (USA), on August 8th in Stockholm and August 25th in Copenhagen, equaled WR (10.4s). Amsterdam Olympic winner Percy Williams (CAN) set the WR in 1930 by time 10.3s. It is interesting to note that at the 1932 Los Angeles Olympics, Eddie Tolan and Ralph Metcalfe (USA) achieved the same time in the 100 m final race (10.3s) and equaled Percy Williams' record, but only Eddie Tolan WR was ratified. In the following years, this score was equaled six more times: Ralph Metcalfe in 1933, Eulace Peacock (USA), Christiaan Berger (HOL), Ralph Metcalfe (twice) in 1934 and Takayoshi Yoshioka (JAP) in 1935. Jesse Owens (USA) achieved the time 10.2s in 1936 equaled by Harold Davis (USA) in 1941. In the observed period (until World War II), 15 WRs were broken, 12 of which were achieved by American sprinters, and one each by Canadian, Dutch and Japanese sprinters. In the period 1912-1945, WR was improved for 0.4s,

from 10.6s to 10.2s. The most valuable results in this period were achieved by Ralph Metcalfe (USA) and Eddie Tolan (USA), who each set 3 WRs in the 100m running discipline, and Jesse Owens (USA), who in 1936 achieved 6 WRs in one day (Hymans, 2020). The most important sprinters of this period were:

Percy Williams the Canadian WR holder, who surprised everyone by winning the 100m and 200m races at the Amsterdam Olympics, at only 20 years old. Although he tied WR in the 100m race, after the Games, the American public believed that Williams had accidentally won the medals and invited their best runners to compete against him in exhibition competitions. In a series of 21 races, Williams won as many as 19 races and confirmed that he is by far the fastest sprinter in the world. After serious hamstring injuries, he participated in the Los Angeles Games in 1932, and was eliminated in the quarterfinals, after which his career ended (www.britannica.com/biography/Percy-Williams).

Thomas Edward Tolan, was the first African-American sprinter to win gold medals at the 1932 Los Angeles Olympics in the 100m and 200m events. In March 1935, Tolan won the 75, 100 and 220-yard races at the World Professional Championships in Melbourne, becoming the first man to be the fastest sprinter in both competitions (amateur and professional). During his sprinting career, Tolan won 300 races and lost only 7 (<https://michigansportshof.org/inductee/eddie-tolan/>).

Ralph Metcalfe Harold was the fastest athlete in the world from 1932 to 1934. He became the first man to win the NCAA 200m title three times in a row. At the 1932 Los Angeles Olympics, after viewing the photo-finish in the 100m final, Metcalfe received a silver medal and Tolan a gold medal (both with WR 10.3s). In the final race at 200m, he won a bronze medal. At the next Olympics in Berlin in 1936, Metcalfe again competed in the 100m and was second behind Jesse Owens, and won the gold medal as part of the winning relay team in the event 4x100m (<https://www.britannica.com/biography/Ralph-Metcalfe>).

James Cleveland "Jesse" Owens is an American athlete, who is remembered for his quadruple triumph at the Olympic Games in Berlin in 1936. He won on August 3th in the 100m race, on August 4th in the long jump, on August 5th in the 200m race, and on August 9th, 1936, as a member of the relay team (Jesse Owens, Ralph Metcalf, Foy Draper and Frank Wyckoff) he triumphed in the race, 4x100m. That feat remained unsurpassed for 48 years, until 1984 and the Olympics in Los Angeles, where his feat was repeated by Carl Lewis. A feat that entered the history of athletics was performed by Jesse Owens on May 25th, 1935, at a track and field meet in Ann Arbor, Michigan. Then he broke 6 world records in 45 minutes: 15:15h – 100 yards; 15:25h – long jump; 15:45h – 220 yards and 200 m; 16:00h – 220 yard hurdles and 200m hurdles (www.history.com/this-day-in-history/owens-wins-4th-gold-medal).

Second period – from 1946 to 1983

It is a time period of 37 years, from the end of the Second World War to the holding of the First World Championships in Athletics. The WR set by Jesse Owens in 1936 with a time of 10.2s was tied 11 times between 1936 and 1956. Records were achieved by: Harold Davis (USA)

1941, Lioyd LaBeach (PAN) and Norwood Ewell (USA) 1948, McDonald Bailey (GBR) 1951, Heinz Futerrer (FRG) 1954 and 1956, Bobby Morrow (USA) three times and Ira Murchison (USA) twice. In 1956, 20 years after Owens' WR (10.2s), Willie Williams (USA) managed to beat it by 0.1 seconds. The WR achieved by Williams (10.1s) was equaled by: Ira Murchison and Leamon King twice in 1956 and Ray Norton (USA) in 1959. It is an interesting fact that in 1956 as many as 9 WRs were achieved, of which Ira Murchison (USA) and Bobby Morrow (USA) scored 3 each, Leamon King (USA) 2 and Willie Williams (USA) 1. Armin Hary (FRG) achieved a 10.0s WR in 1960, which was tied by 1968: Harry Jerome (CAN) 1960, Horacio Esteves (VEN) 1964, Bob Hayes (USA) on OG in Tokyo 1964, Jim Hines (USA) 1967, Enrique Figuerola (CUB) 1967, Paul Nash (RSA), Oliver Ford (USA), Charles Greene (USA) and Roger Bambuck (FRA) 1968. Another year that is similar to 1956 in terms of the number of WRs achieved is 1968, in which 8 records were achieved. What makes this year different from the others is the fact that 5 WRs were achieved in one day. At the US National Team OG qualifier held on June 20, 1968 in Sacramento, Charles Greene and Roger Bambuck posted identical times of 10.0s in the fourth qualifying group, tying the WR. Two hours later, in the first semi-final race, Jim Hines and Ronald Smith improved the record to 9.9s. Just fifteen minutes later, in the second semi-final race, Charlie Green equaled the previous record and achieved his second WR of the same evening. At the 1968 Mexico Olympics, Jim Hines equaled WR 9.9s (electronically measured 9.95s). In subsequent years this time was achieved by Eddie Hart (USA) and Rey Robinson (USA) in 1972, Steve Williams (USA) in 1974, Silvio Leonard (CUB) and Steve Williams - twice in 1975, Steve Williams, Harvey Glance (USA) twice and Donald Querrie (JAM) in 1976. In the 100m, men achieved 38 WRs in the period 1946–1983. The first WR was achieved with a result of 10.2s, to be equaled 8 more times. That WR was beaten by 10.1s, which was tied 4 more times. The record breaking continued with a result of 10.0s (equaled 9 more times) and at the end of this period a WR was achieved with a result of 9.9s (first time under 10 seconds), which was equaled 13 more times. In the men's competition, out of 38 WR, American sprinters achieved 28 WR. Steve Williams scored the most - 4 WRs, 3 WRs each were scored by: Ira Murchison, Bobby Morrow and Jim Hines, and 2 WRs each by Leamon King, Charles Greene and Harvey Glance. In the period 1946–1983, the WR improved by 0.3 seconds from 10.2s to 9.9s (Hymans, 2020). The most important sprinters of this period were:

Steve Williams (USA) was a four-time world record holder at 100 m in the mid-1970s. He achieved his first WR in 1974, followed by two records in 1975 and one record in 1976. Due to injuries, he missed the Olympics in 1972 and 1976. He won the World Cup in 1977. (<https://worldathletics.org/athletes/united-states/steve-williams-14355979>).

Jim Hines is an American athlete, the first man to run 100m under 10 seconds (9.95s), in the final of the OG in Mexico City. At the 1968 Olympics in Mexico City, in addition to the gold medal in the 100m race, Haynes also won the gold medal in the 4x100m relay race (<https://olympics.com/en/athletes/james-ray-hines>).

Valeriy Pilipovich Borzov, athlete of the URS, was an Olympic and European champion and a meritorious master of sports. He participated in the Olympic Games in Munich in 1972 and in Montreal in 1976, where he won medals in the 100m, 200m and 4x100m relay races.

The double victory in the sprint at the Munich Olympics in 1972 is the brightest moment of his career. After the victory in the 100m, it seemed that the disqualification of the two best sprinters from the USA, Ray Robinson and Eddie Hayes, due to the delay in the start, made Borzov's path to the gold easier. However, in the 200m race, Borzov beat both of them in a direct competition, proving that he was the fastest sprinter at that moment. In addition to his Olympic successes, he was the European champion in the 200m race (1971), three-time European champion in the 100m (1969, 1971, and 1974), six-time European indoor champion in the 60m race, once in the 50m race and multiple URS champion. At the Montreal Olympics in 1976, he won bronze medals in the 100m and 200m races. At the end of his career, he was the president of the Olympic Committee of Ukraine from 1991 to 1999, and from 1994 he was a member of the IOC and the Ukrainian Minister of Youth and Sports (Marinković, 1984; <https://www.britannica.com/biography/Valery-Borzov>).

Donald Quarrie is a Jamaican athlete, one of the world's greatest sprinters in the 1970s. Don Quarry competed in five Olympic Games. There is a statue of him at the entrance to the Jamaica National Stadium. His first WR (19.8s) achieved in the 200m event in 1971, and equaled it in 1975. The following year, he also achieved WR on 100m race (9.9s). At the Olympic Games in Montreal in 1976, he won a gold medal in the 200m and a silver medal in the 100m race. At the next Games in Moscow, he won a bronze medal in the 200m race. He won his last Olympic medal – silver, in 1984 in Los Angeles in the 4x100m. At the Pan American Games in 1971, he won gold medals in 100m and 200m, and at the Commonwealth Games from 1970 to 1978, he won 6 gold medals in 100m (1970, 1974 and 1978), 200m (1970 and 1974).) and 4x100m in 1974 (<https://olympics.com/en/athletes/donald-quarrie>).

Third period - from 1983 to 2023

It is the period from the first world championship (WC) in athletics to October 2023 (a time period of 40 years). Seven years after the record that Donald Quarri achieved, Calvin Smith (USA) achieved a WR in 1983 with a time of 9.93s. Carl Lewis (USA) equaled the WR at WC 1987 in Rome (9.93) and the following year in the final race at OG in Seoul, Lewis scored a WR with 9.92s. Four years later in 1991, Leroy Burrell (USA) achieved a WR of 9.90s, and the same year at the WC in Tokyo, Carl Lewis achieved a WR of 9.86s. At the Lausanne GP meeting in 1994, Leroy Burrell (USA) improved the record by 0.01s (9.85s). The WR (9.84s) was improved by Donovan Bailey (USA) by one hundredth at the 1996 Olympics in Atlanta, and that record remained until 1999, when Maurice Greene achieved a result of 9.79s at the meeting in Athens. Since 2005, when Asafa Powell (JAM) achieved WR with a result of 9.77s (9.767s), the period in which WRs are achieved by Jamaican sprinters begins. Asafa Powell achieved a time of 9.77s twice in 2006, first at the British GP meeting (9.763s) and then at the Golden League meeting in Zurich (9.762s). The trend of improvement of WR in the most attractive athletic discipline continued in the following years. Thus, Asafa Powell achieved a result of 9.74s in 2007, and Usain Bolt (JAM) first achieved a result of 9.72s in 2008, and then at the OG in Beijing 9.69s (9.683s). After a year at the meet in Berlin, Usain Bolt improved the WR on 9.58s (9.578s). Of the 15 WRs scored in the period 1983-2023, 4 WRs were scored by Asafa

Powell, 3 WRs each by Usain Bolt and Carl Lewis, 2 WRs scored by Leroy Burrell, and 1 WR each by Calvin Smith, Donovan Bailey and Maurice Greene. In the period 1983–2023, WR improved by 0.32 seconds from 9.9s to 9.578s (Hymans, 2020). The most important sprinters of this period were:

Carlton Frederik Lewis (USA) was chosen by the IOC as the best athlete of the 20th century. He won nine gold and one silver Olympic medal. He is an eight-time world champion in athletics at the WC, and that was when the world athletics championships were held every four years, not every two, like today. Carl Lewis repeated the feat accomplished before him by Jesse Owens in Berlin, 1936, who won the 100m, 200m, long jump and 4x100m relay. He repeated the feat of his compatriot Al Oerter, who won the Olympics (from 1956 to 1968, in the discus throw), also winning four Olympics, in the long jump. It should be noted that no one, before or after him, won the long jump event twice. Additionally, no sprinter has won the 100m twice at the Olympics and Carl Lewis did so in 1984 and 1988. Carl Lewis also qualified for the 1980 Moscow Olympics (as a 19-year-old) in the 4x100m relay and the long jump, but did not participate due to the American boycott, possibly denying him a relay medal, which would make him the Olympian with the most medals. However, Carl Lewis is the athlete with the most individual Olympic gold medals - 7, if we count current sports disciplines. Rey Ewry (USA) won 8 individual gold medals in 1900, 1904 and 1908, but in disciplines that have long since ceased to be in the program of the Olympic Games: long jump, high jump and triple jump - from standing. At the first WC in Helsinki in 1983, Lewis won 3 gold medals (100m, long jump and 4x100m relay), and the following year at the Los Angeles Olympics he won 4 gold medals (100m, 200m, long jump and 4x100m relay). At the second WC in Rome in 1987, he defended all three medals from the previous championship, while at the 1988 Games he won two gold medals (100m, long jump) and one silver medal (200m). At the WC in Tokyo in 1991, he won gold medals in the 100m and 4x100m, and a silver medal in the long jump. At the third Olympics in which he participated, in Barcelona 1992, he won gold medals in the disciplines of long jump and relay 4x100m. Lewis won his only bronze medal at the WC in Stuttgart in 1993, and his last appearance at the Olympics, in 1996, ended with winning the fourth consecutive gold medal in the long jump (www.usatf.org/athlete-bios/carl-lewis).

Asafa Powell (JAM) in 2005 and 2006 he achieved the same result three times in the 100m race: 9.77s, but 2007 improved WR on 9.74s. He was a member of the Jamaican relay team that beat WR in 4x100m in 2008. Although he achieved his best result in 2008 9.72s, it wasn't enough to win WR, as his countryman Usain Bolt had already achieved a better time. He is the only sprinter in history who managed to run the 100m under ten seconds 15 times in one season (2008) (<https://worldathletics.org/athletes/jamaica/asafa-powell-14202176>).

Usain Bolt (JAM) first appeared on the world stage at the WC for juniors in 2002, when he won a gold medal in the 200m and two silver medals as a member of the relay team 4x100m i 4x400m. Bolt won the gold medal as the youngest athlete at the competition. During 2003, Bolt won gold medals in the 200m races, at the World Junior Championships and at the high school national championships. In 2004, he became the first junior sprinter to run the 200m in under 20 seconds, making 0.2s better WR for juniors that was set by Roy Martin. Due

to injuries, Bolt had to miss most of the competition in 2004 and 2005. At the 2006 Louisiana Grand Prix, Bolt ran his new personal best – 19.88s. That year, at international competitions, Bolt broke the national records of Jamaica in the 200m, setting a new record – 19.75s. At the 2007 WC in Osaka, Bolt won the silver medal in the 200m, finishing behind his rival Tyson Gay. In May 2008, he achieved WR in 100m with a result 9.72s, and in Athens a new national record in the 200m, 19.67s. In August 2008, at the Olympic Games in Beijing, he won gold medals and won WR, in 100m and 200m. His time 9.6s made him the first athlete to run 100m under 9,7s without the help of the wind. On August 22nd, he participated in the Jamaican 4x100m relay as the third relay holder. In that race, Jamaica team won the gold by a score 37.10s, thereby overthrowing the WR established in 1993. At the WC in Berlin, August 2009, he improved his WR in 100m from Beijing, on 9.578s. At the same competition, he won the gold medal in the 200m final, setting a new record WR (19.19s). He also won the gold medal in the relay race at 4x100m (<https://usainbolt.com/athlete/>).

Table 1: Progression of the men's 100m world record

HAND MEASURED				
Time	Athlete	State	The place of reaching WR	The place of reaching WR
10,6	Donald Lippincott	USA	Stockholm, SWE	11.07.1912.
	Jackson Scholz	USA	Stockholm, SWE	16.09.1920.
10,4	Charley Paddock	USA	Redlands, USA	23.04.1921.
	Eddie Tolan	USA	Stockholm, SWE	08.08.1929.
	Eddie Tolan	USA	Copenhagen, DEN	25.08.1929.
10,3	Percy Williams	CAN	Toronto, CAN	09.09.1930.
	Eddie Tolan	USA	Los Angeles, USA	01.08.1931.
	Ralph Metcalfe	USA	Budapest, HUN	12.08.1933.
	Eulace Peacock	USA	Oslo, NOR	06.08.1934.
	Chris Berger	NED	Amsterdam, NED	26.08.1934.
	Ralph Metcalfe	USA	Osaka, JAP	15.09.1934.
	Ralph Metcalfe	USA	Dairen, JAP	23.09.1934.
	Takayuoshi Yoshioka	JAP	Tokyo, JAP	15.06.1935.
	Jesse Owens	USA	Chicago, USA	20.06.1936.
	Harold Davis	USA	Compton, USA	06.06.1941.
10,2	Lloyd La Beach	PAN	Fresno, USA	15.05.1948.
	Norwood Ewell	USA	Evanston, USA	09.07.1948.
	Emanuel Mc Donald	GBR	Belgrade, YUG	25.08.1951.
	Hajnrih Futterer	FRG	Yokohama, JAP	31.10.1954.
	Bobby Morrow	USA	Houston, USA	19.05.1956.
	Ira Murchison	USA	Compton, USA	01.06.1956.
	Bobby Morrow	USA	Bakersfield, USA	22.06.1956.
	Ira Murchison	USA	Los Angeles, USA	29.06.1956.
	Bobby Morrow	USA	Los Angeles, USA	29.06.1956.
	Willie Williams	USA	Berlin, GER	03.08.1956.
10,1	Ira Murchison	USA	Berlin, GER	04.08.1956.
	Leamon King	USA	Ontario, CAN	20.10.1956.
	Leamon King	USA	Santa Ana, USA	27.10.1956.
	Ray Norton	USA	San Jose, USA	18.04.1959.
	Armin Hary	GER	Zurich, SUI	21.06.1960.
10,0	Harry Jerome	CAN	Saskatoon, CAN	15.07.1960.
	Horacio Esteves	VEN	Caracas, VEN	15.08.1964.
	Robert Hayes	USA	Tokyo, JAP	15.10.1964.

	Jim Hines	USA	Modesto, USA	27.05.1967.
	Enrique Figuerola	CUB	Budapest, HUN	17.06.1967.
	Paul Nash	JAR	Krugersdorp, JAR	02.04.1968.
	Oliver Ford	USA	Albuquerque, USA	31.05.1968.
	Charles Greene	USA	Sacramento, USA	20.06.1968.
	Roger Babmuck	FRA	Sacramento, USA	20.06.1968.
	Jim Hines	USA	Sacramento, USA	20.06.1968.
	Ronald Smith	USA	Sacramento, USA	20.06.1968.
	Charles Green	USA	Sacramento, USA	20.06.1968.
	Jim Hines	USA	Mexico city, MEX	14.10.1968.
	Eddie Hart	USA	Eugene, USA	01.07.1972.
	Rey Robinson	USA	Eugene, USA	01.07.1972.
9,9	Steve Williams	USA	Los Angeles, USA	21.06.1974.
	Silvio Leonard	CUB	Ostrava, CZE	05.06.1975.
	Steve Williams	USA	Siena, ITA	16.06.1975.
	Steve Williams	USA	Berlin, GER	22.08.1975.
	Steve Williams	USA	Gainesville, USA	27.03.1976.
	Harvey Glance	USA	Columbia, USA	03.04.1976.
	Harvey Glance	USA	Baton Rouge, USA	01.05.1976.
9,9	Donald Querrie	JAM	Modesto, USA	22.05.1976.
ELECTRONICLY MEASURED				
9,95	Jim Hines	USA	Mexico city, MEX	14.10.1968.
9,93	Calvin Smith	USA	Colorado Springs, USA	03.07.1983.
9,92	Carl Lewis	USA	Seoul, PRK	24.09.1988.
9,90	Leroy Burrell	USA	New York, USA	14.06.1991.
9,86	Carl Lewis	USA	Tokyo, JAP	25.08.1991.
9,85	Leroy Burrell	USA	Lausanne, SUI	06.07.1994.
9,84	Donovan Bailey	CAN	Atlanta, USA	27.07.1996.
9,79	Maurice Greene	USA	Athens, GRE	16.06.1999.
	Asafa Powell	JAM	Athens, GRE	14.06.2005.
9,77	Asafa Powell	JAM	Gateshead, GBR	11.06.2006.
	Asafa Powell	JAM	Zurich, SUI	18.06.2006.
9,74	Asafa Powell	JAM	Rieti, ITA	09.09.2007.
9,72	Usain Bolt	JAM	New York, USA	31.05.2008.
9,69	Usain Bolt	JAM	Beijing, CHN	16.08.2008.
9,58	Usain Bolt	JAM	Berlin, GER	16.08.2009.

DISCUSSION

Analyzing the progression table of the world record at 100m (table 1), it could be concluded that in the period of 111 years (1912-2023) 67 WRs were achieved, and the Donald Lippincott record from 1912 (10.6s) was improved by "only" one second and now amounts 9.58s (Jusein Bolt). Thirty-one sprinters achieved one WR, six sprinters two WRs, four sprinters three WRs, and three sprinters four WRs. The development of the world record in athletics, and sports in general, was influenced by several factors: the enthusiasm of athletic (sports) experts (Bakov, 1961) evolution of technique (Stefanović, 1992b), development of sport venues (Skempler, 2007), improvement of sport equipment (Stefanović, 2006), higher quality training (Dik, 1980), pharmacological means of recovery (Dikić, 2007), financing (Mitrović, et al., 2019), etc.

The assumption is that the limits of records in athletics will still move, but much more slowly than before. The results of the research showed that until now the longest time distance between the defeat of two WRs was 8 years, and the valid WR was achieved in 2009, fourteen years ago, which indicates to us the fact that the WR will be achieved less and less often. Recent events related to the breaking of world records in athletics (broken WR at 400m, shot put, and pole vault) show us that the limit of human capabilities has not yet been reached.

If one hundredth of second is roughly equated with one year of development of the 100m sprint record, then it can be said that the countries of the former Yugoslavia are currently trotting behind world athletics for an average of 77.5 years. Namely, the national records of six countries from the region were also achieved long ago, on average 21 years ago. Slovenia is the least behind the world (10.13s) Matic Osovnikar, 2007. – 55 hundredths/years with record old 16 years), then Croatia (10.20s Darko Horvat, 2013. – 62 hundredths /years with record old 20 years), then Serbia (10.33s Slobodan Branković, 1993. – 75 hundredths /years with record old 30 years), then Bosnia and Herzegovina (10.42s Nedim Čović, 2010. – 84 hundredths /years with record old 23 years), then Macedonia (10.5s Naum Mitrevski, 2003. – 92 hundredths /years with record old 20 years), with Montenegro at the end of this procession (10.55s Luka Rakić, 2007. – 97 hundredths /years, with record old 16 years).

These national records, already decades old, speak less for the glory of the record holders, but rather sound the alarm about the drastic drop in the level of athletics or 100m sprint in the countries of the former Yugoslavia (if this is even important and if this should be competed at all).

Keeping track of times and keeping world records also has significant consequences. In addition to the world record, continental, national, club, personal and season records are recorded. What ultimately remains to society as a legacy is a more detailed methodology, technique, tactics, motivation of young people to actively engage in athletics and sports (Martinović, at al., 2013), as well as technological aspects that, once the period of industrial secrecy has passed, become part of the everyday life of the ordinary citizen who derives a certain benefit from it. The negative aspects of the competition should not be forgotten. (Miletić, at al., 2016) and the desire to always achieve more, which includes psychological disorders, depression, dissatisfaction with oneself, lack of happiness, up to overtraining, injuries, chronic diseases (Vidaković, at al., 2016) and sometimes fatal outcomes (Stojković, 1989; Simonović, 1981, 1995).

If the phenomenon of world records, and especially the 100m sprint record, is viewed from a philosophical point of view, it can be said that it is a child of capitalism that perfectly instructs the masses of viewers and followers through the media to gladly assume the role of a hamster running endlessly and uselessly inside its wheel, not wondering about the end result. Idols created with great and numerous successes (realized by a very specific mode of life) allow the broad masses of the people another chance for fruitless identification, (Tomić, 1995) with the obligatory patience and blindness to failed personal lives deprived of the essential phenomena of love and communion.

In industrial production, for hundreds of years, this phenomenon has been used, through a reward for surpassing the predicted plan, which then becomes the norm for everyone (because it has been proven that it is possible). After all, in both the short and long term, record holders work directly against themselves and their associates and fellow citizens. While, on the one hand, a personal best has to do with giving one's best to a project or event, on the other hand, achieving "peak" results even more often distances human from the balance between work, rest and leisure, or the three eights proclaimed in the 19th century.

Any great success in a certain field of sport implies a marked violation of the aforementioned balance, which is generally bad and ultimately produces "dogs of sport" (analogous to "dogs of war") who, due to extreme specialization, fail to manage in later normal life and therefore suffer enormous, often fatal consequences.

CONCLUSION

According to the principle of the circular theory of civilizations, it seems that we are at the top of the sinusoid of a time, where many indicators point to an upcoming decline, and strong changes with modifications in social arrangements and political systems. In the past, there are numerous examples when great civilizations, although significantly wounded, collapsed for a long time due to multiple inertia. Here, too, the current well-known question is whether resisting changes or accelerating them will help their realization? The conclusion reached by the sports analysis about the exhaustion of the men's 100m sprint record, when processed at a deeper level, leads to the opposite interpretation, which is reflected in the modification of sports rules or a greater tolerance for mechanical aids, stimulants, aggressive interventions on the human body, and all possible other options that will help to continue breaking the record ie. the projection of a false image of the domination of man over God, and indirectly, propagandistically extended the age of modern society and hide the twilight of civilization that is ahead of us.

It is also time to ask the question about the new system of exercise and human health that comes after major changes or resets of our civilization. The only possible view in this search is a view into tradition. We are of the opinion that the new model will at least for a certain time resemble the Falcony (Gavrilović, 2011), which lost its battle at the beginning of the twentieth century. If we ignore the military aspect of the Falcony organization and the goal of liberating the Slavic nations from the occupiers (which, unfortunately, is still relevant today), it was more important that a large number of people demonstrate a simple gymnastic composition, as opposed to an individual who does gymnastics at the highest level, but is alone in it in to a significant extent.

Since health represents a kind of dynamic homeostasis, the assumption is that the future superior system of exercise and health will neither consider nor seriously encourage the phenomenon of records at any level, except in the sphere of interest.

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DIFFERENCES IN THE MAXIMUM SHOT SPEED OF HANDBALL PLAYERS IN RELATION TO THE RESIN USED

Igor Ilić¹, Slavka Durlević², Toplica Stojanović¹

¹University of Priština - Kosovska Mitrovica, Faculty of Sport and Physical Education, Serbia

²University of Novi Sad, Faculty of Sports and Physical Education, Novi Sad, Serbia

Correspondence: PhD Ilić Igor, assistant professor,
University of Priština in Kosovska Mitrovica,
Faculty of Sport and Physical Education,
Serbia, E-mail: igor.ilic@pr.ac.rs

SUMMARY

A player's ability to execute powerful and accurate shots is crucial for success in handball. The role of adhesives has received less scientific scrutiny in regard to its influence on shot speed. This research investigates the influence of adhesive choice on maximum shot speed in handball, focusing on two prominent resin products: Trimona Classic and Select Profcare. Employing a comprehensive analysis of four distinct shot techniques made both from the standing and running start positions, the research goal was to determine whether different resin types significantly contribute to handball players' shot speed. Contrary to initial expectations, the results revealed no statistically significant differences in shot speed between the two tested resin types. Possible explanations include the limited variability in resin compositions between Trimona and Select, the overriding influence of individual player morphological characteristics and skill levels, as well as the potential of handball players to adapt to different resin types. However, certain limitations, such as the narrow focus on two specific resin types and the small subject sample which consisted of only male players warrant caution when making conclusions. This study creates the foundation for future research with the goal of exploring the influence of different adhesive types in regard to playing position, sex, age category and morphological characteristics.

Keywords: handball, adhesives, throwing speed, performance optimisation

INTRODUCTION

The game of handball is characterised by a variety of tactical plays, split-second decision-making and rapid ball movement. A player's ability to execute powerful and accurate shots is crucial for success on the court (Bragazzi et al., 2020; Vila & Ferragut, 2019; Vila et al., 2020; Wagner et al., 2014). While much attention has been given to aspects such as player strength, technique, and tactical prowess, the role of equipment, particularly the adhesive, has received less scientific scrutiny (Raeder et al., 2015).

The adhesives used in handball ensure a secure grip and facilitate the catching of the ball (Zapartidis et al., 2009). Since modern handball is a fast-paced game, the significance of the grip provided by adhesive has an influence on the shot technique, and consequently the shot speed (Karišik et al., 2016). There is a diverse range of adhesive types available in handball. These include resins, commonly referred to as glue or wax, sprays, and even adhesive-free sticky balls.

Resin is the most commonly used adhesive in modern handball (Bracamonte et al. 2021). Handball players apply it to the hand and the ball before and during training and match, without special control over the amount of glue used. The benefits of using resin in handball are manyfold. The resin increases the friction quotient between the hand and the ball. As a consequence, the players have an improved grip on the ball, which allows them to have better ball control and increased confidence when catching, as well as increased accuracy when throwing the ball. The resin is especially important for wingers, who on average have smaller hands than backs and pivots (Karišik et al., 2018). The resin also reduces the amount of hand perspiration, as well as the overall impact of moisture that comes from the ball's contact with players' sweat during gameplay (Graham, 2023). One additional advantage of using resin is that it reduces forearm fatigue, given that players don't have to worry about constantly readjusting their grip.

It should be noted that there are certain risks involved with resin use. Because of the wide variety of handball resins in use, some players may experience skin irritation and other dermatological issues depending on the ingredients used. The other risk of resin use is its overuse. As previously stated, players who play in the wing position always want as much of the resin on the ball as possible. This can have an adverse effect on the performance of other players, given that overuse of resin can lead to uncommonly increased friction between the hand and the ball, which in turn reduces pass and shot accuracy, as well as overall attacking performance.

There are many different types of resin that differ in many characteristics. Based on the ingredients, natural and synthetic resin can be differentiated. The other notable characteristics are stickiness, durability, ease of application and removal, as well as cost. In the past decade, more emphasis has been set on the resin's environmental effect. The importance of environment-friendly materials used in resin is multiple. Given that handball is an indoor sport, it usually shares the training space with other indoor sports. The resin stains on the floor made by bouncing the resin-covered ball are a common occurrence after practice sessions and

games (de la Rubia et al., 2022; Karišik et al., 2018). These stains must be removed in order to ensure a clean, non-sticky surface that won't interfere with other sports activities. The fact that some resin types require specialised resin removal chemical products in order to clean the floor is also important as it further exacerbates maintenance expenses.

The players' health and safety aspect of the resin usage also plays a critical role. It is important that the resin is thoroughly dermatologically tested, ensuring it is safe for use on the skin. Many of the modern resin products are made from hypoallergenic ingredients, which guarantees that they can be used even by players with sensitive skin (Handballsho.com, 2022).

Taking everything into account, it's understandable that there is a broad choice of resins with different combinations of characteristics. However, there exists a notable gap in understanding how different types of resin impact the shot speed in handball. The goal of this research is to compare and explain the distinct differences in maximum shot speeds of handball players using two different types of resin. These findings are relevant both for handball players seeking to optimise their equipment choices and for coaches, equipment manufacturers, and researchers interested in enhancing the overall understanding of the sport.

METHODS

Subject sample

The subject sample consisted of 15 professional handball players who competed in the Serbian Super B league, which is the second-highest national league flight. The players were male, senior players (age 26 ± 0.9 years, height 179.26 ± 6.82 cm, weight 91.73 ± 10.91 kg), who had been a part of a regular training regime for at least seven years. At the time of testing the players didn't have any significant injuries and weren't taking any medications. This research was approved in advance by the players' respective handball clubs. All experiment procedures, risks and benefits were explained in detail to participants, as well as the coaching and medical staff of their respective clubs. Each player voluntarily provided written informed consent before participating. The research was conducted in accordance with all the ethical standards specified by the Declaration of Helsinki (World Medical Association, 2013).

Variable sample

Two types of resin were used in this research: Trimona Classic (Trimona, n.d.) and Select Profcare (Select Sport, n.d.).

Players performed shots using four different shot techniques, made both from standing still and three-step running start: running jump shot with circular arm swing (ZSSK), running jump shot with direct arm swing (ZSSD), running ground shot with circular arm swing (ZSPK), running ground shot with direct arm swing (ZSPD), standing jump shot with circular arm swing (MSSK), standing jump shot with direct arm swing (MSSD), standing ground shot with circular arm swing (MSPK), standing ground shot with direct arm swing (MSPD).

Procedures

Before the shooting attempts, players were given time to familiarise themselves with both of the resin types used. After the period of adaptation, players were asked to complete a short survey that compares the two resin brands on several characteristics: general feel, stickiness, durability, ease of application and removal. Survey results show that players found that Trimona Classic was pasty, more sticky, more durable, and more difficult to apply and remove than Select Profcare which was in turn described as creamy.

Players were tested in two separate training sessions, with only one resin type used in one session. This was necessary in order to prevent the contamination of the results, given that the removal of one brand of resin and application of another in the same training session produces a feeling of unease in players' fingers and thus may impact the performance.

Before taking the shots, the players were instructed by the experimenter that the goal of the measurement was solely the maximum speed of the shot and that parameters such as precision would not be evaluated. The players directed their shots towards the goal in order to ensure that the situational circumstances were as similar as possible to those they were used to in training sessions and matches. Each shot was performed three times and the best result was recorded. Players were given adequate time to rest between attempts.

In order to measure shooting speed, all shots were recorded using the D5300 camera (Nikon, Japan). The camera was connected to a laptop and its feed was imported in real time to Adobe Premier Pro software (Version 22.2) for video analysis. The video was recorded in 120 frames per second which ensured a high measurement accuracy. The video time was converted to milliseconds. PMML 5 A2 (Parkside, Germany) range finder was used in order to calculate the distance travelled by the ball from the spot where the shot is taken to the goal line. After establishing the time and distance travelled, the software calculated the shot speed in kilometres per hour (km/h).

Statistical analysis

The following descriptive statistic parameters were analysed: mean (Mean), standard deviation (SD), minimal recorded result (Min.), maximal recorded result (Max.), Shapiro-Wilk test statistic (W), Shapiro-Wilk significance level (p). The differences in shot speed between the shots performed with Trimona and Select were calculated with the independent t-test. All statistical analyses were implemented in IBM SPSS Statistics (Version 25).

RESULTS

The descriptive shot speed parameters of different shot techniques based on the resin used are presented in Table 1.

Table 1. Descriptive parameters of shot speed by resin

Variable	Resin	N	Mean	SD	Min.	Max.	W	p
ZSSK (km/h)	Trimona	15	93,0 4	4.74	84.23	101.67	.990	.999
	Select	15	92.75	4,6 8	84.17	101.43	.990	.999
ZSSD (km/h)	Trimona	15	82,2 7	4.30	74.98	90.01	.976	.934
	Select	15	82.04	4.3 6	74.71	89.91	.975	.921
ZSPK (km/h)	Trimona	15	78.17	4,5 4	70.40	86.21	.972	.885
	Select	15	78,3 4	4.4 8	70.28	86.20	.982	.980
ZSPD (km/h)	Trimona	15	67.98	4. 10	61.20	75.97	.984	.991
	Select	15	67.86	4. 10	61.19	75.81	.982	.979
MSSK (km/h)	Trimona	15	79.10	4.44	71.13	86.97	.983	.987
	Select	15	78,99	4.36	70.98	86.17	.979	.959
MSSD (km/h)	Trimona	15	52.20	4,0 7	44.98	59.51	.986	.995
	Select	15	52,0 1	4.07	44.47	59.43	.989	.999
MSPK (km/h)	Trimona	15	63.33	4.1 5	55.73	70.94	.982	.979
	Select	15	63,2 5	4.19	55.31	70.84	.986	.994
MSPD (km/h)	Trimona	15	48,6 8	4.1 4	41.67	56.94	.990	.999
	Select	15	48.58	4.09	41.71	56.64	.989	.999

Legend. N: number of participants; Mean: mean; SD: standard deviation; Min.: minimal recorded result; Max.: maximal recorded result; W: Shapiro-Wilk test statistic; p: Shapiro-Wilk significance level.

Due to the small sample size, determining the presumption of the normal distribution of the shot speed data in regard to the resin type used was important in order to choose an appropriate statistical method. Shapiro-Wilk test did not show evidence of non-normal distribution in any of the observed variables. Based on these results, the independent samples t-test could be performed (Table 2).

Table 2. Independent sample t-test

Variable	Levenov test		T-test za nezavisne uzorke			
	F	str	t	df	p (2-tailed)	MD
ZSSK	.006	.937	0,170	28	.866	0,293
ZSSD	.006	.939	0,143	28	.888	0,225
ZSPK	.016	.900	-0,101	28	.920	-0,166
ZSPD	.003	.957	0,078	28	.938	0,117
MSSK	.003	.955	0,066	28	.948	0,106
MSSD	.001	.979	0,131	28	.897	0,195
MSPK	.004	.949	0,056	28	.955	0,086
MSPD	.002	.965	0,062	28	.951	0,093

Legend. F: Levene's test statistic; p: Levene's test significance level; t: t-test statistic; df: degrees of freedom; p (2-tailed): significance level; MD: mean difference..

Based on the results of Leven's homogeneity of variance test show that the hypothesis of equal variances assumed can be accepted in all variables. The results of the independent sample t-test indicate that there were no statistically significant differences between the two tested resin brands in regard to maximum shot speed in any of the tested variables.

DISCUSSION

The data analysis showed that there were no statistically significant differences in regard to maximum shot speed between Trimona Classic and Select Profcare resins. Even more

interesting are the mean differences, which are almost non-existent, even though the players felt like Trimona Classic was stickier.

The absence of statistically significant differences between the two tested resin types in shot speed across all four distinct shot techniques made from the standing and running starts unveils unexpected insights into the relationship between adhesive choice and handball player performance. Despite the initial hypothesis positing that varying resin properties might influence the shot speed, the findings challenge conventional assumptions and prompt a reevaluation of the factors contributing to shot speed in handball.

One plausible explanation for the lack of significant differences could be the limited variability in adhesive characteristics between the two resin types. Trimona and Select, being reputable brands in the handball equipment market, might share similar adhesive compositions or adhere to industry standards that mitigate substantial differences in their impact on players' performance. It should be noted though that the resin still has an important role in the shot speed. In the research conducted by Bracamonte et al. (2021) on the subject sample of 46 players (31 men and 15 women), statistically significant differences ($p < 0.001$) in shot speed between shots performed with and without resin were established.

Furthermore, the intricacies of handball technique and player-specific morphological characteristics might outweigh the influence of resin choice on shot speed. Factors such as skill, strength, and biomechanics could supersede the effects of the adhesive, rendering any distinctions in resin types negligible in the context of shot speed (Chelly, 2010). Such were the findings of Karišik et al. (2016) who established that the length of the arms has the biggest influence on the shot speed in handball. Future research should delve into a more detailed examination of player-specific characteristics to better explain the correlation between individual morphological attributes and resin.

When considering the results of this research, it is also essential to consider the adaptability of handball players to different equipment. Athletes often develop a level of proficiency and familiarity with specific resin, but the experience in using it is transferable and could potentially mitigate the impact of changes of adhesive type.

While the current findings challenge preconceived notions regarding the influence of adhesive choice on shot speed, it is important to acknowledge certain limitations. The study focused solely on two specific resin types, Trimona and Select, and did not encompass the entire spectrum of adhesive options available in the market. Exploring a broader range of adhesives could reveal more nuanced insights into the potential influence of adhesive characteristics on shot performance.

CONCLUSION

In conclusion, the statistically non-significant differences between Trimona and Select resins in regard to shot speed raise intriguing questions about the fine dynamics governing players' performance of attacking actions in handball. This study creates the foundation for future research with the goal of exploring additional factors influencing shot speed. In regard

to the subject of future research in this area, the influence of different adhesive types in regard to playing position, sex, age category and morphological characteristics should be explored. As the pursuit of performance optimization in handball continues, a more profound understanding of the complex set of elements contributing to shot speed remains crucial for handball players, coaches and researchers in the field.

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CORRELATION OF BASIC AND SPECIFIC PHYSICAL ABILITIES: A STUDY ON THE OBSTACLE COURSE FOR ASSESSING SPECIFIC AGILITY OF POLICE OFFICERS

Radivoje Janković

Correspondence: Radivoje Janković

University of Criminal Investigation and Police Studies, Belgrade, Serbia

* PhD, associate professor; tel. +381 66 889 79 70;

address: Cara Dušana 196, Belgrade, Serbia;

e-mail: radivoje.jankovic@kpu.edu.rs

SUMMARY

This study examines the relationship between basic physical abilities (BPA) and specific physical abilities (SPA), particularly focusing on the obstacle course for specific agility of police officers. The study involved 358 students from the University of Criminal Investigation and Police Studies in Belgrade, Serbia. A variety of tests assessed BPA, including maximal isometric force of hand finger flexors, one-repetition maximum bench press, standing long jump, sit-ups, linear running speed, the Illinois agility test, and anaerobic and aerobic endurance. Results indicated a significant correlation between these basic and specific physical abilities, as measured through the obstacle course. The study suggests that physical readiness significantly influences the performance of police-specific tasks. It underscores the importance of continuous development and assessment of both BPA and SPA, tailored to professional requirements in policing. These findings emphasize the need to consider enhancements to test batteries for assessing physical abilities at the situational level of Specialized Physical Education. They underscore the need for continuous improvements in training and testing methodologies, with the aim of further developing the professional competencies of future police officers.

Keywords: students, police training, physical fitness assessment, law enforcement education

INTRODUCTION

The job of police officers (PO) is considered extremely demanding and high-risk, as it involves various hazardous situations that could potentially be stressful (Marins et al., 2019). While contemporary policing is increasingly considered as sedentary, primarily office-based work (Strauss et al., 2021), police officers must be prepared to respond to any emergency situation at any given moment within their working hours (Bissett et al., 2012; Beck et al., 2015). Efficiency in police work, which includes tasks like rescuing civilians, overpowering suspects, or maintaining public safety, requires police officers to develop both basic and specific physical abilities (Lockie et al., 2018). Apart from the necessity of resolving professional tasks, physical abilities, together with the appropriate morphological characteristics, comprise significant factors related to the health status (Kukić et al., 2022a). Therefore, physical activity programs are crucial not only for enhancing work efficiency (Crawley et al., 2015) but also for improving health status, particularly pertaining to decreasing cardiovascular risks and body mass optimization (Strauss et al., 2021). In other words, the lack of physical activities could cause poor muscle fitness and endurance, as well as increase obesity (Kukić et al., 2019b; Kukić et al., 2020). Consequently, such condition can directly negatively impact work efficiency in resolving emergency situations, as well as become a health risk factor, potentially leading to productivity loss and sick leaves (Strating et al., 2010; Beck et al., 2015; Lockie et al., 2018).

It is precisely the ability to physically, mentally, and tactically resolve critical incidents that classifies PO as tactical personnel (Marins et al., 2019). In order to meet high professional requirements, during the selection of candidates applying to become police students (PS), health status, intellectual abilities, personality traits and the level of physical abilities are assessed (Anell et al., 2015; Koropanovski et al., 2022). The selection segment focusing on physical abilities aims to identify candidates with an appropriate initial level, thus enabling PS to improve these abilities in line with the professional needs (Dimitrijević et al., 2014). Likewise, it is extremely important to first identify the specific physical fitness components, so as to link the curriculum and physical abilities assessment with occupational tasks conducted by PO (Beck et al., 2015). Right before the end of formal education, it would be advisable to conduct a final examination of job-specific physical skills, in order to ascertain whether PS are able to perform police tasks in such a manner so as to not only keep themselves safe, but also to ensure the safety of their colleagues, as well as of the entire community (Lockie et al., 2018). Throughout their selection, education, and career, both PO and PS undergo a series of tests to assess their Basic Physical Abilities (BPA) and Specific Physical Abilities (SPA). Within BPA assessment, most commonly evaluated parameters are various types of strength and endurance, speed and agility (Dimitrijević et al., 2014; Koropanovski et al., 2022), whereas SPA assessment entails job-specific physical skills, i.e., job-related fitness test (Strating et al., 2010; Janković et al., 2015; Lockie et al., 2018).

At the University of Criminal Investigation and Police Studies (UCIPS), BPA and SPA development and evaluation occur within the specialized scientific field called Specialized

Physical Education (SPE). A standardized battery for BPA assessment is used in the selection process, consisting of seven tests: repetitive strength of arm extensors, repetitive strength of abdominal muscles, speed-strength (the Abalakow vertical jump test and standing long jump test), movement coordination, aerobic endurance, maximal isometric force of the back extensors (men), and maximal isometric hand grip force (women). Throughout the studies, BPA is assessed by means of the same tests used at the entrance exam, additionally evaluating: repetitive strength of arm flexors, isometric force of legs extensors, linear sprint performance, agility and anaerobic endurance (Janković & Dopsaj, 2022). Within the selection and evaluation of BPA, female and male students perform the same tests, with grades adjusted to the standards related to sex (Koropanovski et al., 2022). Likewise, SPA assessment test (evaluating job-specific abilities of PO) possesses predefined norms of evaluation separate for men and women. On the other hand, the same evaluation standards for both sexes are applied in expert assessment of martial arts techniques studied within SPE (Janković et al., 2015; Janković & Dopsaj, 2022).

The teaching process of SPE consists of several methodological parts (basic, advanced, and situational levels), with one of its objectives being the development of BPA and SPA, ultimately enabling efficient police work (Amanović et al., 2015). Given that physical readiness is essential for PO, it is necessary to continually evaluate the development and testing of BPA and SPA, as well as implement new methods and measurements to improve the entire system and produce better students with each generation (Strating et al., 2010; Dopsaj et al., 2012). At UCIPS, BPA assessment is an integral part of the selection process and has an eliminatory factor (Koropanovski et al., 2022). After completing each level of SPE, students must achieve defined norms for both BPA and SPA to proceed to the next level. At the situational level of SPE, SPA is assessed for both genders through the obstacle course for specific agility of PO (OCSAPO1) (Janković & Dopsaj, 2022). The tasks of OCSAPO1 include various ways of running (in a straight line and with direction changes), overcoming obstacles (skipping them and crawling under them), and solving specific motor tasks (application of martial arts techniques). Likewise, the tasks involve the specific use of weapons and police equipment, such as magazine changes, baton use, and handcuff use (Janković et al., 2015). This study aims to determine the relationship between BPA and the results of OCSAPO1 in both male and female students. It is hypothesized that there is a correlation between BPA and SPA, and that certain tests can be isolated from the BPA space to improve OCSAPO1 results. The significance of this study may lie in developing additional testing methods and programs for BPA and SPA at the situational level of SPE, leading to more effective emergency situation resolution.

METHODS

This study was conducted with the aim of determining the correlation between basic and specific physical abilities among male and female students at UCIPS. The testing was organized during the summer semester, as part of SPE classes. Initially, all participants were acquainted with the objectives and protocols of the testing. Subsequently, each participant underwent a series of tests, which were conducted with appropriate time intervals. This

sequential approach not only enabled an organized and efficient evaluation process but also provided necessary rest intervals between the tests.

Entity Sample

The research involved 358 third-year students of the University of Criminal Investigation and Police Studies, Belgrade, Serbia. The total sample was divided into two groups. The first one consisted of 160 women (FPS) with the average 21.6 ± 0.8 years of age (BH = 169.6 ± 5.1 cm; BM = 63.1 ± 6.8 kg; BMI 21.9 ± 2.1 kg/m²). The second group was comprised of 198 men (MPS) with the average 21.9 ± 1.1 years of age (BH = 182.4 ± 6.7 cm; BM = 82.3 ± 9.2 kg; BMI 24.7 ± 2.3). This study was conducted in strict accordance with the ethical standards of the Helsinki Declaration (Williams, 2008).

Procedures and Variables

In the view of determining the link between basic and specific motor abilities, a total of nine tests were used (eight of them for ascertaining the BPA level and one for estimating the specific agility of police personnel).

1. The maximal isometric force of the hand finger flexors (FmaxHG) was measured by means of the standardized Hand grip test using a hand dynamometer equipped with strain gauge sensors (Physical ability test 02, UNO-LEX, NS, Serbia). The standard measurement procedure is such that the standing respondents hold a measuring device at the distance of approximately 10 cm from their bodies. The respondents performed a power grip at the measurer's signal, whereby all of their fingers were flexed around the measuring device. Out of two attempts, the better result was counted, expressed in dekaNewtons (DaN) (Ivanović et al., 2009).
2. As for the upper body muscular strength, one repetition maximum free weight bench press (BP1RM) was used. During the warm-up phase for the one repetition maximum free weight bench press test, each respondent had the freedom to choose the number of sets and repetitions with lighter weights. This flexibility allowed them to individually gauge their readiness for maximal effort. To ensure that participants were adequately prepared for the maximal lift, their performance during warm-up were closely monitored. Only after confirming these indicators of readiness, the standard protocol of progressive resistance increase was initiated, culminating in the determination of BP1RM. As far as the final result was concerned, the standard protocol of progressive resistance increase across attempts was used, until BP1RM was achieved (Schick et al., 2010). The test results were shown in kilograms.
3. The explosive strength of leg extensors was assessed by standing long jump test (SLJ). The respondents take off and land using both feet, swinging the arms and bending the knees to provide forward drive. The result pertains to the distance from the marked start line to the body part closest to it after the jump. The respondents are allowed two attempts, whereby the better score is the one counted. The result is recorded in centimeters, with a measurement precision of one centimeter (Koropanovski et al., 2020).

4. Trunk muscular power and muscular endurance were assessed via the maximal number of sit-ups that could be performed in 30 seconds (SU). The starting position implies lying on one's back with bended knees (90-degree angle), with anchored feet, palms crossed behind the head and the elbows apart. Men performed an abdominal flexion with trunk rotation, whereas women performed an abdominal flexion by moving the chest to the thighs and then returning to the initial position. The result was expressed by the number of correctly performed SUs (Kukić et al., 2022b).
5. Linear running speed is test that consists of two components: acceleration (Acc10m) and running speed (LSR10m). The running sensors are set at the start line, at the distance of 10 m, as well as at the finish line, 20 m away from the start line. The respondents wait for the signal in the standing position, immediately behind the line of the first pair of sensors. At the signal, they start running at the maximum speed. Moving through the first pair of sensors starts the chronometer, followed by the second pair of sensors set 10 meters away, running through which helps obtain the Acc10m result; i.e., the running time between the first and second pair of sensors represents acceleration. Running through the final pair of sensors deactivates the chronometer, whereby LSR10m, is obtained; i.e., the running time between the second and third pair of sensors (Janković & Dopsaj, 2022). The time was measured with photocells connected to a computer system designed for physical ability testing (Physical ability test 02, UNO-LEX, NS, Serbia), with the precision of 0.001s.
6. Running with direction changes – Illinois agility test (IAT) shown in Figure 1 was performed in such manner that respondents are firstly at the start line (Start) in a standing position. At the signal, they start running toward the first direction changing cone (TC1). Running through the first pair of sensors activates the chronometer. At TC1, they turn and run back toward the central turning cone (CC1), change direction and then run towards the fourth central turning cone (CC4). On their way back to CC1, respondents run slalom through the central markers in both directions. The final segment of the test implies running to the second direction changing cone (TC2), turning and running to the finish line (Finish). Passing through the second pair of sensors deactivates the chronometer (Orr et al., 2019). The time for this test was measured by means of the same system as LSP20m (Physical ability test 02, UNO-LEX, NS, Serbia), with the precision of 0.001s.

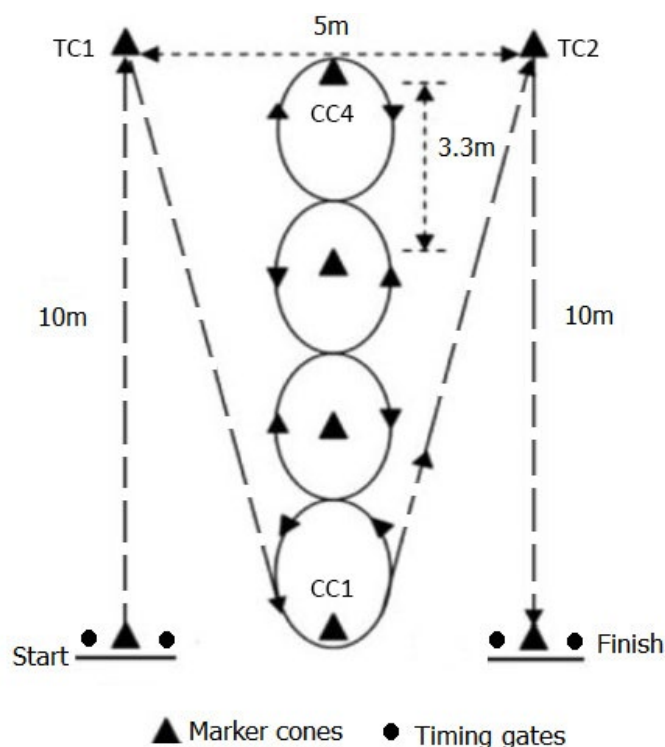


Figure 1. Schematic display of IAT

7. The assessment of anaerobic endurance was conducted by means of the 300-Yard Shuttle Run (ShR300y). The testing protocol is such that the participants run between two reference points set at 25 yards from one another. They start at the signal, from the standing position, run to the opposite line, touch it with their foot, turn and run back to the start line. This procedure is repeated six times (from the start to the opposite line and back) without stopping. The test is completed once the participant has finished six cycles; i.e., after running 300 yards total (Janković & Dopsaj, 2022). The time taken to complete ShR300y is measured with a stopwatch (Casio HS-70V, Tokyo, Japan), with the precision of 0,01s, expressed in seconds at the first decimal.
8. General aerobic endurance was assessed using the 12-minute Cooper running test (CT). The participants run across a 230-meter-long circular track, marked at each 5 meters, in the view of running the maximum possible distance within the period of 12 minutes. The result of CT is expressed in meters (Kukić et al., 2019a).
9. The test for assessing the specific agility of police officers - OCSAPO1 was conducted at 25x15 meters of range. Testing procedure included measurement of the time needed to complete the task as an indicator of efficiency, i.e., the level of specific motor abilities. The candidates performed the OCSAPO1 test presented in Figure 2 in accordance with the standard procedures that imply familiarizing with the tasks, mock performances, adequate recovery and test realization. The test was performed in sports equipment, and the participants were wearing a holster with a CZ 99 gun, and a spare magazine with no ammunition, baton and restraint devices (Janković et al., 2020). The performance efficiency was defined as the SSP1 realization time, expressed in seconds and measured by means of a computer system for physical ability testing PAT 02 (UNO-LEX, NS, Serbia).

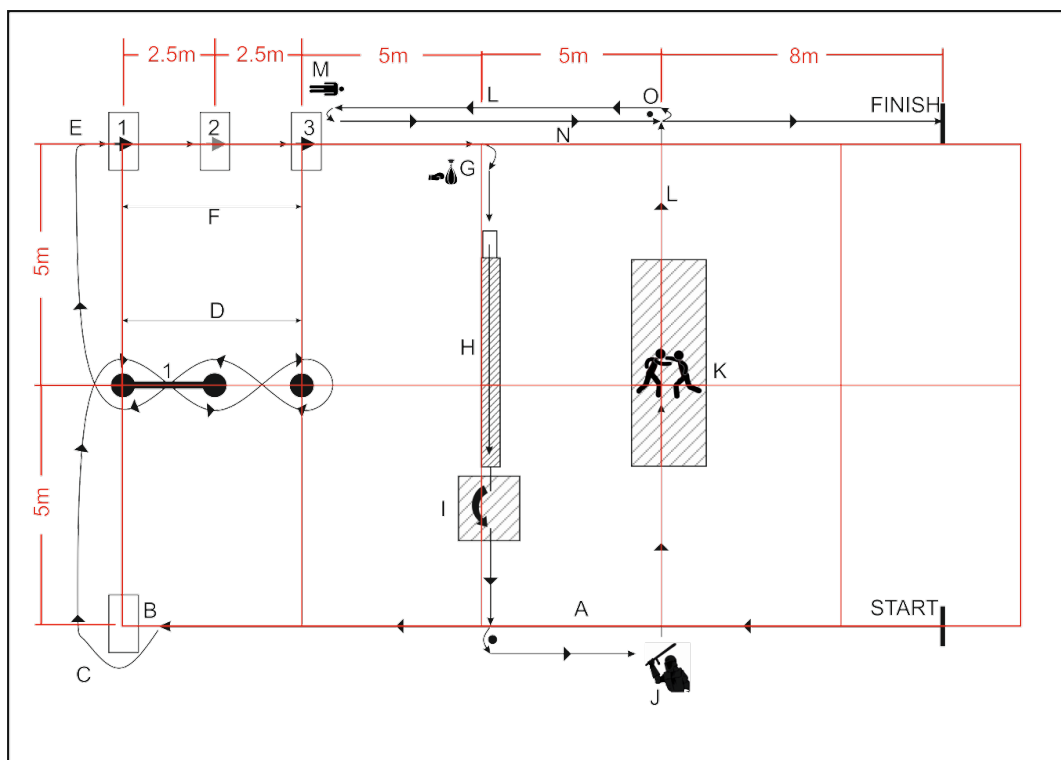


Figure 2. Obstacle course for the assessment of specific abilities of PO: A. Start at the sound signal and sprint 20 m in a straight line; B. Stop, take cover and reach for a firearm; C. While holding the gun in the firing position, leave the cover from the left; D. Pass the cones from the outer side and crawl underneath the rope set at a height of 55 cm in marked spots. Distance between the cones is 250 cm; E. Stop and take cover, change the magazine and put the firearm back into the duty belt; F. Three-part task: 1) Cross over a 110 cm-high obstacle; 2) Crawl beneath a 55 cm-high obstacle (F'); 3) Cross over a 110 cm-high obstacle. Distance between the obstacles is 250 cm; G. Approach the focus pad (held by an assistant), throw 4 punches and 2 kicks with maximum speed and intensity; H. Climb a 70 cm-high platform and cross a 120 cm-high and 500 cm-long balance beam; I. Leap on a mat with a forward roll; J. Approach a punching bag, take a baton, hit the bag 4 times with maximum efficiency and put the baton back on the duty belt; K. Reach the mats and defend against a predetermined attack, overcome the attacker using defence tactics, control and handcuff the suspect; L. Sprint 15 m at maximum speed, with a change of direction, towards the dummy (weighing 60 kilos); M. Reach the dummy; N. Carry the dummy (or drag it – optional for women) to a marked point (10 m); O. Safely place the dummy on the ground and run through the finish line.

Statistical analysis

In the first step of data processing, we applied descriptive statistical analysis, which involved calculating measures of central tendency, such as the arithmetic mean (Mean), measures of dispersion, such as the standard deviation (SD), minimum and maximum values (Min, Max), and measures of data distribution shape, such as the asymmetry coefficient (Skew) and tailedness coefficient (Kurt). The normality of data distribution was confirmed by the Kolmogorov–Smirnov test, indicating no significant deviation from normal distribution. Furthermore, to assess the link between the observed basic motor abilities and specific agility evaluation test results, we used the Pearson correlation analysis method and linear regression, backward method. The statistical significance of the identified relationships was established at a 95% confidence level, with a significance threshold set at $p < 0.05$. (Hair et al., 1998). Effect size analysis was conducted for correlation and regression models to quantify the strength of associations. Cohen's d values were interpreted as small (± 0.2), medium (± 0.5), and large (± 0.8) for Pearson correlations. The R^2 coefficient in linear regression was used to assess the explained variance, with 0.04, 0.25, and 0.64 indicative of small, medium, and large effect

sizes, respectively (Sullivan & Feinn, 2012). All statistical analyses were conducted using the Statistical Package SPSS Statistics for Windows, Version 20.0.

RESULTS

Basic descriptive statistics for observed variables FPS and MPS are showed in Table 1 and Table 2, respectively. Both tables enumerate mean values, standard deviations, minimum and maximum values, and coefficients of skewness and kurtosis for each variable. Table 3 displays the Pearson's correlation coefficients, indicating the relationships between BPA and OCSAPO1 results, along with their respective levels of statistical significance. Table 4 and Table 5 provide summaries of the linear regression models FPS and MPS, respectively, delineating the predictive variables significantly influencing the OCSAPO1 scores. These tables report the unstandardized and standardized coefficients, t-values, and significance levels, elucidating the predictors contributing to specific agility task performance in both groups.

Table 1. Basic descriptive indicators of the observed variables for FPS

	Mean	SD	Min	Max	Skew	Kurt
F_{max}HG (DaN)	35.5	4.1	24.8	52.1	0.247	0.912
BP_{1RM} (kg)	40.8	6.8	27.5	70.0	0.887	1.798
SLJ (cm)	177.9	14.4	150	232	1.069	1.337
SU (No)	25.1	2.6	14	32	-0.021	1.240
Acc_{10m} (s)	2.218	0.137	1.840	2.917	0.957	3.638
LSR_{10m} (s)	1.657	0.125	1.381	2.151	0.831	1.624
IAT (s)	21.048	1.265	17.555	24.042	-0.290	0.053
ShR_{300y} (s)	77.1	4.4	66.1	91.0	0.191	0.755
CT (m)	2250	199.5	1750	2910	0.562	0.355
OC_{SAP01} (s)	94.41	8.52	71.34	118.42	-0.017	0.142

Table 2. Basic descriptive indicators of the observed variables for MPS

	Mean	SD	Min	Max	Skew	Kurt
F_{max}HG (DaN)	60.7	8.4	44.4	93	0.922	1.672
BP_{1RM} (kg)	97.9	15.9	60.0	145	0.491	-0.119
SLJ (cm)	233.3	15.7	190	285	0.546	0.765
SU (No)	28.7	2.7	21	34	0.326	0.533
Acc_{10m} (s)	1.943	0.120	1.652	2.331	0.672	0.928
LSR_{10m} (s)	1.385	0.092	1.178	1.988	1.630	1.432
IAT (s)	18.299	0.995	16.295	21.330	0.493	-0.159
ShR_{300y} (s)	66.81	3.39	57.7	79.1	0.402	0.669
CT (m)	2670.7	198.6	2150	3205	-0.077	-0.136
OC_{SAP01} (s)	86.89	7.52	57.7	79.0	-0.065	-0.143

Table 3. Pearson correlation analysis results

	F _{max} HG	BP _{1RM}	SLJ	SU	Acc _{10m}	LSR _{10m}	IAT	ShR _{300y}	CT
FPS OC _{SAP01}	-0.216**	-0.288**	-0.551**	-0.337**	0.400**	0.405**	0.611**	0.532**	-0.292**
MPS OC _{SAP01}	-0.166*	-0.209**	-0.320**	-0.250**	0.257**	0.412**	0.357**	0.348**	-0.291**

FPS - Female Police Students; MPS - Male Police Students;

Pearson correlation; **correlation significance at the level of 0.01; *correlation significance at the level of 0.05

Table 4. Summary of linear regression model for FPS

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate	
6	0.678	0.460	0.446	6.349	
Coefficients					
Model 6	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	43.886	18.691		2.348	0.020
BP _{1RM}	-0.137	0.078	-0.110	-1.756	0.081
SLJ	-0.122	0.047	-.207	-2.628	0.009
IAT	2.336	0.542	0.347	4.312	0.000
ShR _{300y}	0.372	0.151	0.193	2.467	0.015

Table 5. Summary of linear regression model for MPS

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate	
6	0.484	0.234	0.218	6.651	
Coefficients					
Model 6	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	57.108	14.300		3.993	0.000
BP _{1RM}	-0.078	0.030	-0.165	-2.597	0.010
IAT	1.172	0.599	0.155	1.956	0.052
LSR _{10m}	20.998	6.457	0.259	3.252	0.001
CT	-0.005	0.003	-0.130	-1.885	0.061

DISCUSSION

The primary goal of this study was to explore the potential connection between basic physical abilities and job-related fitness test outcomes. Pearson correlation analysis revealed a range of interconnectedness between OCSAPO1 assessments and all observed BPA variables in police students of both genders, ranging from $r = 0.219$ to 0.611 for FPS and $r = 0.166$ to 0.412 for MPS (Table 3). The accompanying effect size analysis highlighted that the correlations mainly fall within small to medium ranges. This underscores a varying strength in the association between BPA and specific agility performance, with some correlations nearing large effect sizes for FPS (IAT, ShR300y and SLJ). In addition, the linear regression models demonstrated moderate to substantial explained variances. The model for FPS (Table 4), accounting for 46% of the variance, identified BP1RM, SLJ, IAT, and ShR300y as key predictors. Meanwhile, the MPS model (Table 5), explaining 23.4% of the variance, highlighted BP1RM, IAT, LSR10m, and CT as significant.

Previous studies, such as Rhodes and Farenholtz (1992), have also identified a correlation between BPA and the efficiency of job-related fitness test performances. In this research, the Police Officers' Physical Ability Test was utilized for assessing SPA. The study found that 55% of the variance in the run component was linked to aerobic and anaerobic endurance, while the test's fight components moderately correlated to certain BPA (push-up, pull-up, sit-up, and grip strength). Similarly, Beck et al. (2015) found a connection between Officer Physical Ability Test and certain BPA, such as agility and aerobic capacity. Moreover, while not directly related to the overall completion time of the Officer Physical Ability test, specific BPA assessments were associated with various occupational tasks, specifically push-ups with building entry, and curl-ups with stair ascent/descent and 159 m run. In a similar vein, Lockie et al. (2018) explored the relationship between various physical fitness measures and performance in work-specific physical tasks. This study used the PT500 battery for BPA assessment, containing push-ups, sit-ups, mountain climbers, pull-ups, 201 m run, and 2.4 km run. SPA was evaluated using the work sample test battery (WSTB), consisting of 99-yard obstacle course run, body drag, chain-link fence climb, solid wall fence climb, and 500-yard run. The results indicated small-to-moderate correlational and predictive relationships between the PT500 and WSTB, implying potential benefits of muscular endurance development, upper-body pulling strength, anaerobic and aerobic capacity, which could lead to a more efficient performing of police personnel's job-specific tasks.

The intensity, duration, and execution methods of OCSAPO1, along with specific running-related tasks, may explain both the efficiency of its completion and the BPA associated with anaerobic endurance, explosive strength, maximal running speed, and directional running. The greatest correlation in FPS were found between OCSAPO1 and IAT ($r = 0.611$, $p < 0.001$), SLJ ($r = 0.551$, $p < 0.001$), ShR300y ($r = 0.532$, $p < 0.001$), whereas the link established in MPS was between LSR10m ($r = 0.412$, $p < 0.001$), IAT ($r = 0.357$, $p < 0.001$), and ShR300y ($r = 0.348$, $p < 0.001$). Specifically, linear sprinting and directional changes may enhance efficiency, being related to the ability to manoeuvre around corners and obstacles (Lockie et al., 2018). Furthermore, the realization of OCSAPO1 leads to physical exhaustion (heart rate above 95% of individual potential and lactate concentration above 11 mmol/L). Under these conditions, especially in the anaerobic-lactate energy production zone, it's essential to perform all tasks correctly (Dopsaj & Janković, 2014), leading to an expected link between ShR300y and obstacle course results. Apart from various modes of running, the obstacle course requires PO to perform certain specific tasks incorporating martial arts elements such as: punches, fall downs, overpowering a suspect, specific weapon and equipment usage (magazine change, baton and handcuffs use), as well as a simulation of assisting the injured in the sense of body drag (Janković et al., 2015). The abovementioned tasks require various types of strength; therefore, it could be presumed that OCSAPO1 results correlate to s FmaxHG, BP1RM, SLJ and SU in the range of $r = 0.216 - 0.551$ for FPS and $r = 0.166 - 0.320$ for MPS (Table 3). Furthermore, enhanced aerobic and anaerobic endurance may positively influence focus, in order for SPE techniques to be conducted correctly, in the condition of increased fatigue and at the right time. Research conducted by Dillern et al. (2014) found a strong

correlation between a general physical test index and an arresting simulation test index, pointing to the fact that a specific level of physical fitness might enhance one's ability to overcome an unyielding suspect during critical incidents. In other words, in situations where SPE techniques are required, whether for defending oneself, or subduing an opponent, higher strength and power capacity could be beneficial. Considering these findings, the similarities with previous studies suggest that aerobic capacity, anaerobic endurance, and various types of strength may influence police officers' capabilities, especially pertaining to chasing a suspect, or performing tasks of a combative nature. To rephrase it, BPA may be understood as a significant basis for performing specific police tasks within all three components of critical incidents resolution: chase, subduing and problem removal.

Primarily, the significance of developing police officers' physical fitness is linked to their overall health condition, i.e., to the idea that health-based screening may prevent job related injuries (Lonsway, 2003; Strauss et al., 2021). Secondly, it is to be found in the link to professional efficiency, since it could predict a successful job performance in critical incident resolution (Lockie et al., 2018; Janković & Dosaj, 2022). To meet professional standards, the UCIPS selection system filters out candidates with inadequate physical abilities, hence enabling the selected students to follow the SPE educational process. Furthermore, they could achieve the objective of developing their physical abilities to the projected level above the 66.6th percentile, in comparison with the general population's average (Dopsaj et al., 2007). During BPA assessment at the entrance exam, the tests candidates perform are the same for female and male candidates; however, they are later graded in accordance with the sex-specific standards. This method ensures the selection of the most physically adept students of both genders, thereby reducing potential bias due to biological differences. In other words, even when the grading system included the assessment of physical capabilities, the criteria were adjusted based on sex, ensuring that all students had an equal chance to pass the exam and receive a fair grade (Koropanovski et al., 2022). This type of evaluation (adjusted to sex), is justified when it comes to UCIPS students, i.e. future PO. During the selection process, they manage to meet the minimum fitness standards, which enables them to successfully follow and acquire the techniques prescribed by the SPE program (Dimitrijević et al, 2014). However, different work positions within the Ministry of Internal Affairs do not require the same level of physical fitness. In other words, prior to assigning a specific job role, it's crucial to ascertain candidates' BPA and SPA levels of BPA and SPA, defined in relation to the required professional competences (same job – same standard). With the standards thus established, corresponding to bone fide professional requirements, would be independent of sex or age (Strating et al., 2010; Janković et al., 2020).

Resolving problematic situations demands both physical and psychological resilience. Physiological responses, intensified by physical exertion and psychological stress, can reach significant levels. Therefore, efficiency, in addition to the level of developed BPA and SPA, may also depend on the psychological characteristics of PO (Živković et al., 2022; Amanović & Milošević, 2022). Additionally, the efficiency in managing such situations is influenced by the quality of equipment available to PO. Lastly, tactical readiness allows for the integration of all

the mentioned resources, in order to respond to each individual critical incident in best possible way (Vučković et al., 2011). Effective response in stressful situations, necessitating sound judgment, hinges on adequate training. The result of this training would be enabling people who are capable of operating effectively in highly demanding circumstances and possess the necessary physical condition to perform at their best in those conditions (Crawley et al., 2015). Consequently, a holistic educational approach that integrates physical, technical-tactical, and psychological aspects is crucial in SPE training. Additionally, during the evaluation of the effects of the educational process, an appropriate battery of tests should be used to assess the corresponding BPA and SPA, which could to a certain extent predict effectiveness in problem-solving situations (Janković & Dopsaj, 2022).

CONCLUSION

This paper suggests BPA can to some extent influence the results of job-related fitness test, i.e., that suitable physical readiness at a general level could positively impact the manifestation of police officers' specific motor abilities. Furthermore, considering the structure of OCSAPO1 tasks, certain observed BPA may be presumed to greatly influence specific sections of the test. For instance, Acc10m, LSR10m, IAT, ShR300y and CT could strongly affect the efficiency of performing tasks which require various running modes; SLJ and SU may possibly influence the ability to overcome obstacles; BP1RM could affect the ability to overcome an attacker and carry a dummy, whereas FmaxHG might be a significant component affecting specific manipulations, such as changing a magazine, or handcuffing a suspect.

Given the relationship between BPA, professional efficiency, and PO's health status, refining the test batteries for situational SPE assessment is recommended. What is more, future research should focus on ascertaining the appropriate minimum fitness standards for police students in their final UCIPS years, so that their work abilities can be classified based on this criterion. Likewise, it is necessary to constantly monitor and improve the ways of training and testing, which could be conducive to future police officers gaining even more adequate professional competences.

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ASSOCIATION OF PHYSICAL ABILITIES TO ACADEMIC SUCCESS IN POLICE STUDENTS

Filip Kukić¹, Radivoje Janković², Nenad Koropanovski²

¹Faculty of Physical Education and Sport, University of Banja Luka, Banja Luka, Republika Srpska, Bosnia and Herzegovina

²University of Criminal Investigation and Police Studies, Belgrade, Serbia

Correspondence: doc. Filip Kukić, Assistant professor;

filip.kukic@ffvs.unibl.org

SUMMARY

As physical abilities are essential for good health and performance in police officers, they are also one of the major factors for the enrolment in a police academy. However, their relationship to academic success and efficacy has not yet been clearly established, especially in females. The aim of this research was to investigate the association of physical abilities with academic success measured by grade point average (GPA) and academic efficacy measured by time to graduate of female candidates for police studies. Physical abilities of 40 female candidates for the admission to the University of Criminal Investigation and Police Studies were analyzed at the time of selection and their study success and efficacy were obtained after they graduated. The correlation and regression analyses were used to investigate the association of physical abilities with GPA and time to graduate. The GPA was associated with repetitive power of upper extremities and whole-body contraction extension test (WBCE). It could be concluded that students whose physical exercise culture was better developed also had stronger chances of a favorable academic outcome. It could be argued that the UCIPS students who have a better-developed exercise culture also have stronger chances of a favourable academic outcome. The results of this research could be used as the foundation for future research that would investigate the association between physical abilities and success in policing jobs. This would help in the identification of the best individuals for the job and in the development of new selection, education, and exercise programs for police officers.

Keywords: recruitment; education of police officers; police; special physical education.

INTRODUCTION

Physical abilities are among the main aspects of good health and performance in police officers; thus, they are regarded as one of the major factors in the process of enrolment in a police academy. The duties of a police officer may consist of a wide diversity of tasks, ranging from long hours sitting behind the desk or in a patrol car to psychologically and physically demanding tasks, such as protecting sports events, on-foot suspect chase, or entering a burning building. The police duty is to maintain social safety and security, often engaging a set of specialized motor skills such as martial arts, which highly depend on the level of physical abilities (Anderson et al., 2001, 2002; Kukić & Maamari, 2017; Sorensen et al., 2000). The strategic management of improvement and maintenance of the performance and health of POs should be based on a professional and sustainable expert system that would aim to increase the precision of the selection processes. The recruitment process is highly important for law enforcement agencies because a good selection may decrease the probability of premature discontinuation of the educational process in police students, and ultimately optimize the economic cost of educating future police officers.

Police students' physical abilities can play an important role in addressing the issue of predicting success in graduation (Lockie et al., 2019; Shusko et al., 2017). Therefore, the initial phase of the police officers professional education represents the selection process, whereby one of the main parameters is testing the level of physical abilities in order to identify the most capable candidates (Janković & Koropanovski, 2017; Strating et al., 2010). After the selection, it is necessary to further develop, maintain and control the POs' physical abilities because their inadequate level may be a limiting factor in the performance of professional duties and could lead to poor productivity, injuries and long-term disability, the final result of which may be the loss of human resources and economic costs (Lonsway, 2003). In that regard, an effective selection followed by an adequately efficient study process is highly significant for each police student, and for the development of a safe and secure society.

The enrollment criteria, which are fundamentally influenced by the university curricula and the duties that police students are required to conduct once they graduate, may differ between countries. Although it is generally expected that the selected candidates would be successful in the study process, research has showed that not all students graduate (Lockie et al., 2019; Nora et al., 2005). In that regard, several studies have investigated the effects of physical activity, the level of physical abilities and/or physical fitness on study success (Danbert et al., 2014; Lockie et al., 2019; Shusko et al., 2017). It has been reported that physical activity has a positive effect on students' academic success, whereby students who were recreational sports fitness members had a higher graduate point average (GPA) and cumulative credit completed (Danbert et al., 2014). Shusko et al. (2017) found that the low performance in push-ups and 1.5-mile run-time at the baseline of police academy studies was most strongly associated with failure to graduate, while Lockie et al. (2019) recently reported that recruits with better high-intensity running capacity and aerobic fitness had higher probability of completing the police academy.

Previous studies have reported the influence of physical education and various teaching programs on students' physical abilities in higher police education (Dimitrijević et al., 2014; Lagestad & van den Tillaar, 2014), while some studies have focused on the influence of recruits' physical abilities on completing the police academy (Lockie et al., 2019; Shusko et al., 2017). Overall, these studies have highlighted the need for the adequate initial level of PSs' physical abilities. However, it is unclear how these may reflect on the study process in terms of academic success and efficacy. Thus, the aim of this retrospective study was to determine the impact that PSs' initial physical abilities had on the study outcomes, defined by the GPA and time needed to graduate (TG). Therefore, the main hypothesis was that initial level of physical abilities would be associated with study outcomes.

METHODS

Participants

A retrospective data of physical abilities of 40 female candidates for the admission to the University of Criminal Investigation and Police Studies in Belgrade (UCIPS) were analyzed at the time of selection, and their study such as GPA and TG. The system of candidate selection for the UCIPS is designed as a multi-dimensional positive selection model, consisting of success achieved in previous education (maximum 40 points); health status with the evaluation of psychological structure and personal predispositions (eliminatory test); and physical ability assessment (maximum 20 points), general knowledge test (maximum 20 points) and Serbian language test (maximum 20 points) (Dimitrijević et al., 2014). Thus, the physical abilities accounted for 20% of total enrolment criteria. All participants and the testing personnel were informed about the aims and the long-term importance of the data collection. Signing an informed consent was a mandatory part of the selection process. The research was carried out in accordance with the conditions of the Declaration of Helsinki, considering the recommendations guiding physicians in biomedical research involving human subjects (Christie, 2000), and with the permission of the UCIPS Ethics Committee.

Testing procedure

The candidates were divided into groups so that the assessments of all physical abilities could be done in one day in accordance with the UCIPS Laboratory standardized procedure for assessing basic physical abilities. A ten-minute running warm-up and ten-minute calisthenics and active stretching preceded the testing. Following a detailed explanation and qualified demonstration of each test, all participants performed a practice trial followed by two consecutive experimental trials, and the best result was used for further analysis. The rest periods lasted two minutes between the consecutive trials and 15 minutes between the two consecutive tests. Only tests of repetitive abdominal flexors power and aerobic endurance (Cooper 12-min running test) were performed once because a repetition trial would prevent fast body recovery and it would be time-ineffective, considering the number of participants that needed to be tested in a short time.

Muscle force measurements

Using a standardized measurement procedures previously reported in research (Dopsaj et al., 2000, 2019), maximal handgrip strength (HGS) was measured while the participant was in the sitting position with hand extended next to the body. The tensiometric probe with a built-in A/D converter connected to a software system was attached to the adjustable handgrip device allowing comfortable grip. After the signal was given, the participant executed maximal voluntary isometric contraction by squeezing the device as strong as possible, with no movements made in the front and lateral planes. The participants were cheered and encouraged verbally and they had live visual feedback of their force development.

Muscular power of lower limbs

Abalakov vertical jump test (ABL), consisting of a countermovement jump with arm swing, expressed as jump height in cm, was used to measure the explosive leg power in the vertical plane (Markovic & Jaric, 2004). The participant was instructed to jump as high as possible after performing a preceding countermovement with arm swing. The participant was also required to land approximately at the point of take-off. The test was conducted on a contact platform (Contact plate, Globus, Codogno, Italy; accuracy ± 0.001 second) that records flight time (t). The rise of the center of gravity above the ground (height in centimeters) was calculated from the time of flight (t, expressed in s) applying the ballistic law: $h = 1/8 t^2 g$ ($g = 9.81 \text{ m/s}^2$), which was shown to be highly reliable, with ICC > 0.9 (Markovic et al., 2004).

The explosive leg power in the horizontal plane was assessed by a standing long jump (SLJ) test following the procedures of Pihlainen et al. (2018). The participant was instructed to jump as far as possible from the marked line with both feet, his hands free to swing. The distance from the starting to the landing point at the heel contact was measured in centimeters with 1 cm measurement precision (Markovic et al., 2007).

Upper-body muscular power

The repetitive arm extensor power was estimated with a test of the maximum number of push-ups performed within 10 seconds (PU10s). The initial position was with the body prone, arms extended, hands positioned at shoulder width, and only feet and palms touching the floor (Ebben et al., 2011). From the initial position, the participant went down with his chest to the ground, bending only the elbows, while the body remained in a firm starting position. The results were expressed in a number of correctly performed push-ups.

The abdominal flexor repetitive power was estimated as the number (No) of sit-ups in 30 seconds (SU30s), with alternate rotations of the upper body to the left and right and contact between the opposite knee and elbow (Dimitrijević et al., 2014). The participant lay on his back with legs bent at the knee at a 90-degree angle, feet fixed on the ground, palms crossed behind the head and the elbows apart. The participant performed an abdominal flexion with trunk rotation, first to one side, and then to the other side after returning to the starting position. The results were expressed in a number of correctly performed sit-ups.

Aerobic endurance

General aerobic endurance was estimated by using the 12-minute Cooper running test (RUN), whereby the participants were required to cover the longest possible distance in 12 minutes, which was shown to have a high predicting value with $r = 0.93$ and $p < 0.001$ (Bandyopadhyay, 2015).

Motor educability

Motor educability was assessed by the Whole-Body Contraction and Extension test (WBCE). The aim of the WBCE test was to estimate the participant's ability to apprehend and learn complex motor tasks (Kolarević et al., 2014). In the test, the participant lay supine on the mat, legs and arms fully extended, with arms above the head at shoulder width. One leg started bending so that the whole foot contacted the ground and continued to bend until the foot and the knee of the opposite leg (still extended) were in the same line. While holding this position, the participant turned to the side of the extended leg and after reaching the lateral position, he flexed the whole body simultaneously (trunk, arm and leg flexion) and assumed a position with open palms on each side of the head, elbows on the upper knees and feet in dorsiflexed position. Now the participant extended the whole body simultaneously, returning to the initial position, and repeated the entire movement with the other side of the body. The participant performed 24 whole-body consecutive alternate flexions and extensions, 12 on each side. The requirement was to perform the test as fast as possible, while each incorrect repetition was recorded as an error and the result was expressed as the total number of errors.

Statistics

All data were analyzed using descriptive statistics to calculate the basic parameters of central tendency: the arithmetic mean (Mean), the standard deviation (St. Dev.), Minimum (Min.) and (Max.). Pearson's coefficient of correlation and the linear regression analysis were used to establish the association between physical abilities and study outcomes. Statistical significance was defined at 95 percent probability, i.e. at $p < 0.05$ level (Hair et al., 1998) and all statistical analyses were conducted in the SPSS for Windows, Release 11.5.0 (Copyright by SPSS Inc., 1989-2002).

RESULTS

The descriptive parameters for the entrance exam physical abilities, the GPA and TG are shown in Table 1. The correlation analysis revealed that GPA was significantly associated with PU10s ($r = 0.320$, $p = 0.44$) and WBCE ($r = 0.343$, $p = 0.30$), while TG was not significantly associated to any of physical abilities.

Table 1. Descriptive statistics.

Variables	Mean	St. Dev.	Min.	Max.
GPA (No)	7.91	.82	6.53	9.73
TG (months)	56.28	11.22	44.00	80.00
HGS (DN)	33.07	5.30	19.10	45.10
ABL (cm)	32.60	5.23	18.00	42.00
SLJ (cm)	177.23	20.59	123.00	212.00
PU10s (sec)	5.50	2.67	0.00	9.00
SU30s (sec)	22.40	3.04	16.00	29.00
RUN (m)	2234.18	222.43	1585.00	2745.00
WBCE (No)	5.35	5.60	0.00	22.00

Note: GPA – grade point average, TG – time to graduate, HGS – handgrip strength, ABL – Abalakov jump, SLJ – standing long jump, PU10s – number of push-ups in 10 seconds, SU30s – number of sit-ups in 30 seconds, RUN – Cooper running test, WBCE – whole body contraction-extension test

The regression analysis revealed a significant moderate association of the initial level of physical abilities with the GPA of female police students (Figure 1). Within the regression model, the most significant unstandardized coefficients were PU10s and WBCE (Table 2). Regarding the TG, the regression analysis did not reveal significant association with initial level of physical abilities (SEE = 11.12, $F = 1.10$, $R^2 = 1.94$, $p = 0.386$).

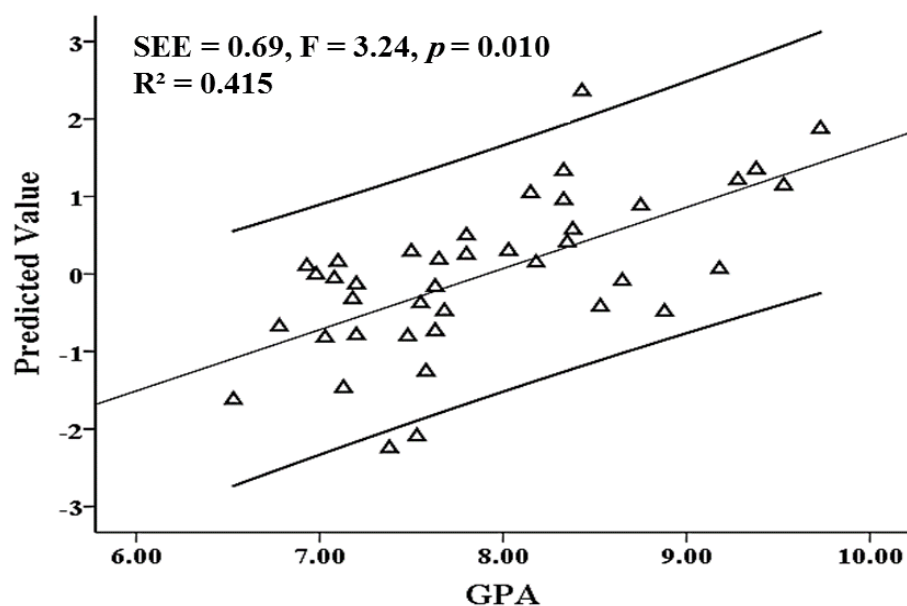


Figure 1. Regression analysis. Note: SEE – standard error of measurement, GPA – Grade point average..

Table 2. Unstandardized coefficients of GPA prediction from physical abilities.

Variables	Coefficients		t	Sig.	Confidence Interval	
	B	St. Err.			Lower bound	Upper bound
Constant	10.032	1.852	5.418	.000	6.260	13.804
HGS	.016	.022	.710	.483	-.030	.062
ABL	-.006	.043	-.145	.885	-.094	.082
SLJ	-.009	.011	-.792	.434	-.031	.014
PU10s	.234	.066	3.551	.001	.100	.369
SU30s	-.080	.051	-1.574	.125	-.184	.024
WBCE	.062	.024	2.627	.013	.014	.110
RUN	.000	.001	-.510	.614	-.002	.001

Note: HGS – handgrip strength, ABL – Abalakov jump, SLJ – standing long jump, PU10s – number of push-ups in 10 seconds, SU30s – number of sit-ups in 30 seconds, RUN – Cooper running test, WBCE – whole body contraction-extension test

DISCUSSION

This study investigated the association of physical abilities with success and efficacy. The main findings showed that 41.5% of GPA could be explained by physical abilities. Specifically, PU10s and WBCE bear a significant coefficient of determination of students' GPA. Therefore, the main hypothesis of this study was true, which suggests that physical fitness is of crucial importance for successful graduation, hence preparation for police job.

The results of this study are somewhat similar to previous observational investigations, which found that candidates who enrolled in police academy study programs possessed better physical abilities than the ones who failed to enter the studies or who did not graduate (Lockie et al., 2019). This is particularly important, given that most of the education within the curricula at the UCIPS belongs to social sciences and law, while specialised physical education consists of three one-semester subjects, or 7.5% of the total GPA. This notion suggests that the view of how physical education could be implemented within the curricula of the UCIPS could potentially be reviewed and adjusted. More importantly, non-police university colleges might consider the strategies of enhancing their students' physical fitness to improve their study success, while at the same time they would improve their health and quality of life. However, the results suggest that not all physical abilities were equally sensitive and indicative of academic success. This could be related to the specificity of highly selected sample of participants based on their physical abilities (i.e., homogenous sample). However, future research is needed to investigate this notion.

Although physical fitness profile represented by all measured tests was a significant predictor of study success, only upper-extremity power and motor educability were sole significant predictors. More precisely, 23.4% of the variance in the GPA was explained by the repetitive power of upper extremities and 6.2% was explained by the ability to learn movement quickly. It is not clear why only these two variables played the most significant role among physical abilities. A potential factor contributing to this phenomenon may be rooted in the historical development of the police force and police education, originally designed with a male-dominant orientation, emphasizing men as primary duty performers (Anderson et al.,

2001; Rabe-Hemp, 2009; Starheim, 2019). Consequently, these inherent characteristics may persist, rendering the physical demands of the PU10s test, measuring upper limb strength, notably challenging. It appears that female candidates in police studies who demonstrate proficiency in executing this test through a "masculine approach" may navigate the academic process more successfully. Conversely, activities such as running and abdominal exercises, deemed biologically more aligned with women in comparison to push-ups (integral to the pushing and pulling arm pattern (Morris et al., 2020; Sterkowicz-Przybycień & Ambroży, 2013)), do not exhibit significant differentiation among the already highly selected participants. However, achieving proficiency in push-ups necessitates heightened training and motivation for women. It is conceivable that their motivation for physical performance may extend to a greater commitment to academic excellence.

Considering nature of the WBCE test, the ability to perform complex movement repeatedly with as low number of errors as possible it could be that the selection process is biased toward physically more capable female candidates. While WBCE performance alone plays a minor role in GPA of female students, its significance suggests that it may add to the overall quality (higher GPA) of the female police students (i.e., female police officers in the policing system of the Republic of Serbia). It should be noted that the WBCE is an indicator of motor intelligence, which is a component of general intelligence, hence providing a potential rationale for the observed correlation. However, given that GPA is only one indicator student's quality (Soh, 2010) nor the best predictor of job success (Bretz, 1989) future research is needed to investigate this further.

CONCLUSION

This paper analysed the physical abilities of the candidates for the UCIPS with the aim to investigate the association between the initial level of physical abilities, and academic success and efficacy. The academic success and efficacy were measured by the GPA and the number of months the students needed to graduate, respectively. The correlation and regression analyses revealed a significant association of physical abilities on recruitment day and students' GPAs. Namely, better performance at the test of the repetitive power of upper extremities and the ability to learn complex motor tasks quickly were shared significant variance in GPA. It could be argued that the UCIPS students who have a better-developed exercise culture also have stronger chances of a favourable academic outcome. The results of this research could be used as the foundation for future research that would investigate the association between physical abilities and success in policing jobs. This would help in the identification of the best individuals for the job and in the development of new selection, education, and exercise programs for police officers.

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