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Contents

ORIGINAL SCIENTIFIC ARTICLES

Теорія та методика фізичного виховання
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ORIGINAL SCIENTIFIC ARTICLE

SOCCER TRAINING METHODOLOGY: A COACH'S VISION

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. Based on the fundamental principles of training, the methodology that each coach develops in the planning of sessions can be effective in improving the performance of their athletes.

Study purpose. Therefore, the general objective pursued in this study was to find out the type of work carried out by the coaching staffs in their different teams/clubs.

Materials and methods. For this work, a descriptive cross-sectional study was carried out on a sample of 517 coaches from different divisions and nationalities. To characterise the sample, descriptive measures were used and Pearson's chi-square was used to study whether there is a relationship between the variables studied. All statistical analyses were performed with Stata and statistical significance was always set at a p-value < 0.05.

Results. The results indicated that the methodology preferred by the coaches for working on the technique was the Coerver and analytical methods. The global and analytical methods were the most used on average by the coaches for tactical work. The coaches, regardless of the division or category in which they train, indicated that strength is the most important capacity to work on.

Conclusions. The results of this study can be very useful for future coaching staffs when distributing training sessions and workloads.

Keywords: football, methodology, training, coaches, coaching staff.

Introduction

In recent years there has been a substantial growth in research related to football specific training methods with a strong emphasis on the effects of small-sided games (SSG). The increase in research on this topic coincides with the rise in popularity gained by football-specific conditioning, which involves training players to cope with football match situations. Available studies indicate that physiological responses, tactical and technical skill requirements can be modified during SSGs by altering factors such as the number of players, field size, game rules and coach encouragement (Aguiar et al., 2012). Football is a situational sport, subject to many variables such as field, opponent, teammates, presence of the ball and other factors. However, the aspects that significantly affect training in this sport are: conditional, psychological and technical-tactical aspects (Gaetano & Rago, 2014). In the same way, football coaches also value their autonomy, self-efficacy and the fact that training sessions are varied and demanding as positive aspects for their professional satisfaction (Sanmiguel-Rodríguez, 2021a).

Traditional periodisation models in football have some characteristics such as the individualisation of the training load and the response of the training load based on biological laws. Therefore, most of these models aim for the athlete to reach a peak of fitness at a certain time (Martín, 2022). However, in a sport such as football, peaks of fitness have to be constant during the course of the season. Tactical Periodisation is a training methodology, originally

developed for football that focuses primarily on the Pattern of Play that a team intends to use in competition. It has been popularised by successful European coaches and has subsequently been proposed as a model for other sports (Martin, 2022). Branquinho, Ferraz and Marques (2020) indicated that training load has become relevant for coaches in recent years. The correct choice of training method can help coaches to increase the performance of their teams and achieve the proposed training objectives (Branquinho, Ferraz & Marques, 2020).

Based on the fundamental principles of coaching, an effective working methodology has to be used to improve performance in each of the sport specialities (Poveda & Poveda, 2006). Each sport has a model of competition and a dynamic of actions and efforts that mean that training has to be diverse in its approach. In football, not only must energy metabolisms and the required motor capacities be trained, but it must also be done with methods that ensure a good transfer to each competition match (Poveda &Poveda, 2006). Thus, the evolution of training and teaching methods has been a frequent topic of research in sport science for many years, reaching all sport modalities, including football (Barrero, 2023). Likewise, the modelling of sport training in football must consider principles such as specialisation and sport specificity, as the different functions of the game show notable modifications in the application of physical stimuli; therefore, certain indicators for training must be taken into account (Morocho, 2022). There are substantial differences between one type of training methodology and another, mainly due to the way of planning and imparting the contents, the tasks and the control of its effectiveness by the coaches. Morejón Rodríguez and Martín Agüero (2019) pointed out the advantages of the Structured Constitutive Alloy training as a type of training that is coupled to the characteristics of the General Identity Game Model, to the preparation for competition, as well as to the game system with its respective model and tactical drawings; also adjusting to the individual characteristics of the footballers, their position and function within the system and the game model.

To talk about physical fitness training is to talk about the human being's ability to adapt. For decades, football has developed different schemes, means and methodologies in the sports training cycle, with the sole purpose of obtaining better results. In the origins of football before the 1900s, the game was based on actions in which strength and endurance predominated, the objective was to mark the opponent by means of any action or basis of the game, regardless of the technique of execution (Perlaza & Chávez, 2014). Over the years, football began to take on new perspectives, from periodisation to the preparation of the different aspects of sports training, based on physical preparation. Nowadays, football has become more strategic, physical and tactical, the classic game no longer predominates, on the contrary, we now see a more stylised, faster football, typical of the evolution that occurs year after year (Perlaza & Chávez, 2014). Physical, technical and tactical preparation becomes essential when planning the sports training cycle, and this is what leads to sporting success in football teams. When talking about tactical periodisation and its role in football planning in competition, it is important to know that the coaching staff is the only one who decides and applies its training and control system (Perlaza & Chávez, 2014). For its part, the teaching of ball control technique in football generates great impact in the sporting sphere, provoking in the players the necessary stimulus to learn the technical gesture, encouraging athletes to prepare themselves to reach the elite and participate at international level in the major world leagues (Lasso Morales et al., 2023).

The sport initiation processes are fundamental for children to learn the basics necessary to practice sport. In the different training categories in football, various teaching methods are applied, with the analytical method being the most accepted; the planning of exercises similar to competition and focused on tactics suffer alterations (Motato Rodríguez & Quilindo, 2021). Pre-sports games are considered essential resources when practising a sport, and football in particular, as they help in the development of areas such as motor, cognitive and social, i.e. they offer a comprehensive training in the human being, in addition, they allow the development of skills and necessary abilities (Vargas-Cuenca & Avila-Mediavilla, 2022). The most relevant findings are characterised by demonstrating the lack of knowledge of the methodology of pre-sports games and the lack of application in training. It is concluded that, within the football academies, coaches do not include this methodology in their daily planning for football practice (Vargas-Cuenca & Ávila-Mediavilla, 2022). The training methodology in training football should not be based on applying the same methodology as in adult football by reducing its volume, intensity and complexity. It is about applying another methodology according to the biological age within each stage (Ruiz, 2004). Sports training with young people should transmit educational values by developing mechanisms for personal improvement and respect for opponents in a favourable environment for all the agents involved (Pinheiro et al., 2014).

On the other hand, top-level competitive sport, in the pursuit of sporting success, has among its main objectives the victory and the improvement of results. Sport sciences maintain a continuous effort in relation to the application of new methodologies and training systems to improve and maintain the performance of athletes. Team sports require methodologies adapted to their idiosyncrasies (Pons et al., 2020). The detection of sporting success constantly drives coaches, performance analysts and researchers to evaluate and promote new methodologies to improve performance. Technique has often been the subject of debate about the real methodological approach to adopt in adolescence (Pietro & Filomena, 2019). However, knowing the reality and the events that occur in professional competitions allows coaches to propose different training programmes, as well as to change the game model as needed, adapting to the competitive reality (Fernández-Cortés et al., 2020). The complexity of the physical demands of football requires the implementation of a multi-component training programme. The development, planning and implementation of such a programme is difficult due in part to practical constraints related to the competitive calendar. Therefore, effective planning and organisation of training is crucial to the effective delivery of the training stimulus for both individual players and the team (Morgans et al., 2014).

Therefore, the overall objective pursued in this study was to understand the type of work that coaching staffs carry out in their different teams/clubs.

Materials and methods

Study participants

For this study, a descriptive cross-sectional study was carried out on a sample of 517 coaches (men n = 500; women n= 17) from different divisions and levels with an average age of more than 37 years (M = 37.16 ± 9.925), an average professional experience of more than 10 years (M = 10.08 ± 7.857).

To calculate the sample size, the database of federated licences issued in Spain by the Royal Spanish Football Federation in the year 2022 (Ministry of Culture and Sport, 2023) was used, registering a total of 1,137,651, which, establishing a margin of error of 5% and a confidence interval of 95%, requires a minimum sample size of 385 subjects. The calculation of sample size for survey research is key to ensuring conclusive results.

For the analysis of the results, the sample was divided into categories according to the division in which they were training, being first division/national team (n = 7), second division (n = 4), third division (n = 17), preferential (n = 64), regional (n = 77), base (n = 333) and no team (n = 15).

Study organization

The instrument used was an ad hoc questionnaire to collect information on the distribution of training sessions (number of sessions, time dedicated to basic skills, technique, tactics, methodological aspects of training, psychological variables and other questions related to job satisfaction). To obtain information, they completed a questionnaire of 35 questions divided into 3 sections (Table 1). For the elaboration of this study, only 5 questions of the 35 in the questionnaire were used, as these questions were the ones focused on the objective of this research.

Table 1. Questionnaire sections and questions

Sections of the questionnaire	Questions
Demographic aspects (9 items)	Gender, age, years of dedication, nationality, division in which he/she trained or currently trains, highest category in which he/she trained and in which he/she most enjoyed
Distribution of the training session (19 items)	Number of sessions, time spent on different skills, technique, tactics, methodology and psychological variables
Other general aspects (7 items)	Aspects of satisfaction with the profession and changes in training during COVID-19

All study factors were treated as nominal or continuous variables, and the response format used in the instrument was closed-ended and open-ended. The reliability of the questionnaire was determined by standardising the survey administration protocol for all participants.

The questionnaires were completed online from August to September 2020. The questionnaire was available through Google Forms containing informed consent and information related to research ethics. These questions were randomly provided to coaches and members of the coaching staff of different clubs and, in turn, the presidency of the Football League and the Galician Football Federation were contacted to distribute the questionnaire among the coaches who have the following information.

Statistical analysis

Descriptive measures (frequencies, percentages, mean and standard deviation) were used to characterise the sample. All statistical analyses were performed with Stata version 12 (StataCorp., United States) and statistical significance was always established at a value of $p < 0.05$.

The ethical recommendations for research in the field of Sports Science (Aragón-Vargas, 2015) were followed at all times, maintaining the confidentiality of the data, the anonymity of the participants and informing them that they could cancel their participation in the study at any time during the study.

It was explained to all participants that the study respected the ethical principles of the Helsinki declaration and the Data Protection Act 15/1999 (Government of Spain, 1999).

Results

The average method most used by the coaches of the first division/national team, preferential and base for the work of the technique was the coerver with 28.6%, 18.8% and 17.4%. More specifically, those in the first division/national team and second division indicated that they preferred the analytical method with 28.6% and 25% respectively. These second division coaches also indicated an equal preference for general methods (25%), integral (25%) and simple individual exercises (25%). On the other hand, third division coaches used more the mixed method 29.4%; while regional coaches used more the methodised method 20.8%.

On the other hand, the global method was the most used on average by second division, preferential, regional and grassroots coaches for tactical work with 25%, 23.4%, 24.7% and 18.6% respectively. In addition, second division coaches also indicated an equal preference for integrated and collective methods (25% in both cases). However, first division/national team coaches preferred the analytical method (42.9%), while third division coaches preferred integrated and zone work (23.5% in both cases).

The variable indicated by the coaches of all divisions as the most important to work on in training was technique, except for the second division coaches who indicated that it was the psychological aspects (Table 2).

When asked about the most important quality to work on, the coaches, regardless of the division or category in which they trained, indicated that strength was the most important capacity to work on in their session planning (Table 3). Likewise, the work method preferred by the coaches, regardless of the division or category in which they trained for the development of the basic physical capacities was aerobic or analytical (Table 4).

When asked what they liked most about coaching, third division and regional coaches indicated that it was competing; for first division/national team, second division

Table 2. Most important variable to work on in training sessions

Current Division			Frequency	Percentage
Regional	Valid	Psychological aspects	19	24.7
		Technical	30	39.0
		Tactical	14	18.2
		All	11	14.3
		Strategy	3	3.9
		Total	77	100.0
Base/children	Valid	Psychological aspects	67	20.1
		Technical	108	32.4
		Tactical	63	18.9
		All	42	12.6
		Physical qualities	32	9.6
		Group management	8	2.4
		Strategy	12	3.6
		No opinion/no reply	1	0.3
		Total	333	100.0
Preferential	Valid	Psychological aspects	7	10.9
		Technical	25	39.1
		Tactical	12	18.8
		All	9	14.1
		Physical qualities	6	9.4
		Group management	1	1.6
		Strategy	2	3.1
		No opinion/no reply	1	1.6
		Total	63	98.4
	Valid	System	1	1.6
	Total		64	100.0
Second division	Valid	Psychological aspects	2	50.0
		Technical	1	25.0
		All	1	25.0
		Total	4	100.0
Third division	Valid	Psychological aspects	4	23.5
		Technical	9	52.9
		Tactical	1	5.9
		All	1	5.9
		Physical qualities	2	11.8
		Total	17	100.0
First division / National team	Valid	Technicians	4	57.1
		Tacticians	1	14.3
		All	1	14.3
		Physical qualities	1	14.3
		Total	7	100.0
No equipment	Valid	Psychological aspects	3	20.0
		Technical	6	40.0
		Tactical	3	20.0
		All	1	6.7
		Physical qualities	2	13.3
		Total	15	100.0

Table 3. Most important quality to work on

Current Division			Frequency	Percentage
Regional	Valid	Strength	31	40.3
		Endurance	20	26.0
		Speed	17	22.1
		Flexibility	9	11.7
		Total	77	100.0
Base/children	Valid	Strength	137	41.1
		Endurance	122	36.6
		Speed	60	18.0
		Flexibility	14	4.2
		Total	333	100.0
Preferential	Valid	Strength	22	34.4
		Endurance	22	34.4
		Speed	17	26.6
		Flexibility	3	4.7
		Total	64	100.0
Second division	Valid	Strength	4	100.0
Third division	Valid	Strength	7	41.2
		Endurance	5	29.4
		Speed	4	23.5
		Flexibility	1	5.9
		Total	17	100.0
First division / National team	Valid	Strength	3	42.9
		Endurance	2	28.6
		Speed	2	28.6
		Total	7	100.0
No equipment	Valid	Strength	2	13.3
		Endurance	10	66.7
		Speed	1	6.7
		Flexibility	2	13.3
		Total	15	100.0

and preferential division coaches it was programming and grassroots coaches indicated their preference for transmitting and teaching. The coaches, regardless of the division in which they coached, showed that what they liked least about coaching was the families and the environment. Regardless of age and years of professional dedication, the time spent training, expressed in minutes on average, was practically the same. Those over 40 spent more time on technique and strategy and those aged 31-39 on tactics and basic physical skills (Table 5).

Discussion

Work on technique and tactics

The results of this study indicated that coaches in all divisions (except those in the second division who indicated psychological aspects) indicated technique as the most important variable to work on in their sessions.

Lázaro Paulina et al. (2022) suggested that the assessment of coaches' and players' perception of competences to detect talent was similar for all dimensions, highlighting tactics, technique and psychosocial aspects. Following these contributions Sgrò et al. (2018) indicated that high level of technical skills and tactical behaviour are key factors for optimal performance in football matches. For Aedo-Muñoz et al. (2020) a technique-based biomechanical perspective could offer a promising strategy to improve, based on technique training and analysis, performance in football. Barquero-Ruiz et al. (2022) suggest that tactical training in introductory football, including team, small groups and individuals, favoured the understanding of the game and tactical learning. In other research (Bernal-Reyes et al., 2018) they evaluated fundamentals such as dribbling, ball handling and striking the ball with both feet and head. The results indicated that both groups improved in all technical fundamentals at the end of the training programme. For the design of an introductory football teaching programme,

Table 4. Preferred working method physical abilities

Current Division			Frequency	Percentage
Regional	Valid	Circuits	5	6,5
		Analytical	8	10.4
		Global	8	10.4
		Aerobic	12	15.6
		Own	7	9.1
		Autoloads	12	15.6
		Integrated	7	9.1
		With ball	4	5.2
		No opinion/no reply	14	18.2
		Total	77	100.0
Base/children	Valid	Circuits	29	8.7
		Analytical	32	9.6
		Global	36	10.8
		Aerobic	61	18.3
		Own	33	9.9
		Autoloads	28	8.4
		Integrated	26	7.8
		With ball	14	4.2
		No opinion/no reply	74	22.2
		Total	333	100.0
Preferential	Valid	Circuits	5	7.8
		Analytical	11	17.2
		Global	8	12.5
		Aerobic	11	17.2
		Own	9	14.1
		Autoloads	3	4.7
		Integrated	1	1.6
		No opinion/no reply	16	25.0
		Total	64	100.0
Second division	Valid	Global	1	25.0
		Aerobic	1	25.0
		Own	1	25.0
		With ball	1	25.0
		Total	4	100.0
Third division	Valid	Circuits	2	11.8
		Global	1	5.9
		Aerobic	6	35.3
		Own	2	11.8
		Integrated	1	5.9
		With ball	1	5.9
		No opinion/no reply	4	23.5
		Total	17	100.0
First division / National team	Valid	Circuits	1	14.3
		Analytical	3	42.9
		Global	1	14.3
		Aerobic	1	14.3
		With ball	1	14.3
		Total	7	100.0
No equipment	Valid	Circuits	1	6.7
		Analytical	4	26.7
		Global	3	20.0
		Aerobic	2	13.3
		With ball	1	6.7
		No opinion/no reply	4	26.7
		Total	15	100.0

Table 5. Bivariate correlations between the variables analysed

	A	YT	WTS	WTH	MT	WT	MOT	WTS	WTM	WPW	PWS	MBSS	MS
E	1.0000												
YT	0.5274*	1.0000											
WTS	0.0330*	0.1516*	1.0000										
WTH	0.0240	0.1277*	0.1639*	1.0000									
MT	0.0211	0.0982*	0.0530*	0.1068*	1.0000								
WT	0.0959*	0.1835*	0.6444*	0.1637*	-0.0597*	1.0000							
MOT	0.0683*	0.1098*	0.0249	0.0370*	0.1245*	0.1390*	1.0000						
WTS	0.0831*	0.1451*	0.4838*	0.1847*	0.0088	0.6003*	0.0764*	1.0000					
WTM	0.0117	0.0954*	0.1560*	0.1226*	0.1857*	0.1708*	0.3980*	0.2679*	1.0000				
WPW	0.1441*	0.1436*	0.4992*	0.1478*	-0.0241	0.4817*	0.1080*	0.4764*	0.1993*	1.0000			
PWS	0.0775*	0.1383*	0.0359*	0.1180*	0.1346*	0.1131*	0.3469*	0.1738*	0.5280*	0.1862*	1.0000		
MBSS	0.0770*	0.1326*	0.2855*	0.1466*	-0.0103	0.2483*	0.0671*	0.3749*	0.0550*	0.3285*	0.0765*	1.0000	
MS	0.1455*	0.0888*	0.0902*	0.0442*	0.0799*	0.0823*	0.1908*	0.1042*	0.2832*	0.0448*	0.1840*	0.1632*	1.0000

Note. *p<0.05. A: age; YT: years of training; WTS: weekly training sessions; WTH: weekly training hours; MT: minutes of training; WT: weeks of tactics; MOT: minutes of technique; WTS: weekly tactical sessions; WTM: weekly tactical minutes; WPW: weekly psychological work; PWS: psychological work session; MBSS: minutes of basic skills session; MS: minutes of strategy.

activities involving both models could be used to improve all technical gestures of the participants (Bernal-Reyes et al., 2018). Lasso Morales et al. (2023) show the importance of applying useful tools for the teaching of technical fundamentals at infant ages aimed at developing skills and abilities through the implementation of a guide of playful activities structured by the phases of initiation, organisation, development and completion.

Work on basic physical qualities

The results of this study showed that coaches, regardless of the division or category in which they develop their profession, indicated that strength is the most important capacity to work with athletes, with the aerobic or analytical method being the preferred one.

According to Bernal-Reyes et al. (2018) studies focused on the comparison of football teaching methodologies in sport initiation have not obtained conclusive results on which is the appropriate methodology in football teaching. The results of these authors (Bernal-Reyes et al., 2018) suggest that both the analytical and the global method seem adequate to improve the individual football skills of children in sport initiation. Following these contributions, Barrero (2023) developed two training sessions with two different methodologies, one traditional and the other with an active methodology, and the results showed that the active methodologies favoured learning and adherence to the sport and also obtained higher levels of satisfaction than the traditional methodologies. According to Motato Rodríguez and Quilindo (2021) the use of the methods implied adopting teaching styles that, although they give importance to traditional interaction, generate mixed styles mediated by the competitive interest of the coaches. This is a common factor among them, which provides a stance towards the training process in football involving children from 5 to 12 years old. For his part, Fernández Romo (2005) indicated that training tasks with collaboration and direct opposition simulating competitive actions is an effective method to improve the performance of each player and the team. For Marín-Pagán et al. (2020) the effects of circuit training could contribute to improve aerobic fitness and body composition in football players.

Sanmiguel-Rodríguez (2021b) indicated that sports injuries are becoming a major problem for professionals working with athletes and that it is necessary to identify the characteristics and types of injuries in order to be able to carry out more individualised and specific training. Other authors (Ayala-Obando et al., 2021) described the isometric exercises in the Physical Preparation of young football players, which strengthen certain skills and are preponderant for the practice of this sport. Physical factors include the development of flexibility, balance, strength and coordination, which together have an impact and prevent injuries. However, football clubs do not have a training plan for this type of exercise, which is why there is a lack of methodologies and a lack of knowledge on the part of the coach, making monotonous exercises that limit the athlete's potential (Ayala-Obando et al., 2021). Along these lines, Prieto-Barriga (2021) pointed out that agility is a key factor in the training of athletes and its in-depth study, diagnosis and improvement, through various training methods, could have a direct impact on the performance of football athletes from the grassroots level. In this way, plyometric training favours the development of agility and, at the same time, allows for the strengthening of certain physical capacities in child football players (Prieto-Barriga, 2021).

The ability to accurately control and monitor training load is an important aspect of effective training. The results of this study (Impellizzeri et al., 2004) indicated that training perceived exertion can be considered a good indicator of the overall internal load of football training. This method does not require particularly expensive equipment and can be very useful and practical for coaches to moni-

tor and control the internal load, and to design periodisation strategies. The results of other authors (Branquinho et al., 2020) indicated that the use of the continuous method seems to present the lowest physical impact tendency on internal and external loads compared to the fractional method. In addition, they found that the higher number of exercise repetitions in the fractional method increases the external load compared to the continuous method. The same authors (Branquinho et al., 2020) showed that the application of small sets by the fractional method tends to result in higher training loads. Branquinho et al., (2021) showed that the application of small-sided football games with different recovery times induced variable responses in training load. To maintain high physical performance and high training load, the fractional method with short recovery should be used. In contrast, to carefully manage the players' efforts and decrease the training response, continuous or fractional loading methods with longer recovery periods should be used. In contrast, results from other authors (Morin et al., 2017) showed that sprint training with very heavy sled resistance, using much higher loads than traditionally recommended, clearly increased maximal horizontal force production compared to standard sprint training with no load. The results of Mario Alves et al. (2010) suggested that complex contrast training induced an increase in sprint and jump squat performance, making it a suitable strategy for developing muscle power and speed in football players.

Likewise, according to Pastor Navarro (2004), strength training and its application to sports performance has evolved a great deal in recent decades, both in terms of its scientific foundations and its methods and means. However, there are still sports that, fundamentally, due to external factors, regardless of their characteristics and real needs, are very conservative and are reluctant to incorporate new methodologies, maintaining false conceptual ideas that end up becoming myths and impede their evolution (Pastor Navarro, 2004). For their part, Marín-Pagán et al. (2020) pointed out that strength training is a key factor for football players, but at the amateur level it is difficult to apply due to the lack of infrastructure and the short training time. In this sense, high-intensity resistance circuit-based training could be a suitable method to solve these problems. Circuit training can improve cardiorespiratory and metabolic responses while reducing training time by 66%. On the other hand, Beato et al. (2021) suggested that strength training, proposed as traditional resistance, eccentric and flywheel training, may be a valid method to reduce the risk of injury in athletes. Training strategies that involve multiple components such as a combination of strength, balance and plyometric exercises including strength exercises are effective in reducing injuries. In addition, the use of eccentric training in sports may offer physiological responses compared to other resistance exercise modalities (Beato et al., 2021).

Jovanovic et al. (2011) mentioned that a speed, agility and quickness training programme appear to be an effective way to improve some segments of power performance in young football players. Without proper planning of speed, agility and quickness training, football players are most likely to face a decrease in power performance during the competition period. In the same vein, Milanović et al. (2013) determined the effects of a conditioning programme including speed, agility and quickness training and its effect on agility performance in young football players. This suggests that training these qualities has been an effective way to improve agility, with and without the ball, for football players and can be included in fitness programmes.

Other studies

Furthermore, in another research (Dello Iacono et al., 2017) it was pointed out that training based on game profiles can be considered an advantageous training method for elite football players, capable of stimulating the physical effort and physiological capacities required during a match. This approach is favourable when designing a training intervention according to the principle of sport specificity, as it is based on specific metabolic demands. The results of Dello Iacono et al. (2021) suggest that both game profile-based training and reduced game situations (RSG) are effective for the development of physical fitness among young elite football players during competition. More importantly, these 2 conditioning methodologies can be considered in terms of specificity to selectively improve or maintain fitness-related performance in late-season football. Following these contributions, Sarmento et al. (2018) provided in their review, valuable information on the complex relationship between technical, tactical and physiological interactions in SSGs and how the manipulation of these types of variables can improve the football training process.

For Branquinho, Ferraz and Marques (2021) physical outcomes in football training can be influenced by the interaction of several variables during the performance of SSG. For this reason, it is relevant to understand how the manipulation of variables such as training method, exercise duration, number of repetitions or recovery time affect training loads and performance. The results showed that, during the 5-on-5 game format, the choice of training method (i.e. continuous or fractional) and the manipulation of related variables (number of players and game format) are critical for training load management. Therefore, the manipulation of variables using the 5-a-side football format translates into significant variations in training load and the likely improvement of the different domains of football training (physiological, physical, technical and tactical), evidencing several benefits in the use of this game format (Branquinho, Ferraz & Marques, 2021).

Clemente et al. (2014) carried out a comparison with other reduced game formats and 2 vs. 2 induced significantly higher values of technical/tactical indices, 3 vs. 3 induced significantly higher reserve values and 4 vs. 4 led to significantly higher distance and speed coverage. Other findings (Dellal et al., 2008) showed that some games in confined spaces allow the heart rate to increase to the same level as in intermittent running of short duration. The side game method can be used to provide more variety during training, mixing physical, technical and tactical training approaching the intensity of intermittent sprinting but with more variability between subjects. Sgrò et al. (2018) regarding the most used and innovative training methods, indicated that SSGs seem to be a worthy and valid methodology to simultaneously train many skills by reproducing various conditions of a real match.

Conclusions

The average method most used by the coaches has been the coerver for the work on technique. For tactical work they

prefer global methods. The coaches, regardless of the division or category in which they train, indicated that strength is the most important capacity in the planning of the sessions and that they do this by means of aerobic or analytical work. Regardless of the division in which they work, the coaches showed that what they enjoy most about their profession is programming and competing, while the grassroots coaches showed a preference for teaching. On the other hand, they indicated that the factor they liked least about their job was their families and environment. On the other hand, one of the main limitations has been the number of publications found in the different scientific databases focused on the subject of this study. However, a large part of these articles focus mainly on the study of the SSG. Therefore, the results of this study may be very useful for future technical bodies when it comes to understanding the preferences regarding the choice of methodologies in the different sessions.

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Conflict of interest

The authors declares that there is no conflict of interest.

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МЕТОДИКА НАВЧАННЯ ГРИ У ФУТБОЛ: БАЧЕННЯ ТРЕНЕРА

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 11 с., 5 табл., 46 джерел.

Історія питання. Побудована на фундаментальних засадах тренувань, методика, яку кожен тренер розробляє під час планування занять, може бути ефективною для покращення результативності їхніх спортсменів.

Мета дослідження. Таким чином, загальною метою цього дослідження було з'ясувати тип роботи, яку виконують тренерські штаби в різних командах/клубах.

Матеріали та методи. Для цієї роботи було проведене описове перехресне дослідження на вибірці з 517 тренерів з різних дивізіонів і націй. Щоб охарактеризувати вибірку, використовували описові показники, а для визначення наявності зв'язку між досліджуваними змінними використовували критерій хі-квадрат Пірсона. Усі статистичні аналізи проводили за допомогою програмного забезпечення Stata, а статистичну значущість завжди встановлювали на рівні $p < 0,05$.

Результати. Результати показали, що тренери віддавали перевагу методиці роботи над технікою методом Курвера та аналітичним методом. Глобальний та аналітичний методи тренери в середньому найбільше використовували для тактичної роботи. Тренери, незалежно від дивізіону чи категорії, у яких вони тренують, зазначили, що найважливішою здатністю, над якою потрібно працювати, є сила.

Висновки. Результати цього дослідження можуть бути дуже корисними для майбутніх тренерських штабів під час розподілу тренувальних занять і навантажень.

Ключові слова: футбол, методика, тренування, тренери, тренерський штаб.

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ORIGINAL SCIENTIFIC ARTICLE

PROGRESSIVE MUSCLE RELAXATION: CAN IT REDUCE COMPETITIVE ANXIETY?

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Abstract

The study purpose was to determine the effect of progressive muscle relaxation training on reducing competitive anxiety among shooting athletes.

Materials and methods. An experimental approach with a pretest-posttest control group design was used in this study. The experiment was carried out eight times. A total of 12 athletes, 8 males and 4 females, who were shooting athletes, took part in this research. The athletes in this study, who joined the regional training center in East Java Province, Indonesia, ranged in age from 20 to 44 years. In this investigation, saturated samples, including those from all individuals, were used. Data were obtained from competitive anxiety scales during the pre- and post-test periods. Independent samples t-tests were used to assess the data.

Results. The t-value for this study is -14,210, and the p-value is 0.001. These findings suggest that progressive muscle relaxation training reduces competitive anxiety in shooting athletes. The athlete's awareness of the value of mental training contributes to reduction in competitive anxiety. This study has gained traction since athletes are aware of the value of preparing for training before competing because they attend and participate in the regional training center.

Conclusions. Progressive muscle relaxation training can be used as an intervention to help shooting athletes reduce their competitive anxiety.

Keywords: athletes, competitive anxiety, mental training, progressive muscle relaxation, shooting sports.

Introduction

The somatic approach in the application of mental training in the world of sports aims to increase the level of awareness of the sensations that will be received by the athlete's body (Jannah et al., 2021). One of these somatic approaches is progressive muscle relaxation. Progressive muscle relaxation training is a form of concentration exercise that involves the body's muscles directly in the implementation process (Sholikhin et al., 2019). This training will make the muscles tense, then relax them (Komarudin, 2015).

Unlike other mental training techniques, progressive muscle relaxation does not only focus on relaxing the body but also benefits athletes who are aware of their body's (muscle) tension, so that increased awareness will make athletes more sensitive to their mental state (Jannah, 2017). Using progressive muscle relaxation training techniques will help athletes improve their ability to maintain their psychological state.

The application of progressive muscle relaxation in the world of sports has been done before by Khabiri et al. (2017) and Alwan et al. (2013), which describe that anxiety and negative thoughts experienced by athletes can be reduced by providing progressive muscle relaxation. The results of this study are supported by research (Mokaberian et al., 2021), which says that applying progressive muscle relaxation was shown to reduce the level of cortisol secretion through physical anxiety as well as sympathetic activity.

Mental training through a somatic approach has also been carried out (Burçak Çelik, 2020), which shows that with mental training, the competitive anxiety experienced by athletes can be reduced. This concept is in line with several studies conducted by Townsend (2010), Shirazi & Zargarzadeh (2014), and Gaylord et al. (2009) that found that by doing this mental technique, competitive anxiety can be reduced and one is better able to control oneself emotionally and physically, which are caused by anxiety, tension, and

stress. There are also 116 other studies on progressive muscle relaxation that show that this mental training technique is proven to reduce depression, pain, and anxiety (Ali et al., 2009).

The application of mental training through a somatic approach is very important for shooting athletes because shooting sports are one of the measurable sports that can train athletes to concentrate, make decisions quickly and accurately, and control themselves (Kamseno et al., 2018). Shooting is an activity that is carried out by releasing bullets, which will follow a certain trajectory that leads to the target at a certain distance, which requires encouragement from the tool itself, so that in its use it requires coordination and endurance (Alfianto et al., 2020).

To better understand the mechanics of shooting games, there are several models related to several factors that will affect the performance of shooting athletes, starting with mental factors that affect the athlete's heart rate, breathing, and muscle tension, followed by the position of the weapon on the body, the contact force of the rifle, the movement towards the muzzle of the weapon, and the position of the target point at the time of the shot.

By applying mental training through progressive muscle relaxation technique this will give the body time to rest, such as through muscle relaxation, reduced oxygen consumption, respiratory rate, heart rate, and blood lactate (Mokaberian et al., 2021), which leads to some physiological changes on a regular basis, thus would indicate a potential reduction of anxiety symptoms experienced by athletes.

Competitive will appear when athletes feel that they are unable and afraid to do something related to match performance. Competitive anxiety can be said as a natural reaction to environmental threats, such as sports competitions which can show physical and psychological responses, because athletes get threats or demands from outside (Loveyama & Widodo, 2020). Athletes who are competing, they tend to prepare well and be aware of the body movements and moral skills they are doing (Taneja & Zutshi, 2019).

Like wise athletes in shooting sports, when facing a match, the problem that often occurs is the emergence of different levels of competitive anxiety, which is related to the psychological state of each athlete. This concept is in line with research that has been conducted by (Swadesi, 2015) that competitive anxiety is divided into three levels, namely low, moderate, and high competitive anxiety. Athletes who are classified as having a low level of competitive anxiety, then in competition their performance will be good and can increase, on the other hand athletes who are classified as in high anxiety then their performance will decrease.

Based on the description and identification that has been described, this study aims to determine whether there is an influence progressive muscle relaxation to reduce competitive anxiety?

Materials and methods

Study participants

A total of 12 shooting athletes who were members of the training center for the Province of East Java. The age range of the subjects was 20–44 years, with 8 male and 4 female. Saturated samples, all subjects, were used in this study. Participants were divided into 2 groups: the experimental group and the control group. Each group consists of six athletes: four male and two female.

Study organization

In this study, an experimental approach was carried out. The experimental design used was the pretest-posttest control group design. There were two groups in this design: the experimental group and the control group. In each group, pretest data collection was carried out. After that, the experimental group was given treatment in the form of progressive muscle relaxation. However, the control group was not given any treatment. Then came the final stage of collecting post-test data in the experimental group and the control group. The description of the research design is in accordance with Table 1 of the research design and is as below:

Table 1. Research Design

Subject	Pretest	Intervention	Posttest
Experiment Group	T1	E	T3
control groups	T2	-	T4

Information:
T1 – Pre-Treatment Measurement in the Experimental Group
T2 – Pre-Treatment Measurement in the Control Group
E – The experimental group treatment was in the form of progressive muscle relaxation
T3 – Measurement After Treatment in the Experimental Group
T4 – Measurement After Treatment in the Control Group

The advantage of this design is its proactive history. This means that the pretest describes the subject's initial abilities before the research is carried out. Progressive muscle relaxation was given only to the experimental group. While the control group was not given any treatment. Progressive muscle relaxation is performed eight times consecutively, twice a week.

The Progressive muscle relaxation procedure was tested on a number of shooting athletes according to their characteristics before being used in the study. The Progressive muscle relaxation steps refer to (Jannah, 2017) through Steps 7. The first step is to direct the subject into a position as comfortable and relaxed as possible. Second, the subject is directed to focus on breathing itself, while breathing regularly. Feel the body becoming more relaxed and calm. The third step is to carry out intrapersonal communication with the limbs, from the head to the toes, to feel the sensation of heaviness. The fourth step is the same as the third, but a warm sensation is suggested. The sixth step is to feel a warm sensation on a warm stomach. Step seven: feel a cold sensation on the forehead. The closing section directs the subject to suggest that they feel safe, comfortable, warm, relaxed and happy.

The instrument used is the Competitive Anxiety Scales consist of somatic anxiety, worry, dan concentration disruption. A total of 16 items with alternative score ranges of answer choices 1–4. The maximum score that can be obtained by the subject is 64, while the lowest score is 16. The results of the competitive anxiety scales construct validity

were 0.408-0.560 with a correlation coefficient of 0.643. Based on the competitive anxiety scales score range then categorized into three parts, namely high, medium, and low. The categories are as in table 2 below.

Table 2. Categories of Competitive Anxiety Scales Scores

Categories	ValueRange
Low	16-31
Medium	32-47
High	48-64

This research was conducted in accordance with ethical principles of the Helsinki Declaration for human research and was approved by research Ethics Committee of the Surabaya State University.

Statistical analysis

The data analysis technique used is the independent t test. The purpose of the independent t test is to test the differences between the two groups independently. The scores used are the gain scores of the experimental and control groups. The gain score is the difference between the posttest minus the pretest data. Calculations were performed using a computer application tool, namely Jeffrey's Amazing Statistics Program (JASP) version 0.14.1.0.

Results

The results refer to the superiority of the experimental design used is proactive history. This means that the pretest data is able to provide information on the abilities of the subjects of each group. In each group, pretest data collection was carried out. After that, the experimental group was given treatment in the form of progressive muscle relaxation training. However, the control group was not given any treatment. Then came the final stage of collecting post-test data in the experimental group and the control group. The description of the research design is in accordance with Table 3 of the research design and is as follows.

Table 3. Proactive History

Subject	Experimental Group	Subject	Control Group
A1	60	B1	58
A2	61	B2	59
A3	62	B3	57
A4	58	B4	58
A5	56	B5	60
A6	55	B6	60
Average	58.67		58.67

Based on data from table 3, it shows that the average competitive anxiety score between the control group and the experimental group before the intervention was the same, namely 58.67. When referring to the category of anxiety scores, the score is in the high category, which means that this data describes the information that the condition of the shooting athletes in the experimental group and the control group had anxiety at a high level before doing mental training with the progressive muscle relaxation technique.

Furthermore, the results of the study presented data on emotion regulation scores before and after the intervention of progressive muscle relaxation as a whole. Based on the pretest and posttest data for the experimental group and the control group, the following data were obtained on table 4 below.

Based on data from table 4, after the application of progressive muscle relaxation, the experimental group of shooting athletes refers to the number 36.5, which shows that after carrying out the exercise intervention with the progressive muscle relaxation technique, the experimental group of shooting athletes belongs to the category of moderate competitive anxiety. The gain score in the experimental group is -22.17 which indicates that there is a decrease in sport anxiety in shooting athletes.

In the control group of shooting athletes, the post-test score showed the number 58.67 which stated that the average competitive anxiety of shooting athletes in the control group was in the high category. The control group's gain score was 0.5 which indicated that there was an increase in the competitive anxiety of shooting athletes in the control group.

The changes that occurred in the two groups were tested statistically, whether there was a difference in the gain score between the experimental group and the control group. The results of data analysis show the following:

The results in table 5 show at a value of -14.210 with an ap value of <0.001. This means that there is a difference between the experimental group and the control group. Because the gain score is the difference between the posttest and pretest

Table 4. Description of the Experimental and Control Group Data

Subject	Experimental Group			Subject	Control Group		
	Pre test	Post test	Gain Score		Pre test	Post test	Gain Score
A1	60	42	-18	B1	58	57	-1
A2	61	43	-18	B2	59	61	2
A3	62	39	-23	B3	57	56	-1
A4	58	31	-27	B4	58	59	1
A5	56	34	-22	B5	60	62	2
A6	55	30	-25	B6	60	60	0
Average	58.67	36.5	-22.17		58.67	59.17	0.5

Table 5. Results of analysis independent samples t-test

Variable	t	df	p.s
C-ANXIETY	-14.210	10	< 0.001

Note. Student's t-test

data, this indicates that there are differences in the gain score data for the experimental group and the control group. This difference in gain score is assumed to be due to the intervention of progressive muscle relaxation given to the experimental group. So the results of these calculations also mean that there is an effect of progressive muscle relaxation on reducing competitive anxiety in shooting athletes.

Discussion

The results of this research indicate that there is an effect between mental training and progressive muscle relaxation techniques to reduce anxiety. The two groups studied (the experimental and control groups), before they got the progressive muscle relaxation mental exercise, the anxiety scores of the two groups were in the same position. However, after being given progressive muscle relaxation training, the experimental group began to show scores with a decrease in anxiety. This research is in line with research conducted by Rachmaningdiah & Jannah (2016), which shows that a decrease in anxiety can occur after the implementation of mental training in athletes in the form of autogenic training.

In this study, when progressive muscle relaxation is carried out, it requires at least 3 phases, namely the education, acceptance, and practice phases, in which the three phases are included in the structuring of mental exercises (Terry et al., 2020). Besides that (Komarudin (2015) and Jannah (2016) stated that there are two main components in the progressive muscle relaxation procedure, namely systematic tensing (stretching the muscles for 5 seconds) and relaxing of various muscle groups (making muscles that are initially tense relax for 10-15 seconds).

Mental training given to athletes focuses on developing specific responses that are useful for fighting anxiety (Montero-Marin et al., 2019). The response in question is the relaxation response which is characterized by a series of physiological adjustments that arise without any tension in the mind and body (Jannah et al., 2021), where this will be balanced with the activity of the sympathetic nerves and physical rest (Adwas et al., 2019), also helps to increase the positive and negative emotions that individuals experience (Alexiou et al., 2018), so that the hormones that cause body dysregulation can be reduced (Siregar et al., 2022).

Competitive anxiety in athletes usually appears in situations before and before the competition has many indicators. The causes of this anxiety are divided into three, namely: Competitive Anxiety, Cognitive Anxiety and somatic anxiety (Adisasmito, 2007). Competitive anxiety is a mistake reflecting the feelings of athletes so that it causes an unsuccessful outcome or fear of failure. Cognitive anxiety is an athlete's subjective perception of a competitive situation followed by a somatic response. Somatic anxiety is a physiological state in response to stressful situations that athletes are aware of. This physiological state will lead to two things, namely helpers or obstacles in a match. Thus, the indicators that appear in athletes are competitive, cognitive, and somatic anxiety (Kumbara et al., 2018).

The results of this study are also in line with research conducted by (Mattle et al., 2020), which explains that there is a relationship model between various factors that are interconnected and can affect the performance of shooting athletes. These factors start with mental factors that result in decreased heart rate, tension, breathing rhythm, increased metabolism, and the production of stress hormones (Siregar et al., 2022), which is followed by the position of the body, the strength of the contact towards the gun, the position of the gun, the muzzle movement of the gun, as well as the point position of the target at the time of the shot, and ends with the result of the athlete's shot (Jannah et al., 2021).

Types of sport that in practice require little physical demands, the greater the chance for unwanted behavior to occur (Pahan & Singh, 2022), and the more information that can be received, the greater the probability of success (Lopatiev et al., 2013). By giving progressive muscle relaxation to shooting athletes, the mental training given will make the muscles begin to stretch and relax sequentially (Rochmawati, 2015), so that relaxation will help reduce negative psychological symptoms, such as the feeling of tension that athletes have will slowly disappear (Resti, 2014; Torales et al., 2020).

Conclusions

The conclusion that can be described from this research is that progressive muscle relaxation exercise has an effect on reducing competitive anxiety in shooting athletes, as evidenced by the results of a different test (independent samples t-test) of -14.210 with a significance level of 0.001

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Conflict of interest

The authors declares that there is no conflict of interest.

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ПРОГРЕСИВНА М'ЯЗОВА РЕЛАКСАЦІЯ: ЧИ МОЖЕ ВОНА ЗНИЖУВАТИ РІВЕНЬ ЗМАГАЛЬНОЇ ТРИВОЖНОСТІ?

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 5 табл., 33 джерела.

Метою цього дослідження було визначення впливу тренувань із прогресивної м'язової релаксації на зниження рівня змагальної тривожності у спортсменів-стрільців.

Матеріали та методи. У цьому дослідженні використовували експериментальний підхід за схемою попереднього та підсумкового тестування з використанням контрольної групи. Експеримент проводили вісім разів. Загалом у дослідженні взяли участь 12 спортсменів: 8 чоловіків і 4 жінки, які займалися спортивною стрільбою. Спортсмени в цьому дослідженні, які долучилися до діяльності регіонального тренувального центру в провінції Східна Ява, Індонезія, були віком від 20 до 44 років. У цьому дослідженні використовували насичені вибірки, у тому числі від усіх осіб. Дані отримували за шкалами змагальної тривожності в періоди попереднього та підсумкового тестування. Для оцінки цих даних використовували t-критерії Стьюдента для незалежних вибірок.

Результати. У цьому дослідженні значення величини t становить -14210, а значення величини p дорівнює 0,001. Ці результати свідчать про те, що тренування з прогресивної м'язової релаксації знижують рівень змагальної тривожності у спортсменів-стрільців. Усвідомлення спортсменом цінності ментального тренінгу сприяє зниженню рівня змагальної тривожності. Це дослідження набуло популярності, оскільки спортсмени усвідомлюють цінність підготовки до тренувань перед змаганнями, тому що вони відвідують регіональний тренувальний центр і беруть участь у його діяльності.

Висновки. Тренування з прогресивної м'язової релаксації можна використовувати як втручання, щоб допомогти спортсменам-стрільцям знизити рівень змагальної тривожності.

Ключові слова: спортсмени, змагальна тривожність, ментальний тренінг, прогресивна м'язова релаксація, стрілецький спорт.

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ORIGINAL SCIENTIFIC ARTICLE

DESIGN, VALIDATION, AND RELIABILITY OF A BASKETBALL SKILL AND PERFORMANCE TEST INSTRUMENT IN ADOLESCENT PLAYER

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Abstract

Study purpose. The assessment tools or skills tests, such as the AAHPERD basketball skill test and the Johnson basketball test, are all partial or separate. All these tests are old products, while the game of basketball is constantly evolving. The purpose of this study was to design and validate basketball skills and performance tests for players aged 14–16 years to shorten the test time, shorten the waiting time for results, and be comprehensive so that they can reflect real abilities and can be used as a reference when carrying out selection and evaluation.

Materials and methods. A total of 7 experts assessed the 11 elements (86 items) of the basketball skill and performance test (BSPT). Three academic experts and four basketball coach experts took part in the study. Data was collected using the Delphi technique and test-retest, and data was analyzed using Aiken's formula, intraclass correlation coefficients (ICC), and Cronbach's alpha.

Results. With a value of 0.91, the expert assessment tool shows that the content validity of the aspect is good. Cronbach's alpha was used to measure the reliability of every aspect of the basketball skill and performance test instrument, and the results were 0.918. The result of the ICC score agreement between raters is 0.912, while for one rater, the consistency is 0.596.

Conclusions. The implications of this study could prove that the BSPT can be used to assess the skill level of adolescent basketball players, benefiting not only basketball coaches but also physical education teachers.

Keywords: basketball, skill, performance, validation, reliability..

Introduction

Basketball is a dynamic sport, requiring movements constantly changing in the game and carrying out technical movements repeatedly, be it dribbling, shooting, passing, and so on. This is reinforced by the opinion (Stojanović et al., 2018), which states that basketball is a team sport characterised as a very non-sequential sport in which players constantly change their movements approximately every 1-3 seconds. Individual players must possess a variety of technical and tactical skills, in order to achieve peak performance (Bracco et al., 2019; Heemsoth et al., 2022; Levenberg et al., 2020; Waffak et al., 2022). Technical preparedness, which is laid at a young age, is especially important for improving basketball players' sport skills (Koryahin & Blavt, 2019; Koryahin & Hrebinka, 2023). Certain researchers believe that (Hugo et al., 2018; Koryahin & Blavt, 2019; Makarov, 2013) the problem of basketball players' technical training can be solved by determining the best way to distribute technical training at various stages of sports improvement and by emphasizing the importance of individual training.

A mandatory prerequisite for making a valid and reliable qualitative analysis is to use the organization of information by competent analysts (Ibáñez et al., 2019). During the selection process, sport-specific skills or performance levels are very important and depend on the right assessment norms, such as social, anthropometric, and physical/

physiological factors, as well as cognitive/psychological, tactical, and technical skills (Koopmann et al., 2020). Accurate skill assessment measurements are the right way to compare one player to another (Al-Gendy, 2012), so that the measuring instrument used is also expected to represent the individual's abilities. Having test standards makes these comparisons objective and more accurate. In the 1960s and 1980s, objective tests were the primary method for assessing motor skills (López-pastor et al., 2013). Therefore, the design of test instruments for team sports is becoming an increasingly important research topic.

Top athletes' high level of technical and tactical skills, as well as their training system, point to the need for new, nontraditional approaches to developing the most effective methods for increasing competitive activity efficiency in sports games (Doroshenko et al., 2020; Križan & Mikulič, 2018). Therefore, it is essential to use measurement techniques that can effectively reflect the actual skills of the players to properly evaluate the level of the players and then the level of the whole team (Al-Gendy, 2012). This follows the opinion (D. R. Hopkins, 2013) that a measurement programme related to each sport skill must be implemented. Various tests have been developed previously to measure basketball players' fitness levels; these tests focus on measuring aerobic and anaerobic athletes, while the skill level of players is rarely evaluated (Conte et al., 2019).

However, with the test standards, it would be easier to determine the player's overall performance level (Al-Gendy, 2012). Based on a systematic review (Koopmann et al., 2020) entitled Assessing Technical Skills in Talented Youth Athletes: A Systematic Review explains that technical skills can be operated and evaluated in different ways (focusing on results or processes). On the one hand, technical skills can be easily assessed by measuring time and accuracy. On the other hand, measuring movement techniques during the assessment can also effectively evaluate technical skills. Ultimately, the effectiveness and quality of team performance lie in the selection of basketball players who can leverage individual skills and abilities to earn points in a game situation. Another thing that becomes important is to distinguish the different levels of individual abilities for team development. Thus it can be a reference for the coach in making a valid assessment when selecting the team and acquiring knowledge about the level of potential playing athletes today and in the future.

The development of the form of basketball test is an essential aspect in the process of training athletes as well as the preparation of training programs, so it is essential and necessary to develop an assessment tool that corresponds to the characteristics of the athlete, resembles the situation at the time of the game, comprehensive (skills and performance), and easy to access. The importance of research and development of skills test instruments and basketball performance for players in the age group of 14-16 years is to (a) shorten test time, (b) reduce the waiting time for results, (c) be comprehensive so that it can reflect actual abilities, (d) be accessible, and (e) for coaches, can be a benchmark when carrying out the selection.

Materials and methods

Study participants

Seven experts took part in the study. Three of the seven experts are from the academic experts, four are from the professional basketball coaching experts. In this study, experts who meet the criteria for being experts are chosen to be part of the sample. These criteria are based on expert experience, reputation, availability, motivation to participate in research, discretion, and quality (Ibáñez et al., 2019; Skjong, 2001). The selected experts must meet at least three of the following six criteria: (i) have a Ph.D. degree in Sports Science; (ii) become or have ever been a university lecturer; (iii) have the highest license in a sports federation; (iv) have ten years of teaching experience as a faculty member; (v) have ten years of training experience; (vi) have ever published articles on sports topics or have achievements in training sports (Ibáñez et al., 2019; Ortega-toro et al., 2019; Villarejo & Ortega, 2014). All experts come from the same country (Indonesia) and have no direct contact with the research team.

Study organization

The test instrument development model carried out in the research adapted the test development model developed by (Mardapi, 2017; Oriondo & Dallo-Antonio, 1998). The model was chosen because it was relevant to the development of the test. However, to optimize, the three models were combined and modified to be simpler but not to reduce the completeness and in line with the purpose of this research to develop the test of basketball skills and performance. The study involved adolescent basketball players aged 14-16. Users of the instrument test skills and performance basketball are coaches and players aged 14-16 years.

Methodology

Description of the BSPT

The Basketball Skill and Performance Test (BSPT) is a new test for assessing basketball skills and performance (Fig. 1). The test consists of five items carried out simultaneously and is measured comprehensively on a process-based basis using work demonstration sections and results based on the time completed in performing the test.

The assessment of the BSPT test combines process-based assessment methods using free throw, variation of dribbling, passing, shooting, speed dribbling, and layup. For the measurement of results (outcome-based), use: (a) the time of completion; (b) the penalty time; (c) the performance time (completion time + penalty time).

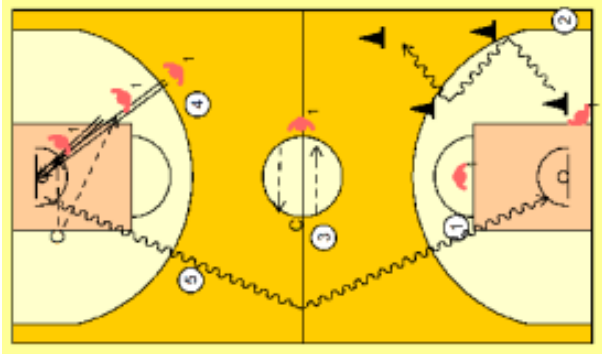

Fig. 1. Basketball skill and performance test Scheme

Table 1. BSPT performance (process-based) assessment rubric

Variabel	Factor	Indicator	Sub-sub Indicator
Performance/ Process Based	Free Throw	Prefix	Legs straight and stretched over the shoulder.
			The knee is flexed and bent to gain an initial lift.
			Relaxing shoulder and balanced body
			Focus on the ring.
		Preparation	The ball is held with both hands above the head or in front of the chest, between the ears and shoulders, or in the front of your chest.
			The shooter's hand is behind the ball, and the balance hand is next to the ball.
			The shooter's arms form a 90-degree angle.
			Elbows tucked in and fingers relaxed with palms off the ball.
		Implementation	The legs and arms move up at the same time.
			Spread your legs, shoulders, and elbows.
			The wrist slides, and the fingers point forward.
			Off-hand shooters remain holding the ball until the ball is released.
		Followthrough	The shooting movement ends with a wrist stroke until the fingers face down and release on the index finger.
			Hold the motion until the ball goes in.
			Index finger pointing at target.
			Keep your arms straight until the ball enters the hoop.
	Dribble	Prefix	The focus ahead.
			The ball is held with both hands on the side of the waist.
		Preparation	Hands on the ball
			The balancing hand is beside the ball.
			Knees bent and body relaxed
			The back legs are prepared.
		Implementation	Release the ball before the pivot foot leaves the court.
			(crossover) The ball changes hands by crossing the ball to form a V in front of the body.
			(between the leg) The ball changes hands by crossing the ball in a V shape between the legs.
			(behind the back) The ball changes hands by crossing the ball to form a V behind the body.
			Hands that are not dribbling and the body are used to protect the ball.
		Followthrough	Stop in a balanced condition, either with a jump stop or one-two stop.
			Hands gripping the ball firmly
	Passing & Catching	Prefix	Ready position.
			Balance in body position
			Looking toward the target.
		Preparation	(Chest pass) Hold the ball tightly with both hands in front of the chest.
			The position of the fingers is on the side of the ball, and the thumb is on the back, resembling a handshake position.
			The elbows are bent equally on both sides, and the knees are bent.
			(One-hand Sidearm Bounce Pass) The active hand position is placed next to the body.
			Passive hand protects the ball
			The ball is between the shoulder and hip.
			The elbows are bent, and the knees are bent.
		Implementation	(Chest Pass) Push the ball by straightening the elbow, followed by wrist and finger movements.
			The direction of the ball's backspin is toward the target at chest height.
			Explosive moves
			(One-hand Sidearm Bounce Pass) The footsteps moved obliquely forward towards the target of the pass.
			Open the elbow spread to the front side, and push the ball by straightening the elbows, followed by wrist and finger movements.
			The ball bounces at two-thirds of the distance from the receiver.
			Explosive moves
		Followthrough	Stop in a balanced state with either a jump stop or a one-two stop.
			Hands gripping the ball firmly

Table 1 (continued). BSPT performance (process-based) assessment rubric

	Shooting	Prefix	Focus on the ring.
			The feet are stretched over the shoulder width with the toes forward.
			Shoulders relaxed, posture balanced.
		Preparation	The shooter's hand is behind the ball, and the balance hand is next to the ball.
			The elbows of the shooter's arms form a 90-degree angle.
			Elbows tucked in and fingers relaxed with palms off the ball.
		Implementation	Legs and arms move up together.
			The wrists are flexible, and the fingers point forward.
			The hand not used for the shooting remains to hold the ball until the ball is released.
		Followthrough	The shooting movement ends with a wrist stroke until the fingers face down and release on the index finger.
			Keep your arms straight until the ball enters the hoop.
			Land with both feet together.
	Speed Dribble-Layup	Prefix	Looking toward the target.
			Stepping with a balanced body position.
			Bend the knees
			The hind legs become repulsive.
		Preparation	Run at full speed of waist-deep.
			The ball is always in front of the body.
			Take a short step with your inner leg before the last dribble.
		Implementation	Catch the ball simultaneously with long strides.
			Vertical jump.
			Point the shooter's hand toward the basketball hoop at a 45- to 60-degree angle.
		Followthrough	Keep eye contact with the basketball ring target.
			The shooting is completed by slashing the wrist to the fingers.
			Land with both legs in balance.

Table 2. BSPT outcome-based measurement rubric

Variabel	Indicator	Reward/ penalty time (s)	Sub Indicator
Skill/ Outcome Based	Free Throw	-2 s	Go all in without hitting the ring.
		-1 s	Go all in with one or both of them hitting the ring.
		+1 s	Only once entered the basketball hoop.
		+2 s	None of the shots made it into the basketball hoop.
	Dribble (Ball Control)	-1 s	Using all dribble techniques (crossover, between the legs, and behind the back) correctly
		+1 s	Missed one or more dribbles
	Passing	-1 s	The direction of passing right on the receiver's chest
		+1 s	The direction of passing is not on target.
	Shooting	-3 s	All shoot made it to the basket. (3pt, medium shoot, under basket)
		-1 s	Only two of the three shots have made it to the basket.
		+3 s	Only one or none of the shots have made it to the basket.
	Speed dribble-layup	-1 s	The ball is entered in one attempt.
		+1 s	The ball was entered in more than one attempt.
		+3 s	Turnover (travelling/ carrying the ball/double dribble/out of bounds)

Testing procedures

The test begins with two free throws, followed by dribbling the ball (crossover between the leg – behind the back), then passing (chest pass and one-hand side bounce pass), shooting (three-point shoot, medium shoot, and under-basket) then speed dribble ending with a lay-up. The assessment from the BSPT test combines the performance assessment method (process based) using the free throw, dribbling, passing, shooting, slide defense, and lay-up performance rubrics (Table 1). Meanwhile, for outcome-based measurement, it uses (a) completion time; (b) penalty or reward time; (c) performance time (completion time + penalty time) (Table 2).

Statistical analysis

In order to conduct an in-depth study, this research applied a developmental method supported by qualitative and quantitative approaches (Creswell, 2016; Harrison et al., 2020; Terwee et al., 2018). Three academic experts and four basketball coach experts approved the data collection. The empirical and content validity of the basketball skill and performance test were used to evaluate its validity. One of the most typical methods for determining the content validity of a questionnaire is expert judgment, which can either suggest which items the instrument should include to define the construct to be measured, or, as in this case, evaluate the items already created based on a series of quantitative or qualitative criteria (giving scores) and suggesting, or adding any changes to their wording if they believe it is necessary (Garrote & del Carman Rojas, 2015; Guillot-Valdés et al., 2022). This procedure is widely used by researchers to assess the content validity of newly created instruments or adaptations of existing instruments (Leyton-Román et al., 2021).

There are three steps to content validity: The authors first gathered relevant research sources, then conducted a preliminary participatory observation study to develop a test, and finally evaluated the data obtained. Second, the researchers used the Delphi technique (Wilpers et al., 2020). The Delphi technique is used to reach expert opinions on a specific subject in a gradual and iterative process (Hasson et al., 2000). The third step was to analyze the data obtained in the form of quantitative results from the evaluation of 7 experts on a 4-point scale and qualitative suggestions from 7 experts (Yudhistira & Tirtawirya, 2021). To calculate the content validity through Aiken's V coefficient, was used to

Table 3. Result of Aiken Validity

Aspect	Rater							S_1	S_2	S_3	S_4	S_5	S_6	S_7	Σs	n(c-1)	V	Ket
	1	2	3	4	5	6	7											
1	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
2	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
3	4	4	3	3	4	3	4	3	3	2	2	3	2	3	18	21	0.85	VALID
4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
5	3	4	3	3	4	3	3	2	3	2	2	3	2	2	16	21	0.76	VALID
6	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
7	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
8	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
9	4	3	4	4	3	4	4	3	2	3	3	2	3	3	19	21	0.90	VALID
10	4	3	3	4	3	3	4	3	2	2	3	2	2	3	17	21	0.80	VALID
11	3	4	3	3	4	3	3	2	3	2	2	3	2	2	16	21	0.76	VALID
12	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
13	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
14	3	4	3	4	4	3	3	2	3	2	3	3	2	2	17	21	0.80	VALID
15	4	4	3	3	4	3	4	3	3	2	2	3	2	3	18	21	0.85	VALID
16	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
17	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
18	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
19	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
20	4	4	2	3	4	3	4	3	3	1	2	3	2	3	17	21	0.80	VALID
21	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
22	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
23	4	3	4	4	3	4	4	3	2	3	3	2	3	3	19	21	0.90	VALID
24	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
25	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
26	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
27	3	4	4	4	4	4	3	2	3	3	3	3	3	2	19	21	0.90	VALID
28	4	3	4	3	3	4	4	3	2	3	2	2	3	3	18	21	0.85	VALID
29	4	4	2	3	4	3	4	3	3	1	2	3	2	3	17	21	0.80	VALID
30	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
31	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
32	4	3	4	4	3	4	4	3	2	3	3	2	3	3	19	21	0.90	VALID
33	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
34	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
35	3	4	3	3	4	4	3	2	3	2	2	3	3	2	17	21	0.80	VALID
36	3	4	3	3	4	4	3	2	3	2	2	3	3	2	17	21	0.80	VALID
37	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID

Table 3 (continued). Result of Aiken Validity

Aspect	Rater							S_1	S_2	S_3	S_4	S_5	S_6	S_7	Σs	n(c-1)	V	Ket
	1	2	3	4	5	6	7											
38	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
39	4	3	4	4	3	4	4	3	2	3	3	2	3	3	19	21	0.90	VALID
40	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
41	3	3	3	4	3	3	3	2	2	2	3	2	2	2	15	21	0.71	NOT VALID
42	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
43	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
44	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
45	3	3	3	3	3	4	3	2	2	2	2	2	3	2	15	21	0.71	NOT VALID
46	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
47	4	4	2	4	4	3	4	3	3	1	3	3	2	3	18	21	0.85	VALID
48	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
49	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
50	3	4	3	3	4	4	3	2	3	2	2	3	3	2	17	21	0.80	VALID
51	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
52	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
53	4	4	3	3	4	4	4	3	3	2	2	3	3	3	19	21	0.90	VALID
54	3	4	3	3	4	4	3	2	3	2	2	3	3	2	17	21	0.80	VALID
55	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
56	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
57	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
58	3	4	3	4	4	3	3	2	3	2	3	3	2	2	17	21	0.80	VALID
59	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
60	4	3	3	4	3	3	4	3	2	2	3	2	2	3	17	21	0.80	VALID
61	4	3	3	4	3	3	4	3	2	2	3	2	2	3	17	21	0.80	VALID
62	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
63	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
64	4	3	3	4	3	3	4	3	2	2	3	2	2	3	17	21	0.80	VALID
65	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
66	3	4	3	3	4	4	3	2	3	2	2	3	3	2	17	21	0.80	VALID
67	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
68	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
69	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
70	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
71	4	4	3	3	4	4	4	3	3	2	2	3	3	3	19	21	0.90	VALID
72	4	4	3	4	4	3	4	3	3	2	3	3	2	3	19	21	0.90	VALID
73	4	4	4	3	4	4	4	3	3	3	2	3	3	3	20	21	0.95	VALID
74	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
75	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
76	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
77	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
78	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
79	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
80	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
81	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
82	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
83	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
84	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
85	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
86	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
87	4	4	4	4	4	4	4	3	3	3	3	3	3	3	21	21	1	VALID
																	0.91	VALID

determine the criteria for the modification or elimination of the variables (Aiken, 1985, 1980; Penfield & Giacobbi, 2009; Torres-Luque et al., 2020).

Cronbach Alpha was used to assess the internal consistency and reliability of BSPT, with less than 0.70 indicating acceptable reliability (Rahayu & Arovah, 2022; Sharma, 2016). Also calculated one-week test and retest reliability on BSPT by calculating each item's intra-class correlation (ICC) (single one-way model) (Schreiber et al., 2006). Reliability was classified as fair (0.5), good (0.5–0.75), very good (0.75-0.9), and excellent (>0.9) based on the ICC value (Koo & Li, 2016; Olaya-Cuartero et al., 2022).

Results

Content Validity

Expert judgment is used to evaluate aspects of basketball skill and performance test instruments designed specifically for adolescent athletes. The expert's evaluation uses a scale of 1 to 4. The assessment criteria are only relevant if the assessment is close to a one on a scale. The closer the assessment is to a four on a scale, the more relevant the assessment criteria. The expert assessment data was then quantitatively analyzed using Aiken's formula.

Using seven raters with four categories to choose from, the V index equals 0.76. From the results obtained from expert judgment, two items were invalid, including items 41 (0.71), and items 45 (0.71). On average, a value of 0.91 is obtained so that the instruments that have been compiled are declared valid.

Reliability

Cronbach's Alpha was used to see how reliable the raters were. The results are shown in Table 4.

Table 4. Result of Cronbach alpha analysis

Cronbach's Alpha	N of Items
0.918	7

In this study, the test-retest reliability correlation coefficient produced positive results. According to (Heale & Twycross, 2015), Cronbach's alpha values > 0.7 indicate high reliability.

Table 5 shows the results of the interrater agreement test or interrater reliability using Intraclass Correlation Coefficients (ICC).

The average agreement between raters is 0.912, while for one rater, the consistency is 0.596. The results of the ICC score, according to (Portney & Watkins, 2009), are included in the excellent reliability category, so it can be concluded that agreement between raters is very strong and each rater has a fairly good level of consistency.

Discussion

The purpose of this research was to examine the content validity and reliability of the basketball skill and performance instrument test. This study determined that the BSPT has high content validity and can be used to evaluate the skill and performance of adolescent basketball athletes. Testing consistency across a number of trials is required for reliable data collection when evaluating sporting performance (W. G. Hopkins, 2000; Lockie et al., 2013; Radman et al., 2016). When compared to previous skill tests that were similarly designed in terms of performance time, penalty time, and number of errors, our results demonstrated greater relative reliability than the Loughborough Soccer Passing Test (LSPT) (ICC: 0.58-0.70) (Ali, 2011; Wen et al., 2018) and Loughborough Soccer Shooting Test (LSST) (ICC = 0.26-0.58) (Ali, 2011; Conte et al., 2019).

Based on the Aikens analysis used to measure the content's validity, the expert assessment instrument achieves a value of 0.91, indicating that the aspect has good content validity. Cronbach's Alpha was used to measure the reliability of every aspect of the basketball skill and performance test instrument, and the results were 0.918. Cronbach's alpha reliability level of 0.70 is the bare minimum. If the Cronbach's Alpha value is greater than 0.7, the aspects of the national development category aerobic gymnastic flexibility test instrument are very reliable (Tavakol & Dennick, 2011).

Meanwhile, because there are more than two raters, this study used Intraclass Correlation Coefficients (ICC) analysis to test the reliability of each rater and the consistency of each rater. Based on the ICC results (table 5), it is feasible to determine that the raters' agreement is very strong and that each rater has a reasonably good consistency (moderate reliability). As a result, the structure of the test was considered feasible for measuring basketball skill and performance in adolescent athletes. This developed test is an adapted or specified test with several basketball techniques because it is similar to the movement of the technique during the game.

Conclusions

Based on the results and discussion, it is possible to conclude that the basketball skill and performance test (BSPT) is valid and reliable for assessing adolescent basketball athletes. As a result, the BSPT can be used to assess the skill level of adolescent basketball players, benefiting not only basketball coaches but also physical education teachers.

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Table 5. Intraclass Correlattion Coefficient analysis result

	Intraclass Correlation	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	0.596	0.510	0.682	12.227	87	522	0.000
Average Measures	0.912	0.879	0.938	12.227	87	522	0.000

Conflict of interest

The authors declare that there are no conflicts of interest.

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РОЗРОБКА, ПІДТВЕРДЖЕННЯ ВАЛІДНОСТІ ТА НАДІЙНІСТЬ ІНСТРУМЕНТУ ТЕСТУВАННЯ БАСКЕТБОЛЬНИХ НАВИЧОК І РЕЗУЛЬТАТИВНОСТІ ГРАВЦІВ-ПІДЛІТКІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 5 табл., 1 рис., 48 джерел.

Мета дослідження. Усі засоби оцінювання або тести навичок, такі як тест баскетбольних навичок AAHPERD (Американський альянс із питань охорони здоров'я, фізичного виховання, відпочинку та танців) і баскетбольний тест Джон-

сона, є частковими або окремими. Усі ці тести є старими продуктами, тоді як гра в баскетбол постійно розвивається. Метою цього дослідження була розробка та підтвердження валідності тестів баскетбольних навичок і результативності для гравців віком 14–16 років, призначених скоротити час тестування, скоротити час очікування результатів, і які будуть комплексними, щоб вони могли відображати реальні здібності та їх можна було використовувати як еталон під час проведення відбору та оцінки.

Матеріали та методи. Загалом 7 експертів оцінювали 11 елементів (86 пунктів) тесту баскетбольних навичок і результативності (ТБНР). У дослідженні взяли участь три академічні експерти та чотири експерти з баскетбольних тренерів. Збір даних здійснювали за допомогою методу Дельфі та повторення тесту, а для аналізу даних використовували формулу Ейкена, коефіцієнти внутрішньогрупової кореляції (КВК) та альфу Кронбаха.

Результати. Зі значенням 0,91 засіб експертної оцінки показує, що валідність аспекту за змістом є відповідною. Альфу Кронбаха використовували для вимірювання надійності кожного аспекту інструменту тестування баскетбольних навичок і результативності, і результати становили 0,918. Результат узгодження оцінок КВК між оцінювачами становить 0,912, тоді як для одного оцінювача показник стабільності становить 0,596.

Висновки. Висновки, які випливають із цього дослідження, можуть доводити, що ТБНР можна використовувати для оцінки рівня навичок підлітків-баскетболістів, що буде на користь не лише баскетбольним тренерам, але й учителям фізичного виховання.

Ключові слова: бакетбол, навичка, результативність, підтвердження валідності, надійність.

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ORIGINAL SCIENTIFIC ARTICLE

ANTHROPOMETRIC AND PHYSIOLOGICAL PREDICTORS OF SOCCER SKILLS IN YOUTH SOCCER PLAYERS

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Abstract

Study purpose. This study aimed at investigating the anthropometric and physiological characteristics that affect soccer skills in advanced-level youth soccer players.

Materials and methods. Ninety advanced youth male soccer players from the U-18 division 1 soccer club were enrolled to participate in this study. The participants were classified into three different positions: defenders, midfielders, and forwards. The anthropometric profiles (height, weight, and body fat) and physiological variables (Y-balance test, Yo-Yo Intermittent Recovery Test Level 1, running-based anaerobic sprint test, sit-up test, countermovement jump test, drop jump test, arrowhead agility test, and 40-m sprint test) were assessed. Soccer-specific skills were measured using the Loughborough soccer passing and shooting protocol.

Results. The multiple regression analysis revealed a statistically significant relationship between physical factors and the Loughborough soccer passing ability ($R^2 = 0.291$, $F_{(15, 74)} = 2.200$, $p = 0.015$). The results indicated that the relative maximum power displayed the strongest association with passing ability, followed by sit-up, countermovement jump without and with arm swing, and fatigue index. Concerning the shooting performance, the predictors accounted for 21.8% of the variance, with sit-up being the sole significant predictor among other factors.

Conclusions. Our findings underscore the significance of relative maximum power, fatigue tolerance, muscular power, and core strength as valuable predictors for enhancing passing ability. In addition, abdominal strength emerged as a crucial indicator of shooting performance. Soccer coaches could use the essential information described in this study for talent identification purposes.

Keywords: physical fitness, muscular power, soccer passing, talent identification, youth soccer.

Introduction

Soccer is a highly unpredictable opened-skill sport that requires exceptional physiological abilities on the professional level, as well as proficiency in movement, motor control, decision-making, and cognitive function (Reilly et al.,2000; Fernandez-Rio & Méndez-Giménez, 2014; Romeas et al., 2016). Renowned, world-class-level soccer players such as Lionel Messi, Christiano Ronaldo, Neymar da Silva Santos Júnior, and Kylian Mbappé have demonstrated exceptional talent from a young age. Therefore, national soccer associations and youth academies of professional clubs worldwide have made significant financial investments in systematically implementing talent identification and development (TID) programs. The primary objective of these initiatives is to identify the most promising young athletes who possess the potential to advance to and excel at the adult professional level (Bergkamp et al., 2019; Mourao, 2016; Till & Baker, 2020). Obviously, numerous soccer clubs and academies prioritize early enrollment as a crucial aspect of long-term player development in the pursuit of training elite players. Performance success in team sports such as soccer

could be reportedly influenced by several critical factors, including anthropometry, physiological fitness, cognitive/psychological characteristics, sport-specific skills, and sociological profiles (Murr, Raabe, & Höner, 2018; Yongtawee et al., 2022). Certain of these parameters have been identified as talent predictors in systematic review studies (Williams & Reilly, 2020). For instance, top professional-level players reportedly exhibit significant differences in traits such as leanness, height, weight, physical fitness, speed, agility, and skill level during adolescence compared to their peers (Carling et al., 2012; Williams, Ford, & Drust, 2020). In the context of TID programs across various countries, specific indicators have been identified that predict future success in adulthood during the early adolescence phase in Germany. These indicators include sprinting ability, agility, dribbling skills, ball control, and shooting proficiency (Höner, Leyhr, & Kelava, 2017). In England, the Elite Player Performance Plan has been implemented since 2012 to optimize homegrown player performance across multiple domains, including physical, technical, tactical, and psychological aspects, through a comprehensive multidisciplinary approach (Premier League, 2012). Likewise, in the Netherlands, several professional soccer clubs have implemented the TID process that primarily involves evaluating a comprehensive test battery assessing multidimensional performance characteristics encompassing physiological, technical, tactical, and psychological aspects (Huijgen, Elferink-Gemser, Lemmink, & Visscher, 2014). Therefore, holistic performance diagnostics appear to be crucial for the long-term international success of national football associations and professional clubs.

In order to reach the pinnacle of professional soccer, young soccer players need to enhance their performance in multiple domains, including physiological, technical, tactical, and cognitive/psychological characteristics (Meylan, et al., 2010; Reilly et al., 2000; Vaeyens et al., 2006). Moreover, when selecting elite athletes, factors such as body composition, aerobic endurance, speed, agility, and balance are crucial. Wong et al. (2009) suggest that anthropometric data can serve as reliable indicators of soccer performance. In the contemporary soccer system, teams often adopt a compact playing style, making it challenging for opponents to create space. Possessing excellent passing skills is thus vital for the players of a soccer team to maintain possession and control the game (Gonçalves et al., 2017; Rein et al., 2017). Developing shooting skills is crucial for soccer players as it is essential for winning games and overall success (Lago-Ballesteros & Lago- Peñas, 2010). Therefore, coaches should consider significantly these specific skills. However, our knowledge concerning the influence of anthropometric and physical fitness profiles on specific skills, such as passing and shooting ability, remains limited. Hence, understanding these physical demands would be essential for recruiting top-level players, particularly considering the positional differences among youth soccer players. Consequently, this study aimed at investigating how anthropometric and physiological characteristics affect soccer skills in advanced-level youth soccer players.

Materials and methods

Participants

We recruited 90 advanced youth male soccer players from the U-18 division 1 soccer club to participate in this study. Each cohort comprised a diverse group of players from different positions including defender, midfield, and forward. All participants had at least 2 years of experience in the national youth competition. None of the participants had musculoskeletal injuries or used anabolic drugs. We informed all the participants about the purpose of the testing procedures and possible risks and gave their informed consent prior to the study. The study protocol was approved by the Ethics Review Committee for Research Involving Human Research Subjects and it was conducted according to the Declaration of Helsinki.

Testing procedures

To evaluate anthropometric and physiological characteristics, we applied nine physical fitness tests as follows: 40-m sprint, Arrowhead Agility Test (AAT), sit-up, muscular power test (i.e., Countermovement Jump (CMJ) and Drop Jump (DJ) tests), Y-Balance test, Running-based Anaerobic Sprint Test (RAST), and Yo-Yo Intermittent Recovery Test level 1 (Yo-Yo IR1). Prior to testing, the participants were instructed to engage in a 15-min individual warm-up involving low aerobic activity and dynamic stretching. Each testing session was divided into two occasions separated by a 24-h recovery period. On the first visit, the demographic data, anthropometrical aspects, and two soccer skill tests (passing and shooting) were measured on the soccer pitch. On the second visit, the physiological profiles were assessed in the following sequence: YBT, sit-up, AAT, CMJ, DJ, 40-m sprint, RAST, and Yo-Yo IR1.

Anthropometry

Standing height was measured to the nearest 0.1 cm (Seca 220e, Hamburg, Germany). Body composition analysis was performed using Inbody 720 (Biospace Co., Seoul, Korea). Fat percentage was recorded using multifrequency bioelectrical impedance analysis.

Aerobic capacity

Aerobic performance was evaluated using Yo-Yo IR1. The participants performed repeated 20-m shuttle runs interspersed with a short active recovery. The time allowed for a shuttle, which progressively decreased, dictated by audio beeps. The objective of the tests was to complete as many shuttles as possible. To calculate maximal oxygen consumption, we used the following equation, as described previously (Bangsbo, 1994):

VO_2max (ml/min/kg) = running distance covered (m) × 0.0084 + 36.4

Anaerobic capacity

The RAST included 6 × 35 m sprints, interspersed by 10 s of active recovery (Draper and Whyte, 1997). The participants were requested to perform the sprints to the best of their abilities in each lap. Two photocells were used to record sprint time intervals. We assessed relative maximum power (Power = Weight × Distance^2 ÷ Time^3) and fatigue index ((Maximum power – Minimum power) ÷ Total time for the six sprints)/body mass based on the RAST results.

Muscular power

Muscular power values were measured using SmartSpeed Pro timing lights and force plate (Fusion Sport, Coopers Plains, Australia) during CMJ with and without arm swing and DJ. The participants completed the power test consisting of three jumps of one maximal CMJ on a force plate. The maximum value was selected as the final measurement. A 15-sec resting period was established to enable sufficient recovery between the jumps. Jump heights were recorded for each trial. DJ was performed from a 30-cm box while the participants were holding their hands on their hips. The participants were instructed to stand on the top of the box facing toward the force platform then step off of the box and rebound as fast as possible.

Muscular endurance

The sit-up test was set up as a protocol to evaluate muscular endurance. The participants were instructed to lay on the floor with 90°-knee joint flexion in a supine position. They were then asked to keep their hands at the side of their head with their elbows pointing straight forward to touch their knees, then lean back so that their shoulders would touch the floor. We counted sit-up repetitions in 40 seconds for each participant (Hohmann et al., 2018).

Agility

AAT was applied to assess the ability to change direction over a range of angles and directions. The AAT time was measured using timing gates (Fusion Sport, Coopers Plains, Australia) positioned at the start line. A total of four trials (2-2 attempts to start from left and right, respectively) were completed.

Speed

The 40-m sprint times were recorded using timing gates (SmartSpeed Pro timing lights; Fusion Sport, Coopers Plains, Australia). The photocells were placed at the start and 40 m. Participants were instructed to perform two maximal-effort 40-m sprints using a standing start position and the fastest time was used for analysis.

Balance

The YBT was applied to evaluate dynamic balance. The participants reached out in the anterior, posteromedial, and posterolateral directions with one foot while standing on the other foot on a centralized stance platform. The test was performed barefoot with both the left and right limbs.

Soccer-specific skills

The Loughborough soccer passing test (LSPT) was set to assess the passing performance. Figure 1 presents the LSPT layout. Four wood boards (2.5 × 0.3 m) were placed in the centermost within the 12 × 9.5 m layout. Four differently colored (green, blue, red, and white), 0.6 × 0.3 m sticker pads were attached to the middle of the boards. A 0.1 × 0.15 m thick black line was also taped to the center of the target areas. The participants were requested to respond quickly and accurately by 16 verbal randomized passing orders (Ali et al., 2007). The test sequence consisted of 8 passes including 3.5 meter (4 red and 4 white targets) and 4 meter (4 green and 4 blue targets) passes.

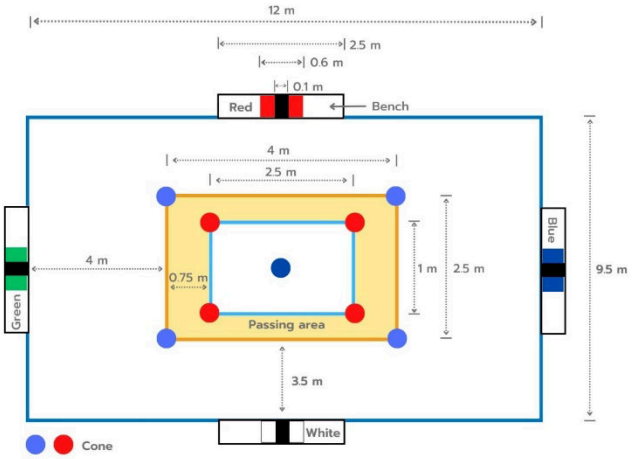

Fig. 1. Loughborough Soccer Passing Test (LSPT) layout

We used the Loughborough soccer shooting test (LSST) to measure the shooting ability. The participants were asked to sprint between two cones of 5.5 meters length from and directly in front of the goal to follow the shot sequence. The shooting zone was an 8.5 × 8.5 m square with a 16.5 m length from the goal line (Figure 2). Each participant completed a single trial of ten shots (5-5 to the right and the left sides, respectively), with a 30-second recovery between each shot order (Stone & Oliver, 2009).

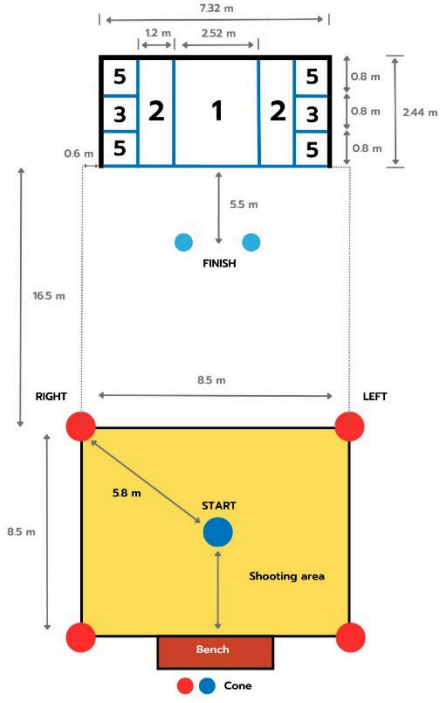

Fig. 2. Loughborough soccer shooting test (LSST) overview

Statistical Analysis

The obtained data were analyzed in terms of means, standard deviation, and multiple linear regression analysis was used to estimate the relative contributions of aerobic capacity, anaerobic performance, power, muscular endurance, balance, speed, and change of direction to specific soccer skills. One-way analysis of variance was used to examine the differences between three positions. The statistical significance was set at a P-value of $p < 0.05$. All statistical analyses were performed using SPSS version 23.0 for Windows (SPSS Inc Chicago, IL, USA).

Results

We performed multiple regression analyses to assess the relationship between anthropometric and physical fitness factor variables (Tables 1 and 2). Multiple linear regression analysis was applied to develop a model for predicting soccer performance including passing and shooting skills. Moreover, we aimed at determining if various physical factors could influence Loughborough soccer passing values (Table 1). The overall regression was statistically significant ($R^2 = 0.291$, $F_{(15, 74)} = 2.200$, $p = 0.015$) with the maximum power being the best predictor of passing abilities

Table 1. Multiple regression analysis of anthropometric and physical fitness factors affecting Loughborough soccer passing

Variable	B	SE	β	t	p
Constant	82.560	31.318		2.636	0.010
Height (cm)	−0.090	0.138	−0.118	−0.653	0.515
Weight (kg)	0.067	0.141	0.100	0.474	0.637
Body fat (%)	0.031	0.175	0.026	0.177	0.860
YBT-right leg composite	0.010	0.072	0.024	0.139	0.890
YBT-left leg composite	−0.054	0.072	−0.124	−0.744	0.459
Sit-up (reps)	0.171	0.072	0.271	2.383	0.020*
Arrowhead agility (s)	−0.604	0.699	−0.093	−0.864	0.390
40-m sprint (s)	−1.055	2.258	−0.058	−0.467	0.642
CMJ(cm) without arm swing	−0.517	0.213	0.496	−2.428	0.018*
CMJ (cm) with arm swing	0.449	0.189	0.516	2.376	0.020*
Drop jump (cm)	0.016	0.097	0.021	0.165	0.870
Relative maximum power (watt/kg)	−1.615	0.602	−0.545	−2.685	0.009*
Fatigue index (%)	1.044	0.446	0.446	2.341	0.022*
VO_2max (ml/min/kg)	0.015	0.132	0.012	0.114	0.910

*p < 0.05; YBT = Y-Balance test, CMJ = countermovement jump, VO_2max = maximal oxygen uptake

Table 2. Multiple regression analysis of anthropometric and physical fitness factors affecting shooting performance

Variable	B	SE	β	t	p
Constant	−4.060	4.876		−0.833	0.408
Height (cm)	0.019	0.022	0.168	0.833	0.380
Weight (kg)	−0.005	0.022	−0.049	−0.220	0.827
Body fat (%)	−0.007	0.027	−0.039	−0.253	0.801
YBT-right leg composite	−0.008	0.011	−0.132	−0.720	0.473
YBT-left leg composite	0.013	0.011	0.204	1.167	0.247
Sit-up (reps)	0.028	0.011	0.298	2.494	0.015*
Arrowhead agility (s)	−0.050	0.109	−0.052	−0.457	0.649
40-m sprint (s)	0.048	0.352	0.018	0.135	0.893
CMJ(cm) without arm swing	0.058	0.033	0.375	1.749	0.084
CMJ (cm) with arm swing	−0.025	0.029	−0.198	−0.865	0.390
Drop jump (cm)	0.001	0.015	0.009	0.067	0.947
Relative maximum power (watt/kg)	−0.001	0.094	−0.002	−0.007	0.994
Fatigue index (%)	−0.026	0.069	−0.074	−0.371	0.712
VO_2max (ml/min/kg)	0.023	0.021	0.126	1.139	0.258

*p < 0.05; YBT = Y-Balance test, CMJ = countermovement jump, VO_2max = maximal oxygen uptake

Table 3. Descriptive anthropometric and performance characteristics of soccer players (n = 90) by positions roles

Variable	Defender (n = 30)		Midfielder (n = 30)		Forward (n = 30)		F	p
	X	SD	X	SD	X	SD		
Age (years)	17.13	0.68	17.13	0.77	17.16	0.83	0.019	0.981
Weight (kg)	63.78	6.65	64.83	6.22	63.84	6.57	0.249	0.780
Height (cm)	173.32	5.98	172.63	5.69	172.22	5.35	0.287	0.752
Body fat (%)	10.74	3.71	12.13	3.83	12.17	3.29	1.510	0.227
YBT-Right Leg composite	115.16	11.56	110.96	10.15	112.55	9.61	1.229	0.298
YBT-Left Leg composite	114.65	11.43	110.99	10.08	110.39	7.8	1.631	0.202
Sit-up (reps)	31.73	7.00	33.53	6.91	33.10	6.61	0.565	0.570
Arrowhead agility (s)	18.93	0.64	19.00	0.65	18.95	0.80	0.101	0.904
40-m sprint (s)	5.49	0.19	5.51	0.25	5.46	0.26	0.400	0.672
CMJ without arm swing (cm)	38.56	3.92	36.17	4.41	36.92	3.96	1.606	0.206
CMJ with arm swing (cm)	44.48	4.72	42.30	4.83	43.56	5.20	1.529	0.223
Drop jump (cm)	35.27	4.71	33.10	5.50	31.74	6.44	3.040	0.053
Relative maximum power (watt/kg)	9.15	1.20	8.91	1.03	9.40	1.96	0.833	0.438
Fatigue index (%)	3.80	1.47	3.46	1.12	4.10	2.60	0.912	0.405
VO_2max (ml/min/kg)	47.15	3.01	47.29	3.57	47.89	3.73	0.391	0.678
Loughborough soccer passing	46.20	4.44	45.67	4.46	45.45	4.12	0.220	0.803
Loughborough soccer shooting	1.68	0.72	1.80	0.55	1.68	0.65	0.329	0.720

YBT = Y-Balance test, CMJ = countermovement jump, VO_2max = maximal oxygen uptake

($p = 0.009$), followed by core strength endurance ($p = 0.020$), countermovement jump with arm swing ($p = 0.020$), and fatigue index ($p = 0.022$). These four variables were significantly crucial indicators to improve passing abilities in young soccer players. Furthermore, the multiple regression analysis indicates the factors affecting shooting performance (Table 2). Sit-up was the only statistically significant predictor of shooting capacity ($p = 0.020$). These factors constituted 21.8% of the explanatory power ($R^2 = 0.218$). Moreover, we identified no significant positional difference among any of the anthropometric- and physiological performance-related variables (Table 3).

Discussion

This study aimed at investigating the anthropometric and physiological characteristics affecting soccer-specific skills in advanced-level youth soccer players. Numerous studies described talent recruitment models to select young soccer players based on anthropometric and physical fitness (Vaeyens et al., 2006; Simon et al., 2019; Bergkamp et al., 2019). The findings of the current study provide a scientific rationale behind the physical capacities influencing soccer passing and shooting. The results showed that sit-ups, CMJ without arm swing, CMJ with arm swing, relative maximum power, and fatigue index were the five major factors influencing passing performance (Table 1). The relative maximum power was the main factor that negatively affected soccer passing, representing the ability of an individual to perform maximum anaerobic power achieved during the short interval sprint. The results of our study were in good agreement with a previous study (Eniseler et al., 2017) stating that the improvement of repeated sprint ability could be used as an effective predictor to enhance short-passing ability. Therefore, RAST is a useful tool to evaluate anaerobic capacity and predict short-distance performance in intermittent sports (Zagatto et al., 2009; Andrade et al., 2015). Moreover, the physical exhaustion also influences the passing ability. The fatigue index refers to the rate at which power declines for the athlete. These current study results suggest that good players should tolerate the fatigue threshold better and maintain anaerobic performance. Rampinini et al. (2008) discovered that exhaustion caused by short-term high-intensity intermittent actions negatively influenced the short-passing skills of the players. In addition, Mulazimoglu (2016) reported that the fatigue level of the players is an important indicator of their technical competencies. Among these, the degree of individual fitness of the players reportedly correlates with the decline in technical proficiency among players brought on by fatigue. Furthermore, CMJ values were positively linked with passing performance, implying that increasing them all indicates an improvement in the ability to perform an explosive vertical jump. This result was similar to that of a study by Benounis et al. (2013) revealing that the LSPT score performance negatively correlated with squat jump and CMJ performances. Our results facilitate using the CMJ test for talent identification and it could be a protocol to predict young soccer players. In agreement with this, Vanttinen et al. (2010) reported that passing accuracy is related to speed, countermovement jump performance, and coordination in adolescent soccer players. Among these listed characteristics, our study indicates that lower limb explosive strength has been anecdotally linked to passing success. Sit-ups also factor if for influencing passing performance,

representing abdominal muscle strength. Core strength is pivotal for stability and movement. The lumbopelvic hip complex is crucial for movement control. Core muscles were confirmed to be essential for soccer players as they provide the basis for endurance, posture, strength, power, and coordination, lowering the risk of injury (Chat, 2011). Our results (Table 2) revealed that sit-up significantly affects shooting performance ($p < 0.05$). However, we observed no significant influence exerted by the other independent variables. A critical finding of our results of anthropometric and physical fitness on shooting ability was that the highest significant abdominal strength would be the best predictor of soccer shooting. In contrast, the previous study found that there were no significant correlation between sit-ups with shooting in college soccer players (Poornabodha et al., 2018). Nevertheless, Sun & Shin (2018) reported that pelvic stability could improve shooting speed and accuracy in junior soccer players. Therefore, during the shooting action, core strengthening could support better soccer shooting efficacy. In addition, the comparison between position roles resulted in no significant difference in any parameter, which was in line with the study of Malina et al. (2004) presenting no positional differences among young defender, midfield, and forward players in vertical jump, sprint time, and intermittent aerobic endurance. Our results also align with a previous study that revealed no significant positional differences in physiological performances including maximal vertical jump height, ball shooting speed, 10- and 30-m sprint times, Yo-Yo IR1, running cost and submaximal running cost, and VO_2max (Wong et al., 2009). In the present study, muscular power performance of defenders were higher than midfielders and strikers. The power seems to be a contributor to support defender characteristics as these players require stamina and strength to tackle and jump to prevent the opponents from scoring during their play in a defensive situation. This discovery was in good agreement with the performance characteristics where defenders showed the strongest jump ability. However, these differences were not significant ($p > 0.05$) versus those observed in goalkeepers and strikers (Wik et al., 2018). According to the rationale that no positional difference could be observed in physiological performances, coaches should modify the strength and conditioning regimens appropriately for youth soccer players. In summary, these results can later be used to evaluate the player's potential and to identify talents in youth soccer players.

Practical Applications

Our results established relationships between specific anthropometric as well as physiological characteristics and specific soccer skills which they impact. Although our discoveries underscore the significance of anaerobic performance and core strength endurance indicators, soccer coaches could use the results of this study for identifying young talents for recruiting and developing future top-level players.

Conclusions

In our study, we clarified that one of the most important factors in various facets of soccer performance is physical fitness. In particular, players with superior muscular endurance, power, and anaerobic capacity would stand comparatively better chances of being selected for a more advanced or higher-development program in the future, according to talent identification purposes.

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Conflict of interest

The authors declare no potential conflict of interest.

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АНТРОПОМЕТРИЧНІ ТА ФІЗІОЛОГІЧНІ ПРЕДИКТОРИ ФУТБОЛЬНИХ НАВИЧОК У ЮНИХ ФУТБОЛІСТІВ

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Реферат. Стаття: 8 с., 3 табл., 2 рис., 40 джерел.

Мета дослідження. Метою цього дослідження було вивчення антропометричних і фізіологічних характеристик, які впливають на футбольні навички у юних футболістів високого рівня.

Матеріали та методи. До участі в цьому дослідженні було залучено дев'яносто юнаків-футболістів високого рівня з футбольного клубу 1-го дивізіону гравців віком до 18 років. Учасників розділили на три різні позиції: захисники, півзахисники та нападники. Оцінювали антропометричні профілі (зріст, вага та відсоток жиру в організмі) та фізіологічні змінні (Y-тест на збереження динамічної рівноваги (з виконанням на Y-подібній підставці на підлозі), тест Йо-йо з переміжним відпочинком (рівень 1), анаеробний спринт-тест на основі бігу, тест на підйом верхньої частини тулубу з положення лежачи, тест на вертикальний стрибок із зустрічним рухом, тест на зістрибування з платформи вниз на підлогу з негайним підстрибуванням, тест на спритність під час бігу зі зміною напрямків за стрілоподібною траєкторією та тест на 40-метровий спринт). Специфічні футбольні навички вимірювали за допомогою протоколу футбольних передач та ударів Лафборо.

Результати. Аналіз множинної регресії виявив статистично значущий зв'язок між фізичними факторами та здатністю до футбольних передач за протоколом Лафборо ($R2 = 0,291$, $F(15, 74) = 2,200$, $p = 0,015$). Результати показали, що відносна максимальна потужність продемонструвала найсильніший зв'язок зі здатністю до передач, за якою слідували показники в тестах на підйом верхньої частини тулуба з положення лежачи, вертикальний стрибок із зустрічним рухом без помаху і з помахом руками та індекс утоми. Щодо результативності ударів, предиктори становили 21,8% дисперсії, при цьому показник у тесті на підйом верхньої частини тулубу з положення лежачи був єдиним значущим предиктором серед інших факторів.

Висновки. Наші висновки підкреслюють важливість відносної максимальної потужності, стійкості до втоми, м'язової потужності та сили м'язів торсу як цінних предикторів для покращення здатності до виконання передач. Крім того, сила м'язів черевного преса виявилася ключовим показником результативності ударів. Футбольні тренери можуть використовувати істотну інформацію, описану в цьому дослідженні, для визначення талантів.

Ключові слова: фізична підготовленість, м'язова потужність, футбольні передачі, визначення талантів, юнацький футбол.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF 6 WEEKS OF COMBINATION OF THREE CONE EXERCISE USING BALL AND HIGH-INTENSITY INTERVAL TRAINING ON THE AGILITY AND DRIBBLING ABILITY OF STUDENT FUTSAL ATHLETES

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Abstract

Study purpose. Three-Cone Drill using the Ball (TCDB) High-Intensity Interval Training (HIIT) is an exercise that requires players to perform fast movements and sharp changes of direction using a ball over three cones with high intensity. This exercise is based on the application of specific training principles using the ball and the principle of overload, which aims to improve agility and dribbling skills. This study aimed to evaluate the effect of TCDB+HIIT on the agility and dribbling ability of student futsal athletes.

Materials and methods. This study used an experimental method with a One-Group Pretest-Posttest Design. The participants in this study were student futsal athletes, totaling 14 players aged 16.6±0.7 years, with body height 170.2±3.36 cm, body mass of 59±9.11 kg, and BMI 20.4±3.25. The research instruments used were the Illinois Agility Test and the futsal dribbling test. Data analysis used the Paired Samples T-Test at a significance level of 0.05; the prerequisite test used was the Shapiro-Wilk test.

Results. Based on the results of the Paired Samples T-Test test, it was found that the sig value (2-tailed) of the speed variable was 0.001 < 0.05, with an increase of 0.99 ± 0.57. In the dribbling variable, the sig (2-tailed) value is 0.001 < 0.05, with an increase of 1.88 ± 1.722.

Conclusions. This study concludes that TCDB + HIIT exercises are effectively applied to increase futsal players' agility and dribbling abilities.

Keywords: futsal, three cone drill using ball, high intensity interval training, agility, dribbling ability.

Introduction

Optimal agility and dribbling skills are essential factors in achieving futsal sports achievements (Dogramaci et al., 2011; Mendes et al., 2022; Travassos et al., 2011). Optimal agility allows futsal players to change direction quickly, avoid or pass opposing players, and maintain control of the ball (Farhani et al., 2019; Naser et al., 2017). Meanwhile, optimal dribbling is also crucial in defending, controlling, and moving the ball with great skill and speed (Corrêa et al., 2016; Doewes et al., 2022; Gioldasis, 2018). To simultaneously improve futsal players' agility and dribbling abilities, specific training is needed with the addition of balls and varied and changing movements (Ayarra et al., 2018). In other words, the required exercises broadly combine the concepts of agility and dribbling with the use of the ball. Such things can provide a more realistic and relevant training experience in actual futsal game situations and conditions (Barron et al., 2020).

One of the exciting exercises to increase agility and dribbling skills simultaneously is the Three Cone Drill using the Ball (TCDB). This drill requires players to perform fast movements and sharp changes in direction using three strategically placed cones while controlling, carrying, and controlling the ball. This exercise can help improve a player's agility and dribbling ability by emphasizing fast movement, changing direction, and effective ball control (Fadillah et al., 2020).

HIIT is a high-intensity interval training. In practice, this exercise uses an anaerobic energy system so that it can

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improve physical abilities related to anaerobic energy, such as endurance, speed, and agility (Kunz et al., 2019; Ouertatani et al., 2022). HIIT has mainly been implemented in football, so this is something new when applied to futsal; this can happen because futsal and football have the same intensity in matches (Barnes et al., 2014; Hostrup & Bangsbo, 2023; Rodrigues et al., 2011).

Therefore, this study aims to evaluate the effect of a combination of the Three Cone Drill using the Ball exercise with HIIT on futsal players' agility and dribbling abilities. In the context of this research, this exercise is considered a novelty and innovative thing because, in previous studies regarding the Three Cone Drill, it has yet to be explored much.

By focusing research on the effect of TCDB+HIIT on the agility and dribbling skills of futsal players, the information obtained can provide a better understanding of the benefits of this exercise in improving the agility and technical abilities of futsal players. This research can also provide a valuable contribution to developing more effective training programs to improve agility and dribbling abilities to increase futsal players' competitive performance.

Materials and methods

Study participants

Fourteen male futsal athletes from senior high school (SMAN) 4 Bojonegoro, East Java, Indonesia, participated in this study. Participants in this study were student futsal athletes aged 16.6±0.7 years, with a height of 170.2±3.36 cm, a body mass of 59±9.11 kg, and a BMI of 20.4±3.25. Furthermore, 14 student futsal athletes were given TCDB+HIIT training. Before the experiment was conducted, participants were informed about the benefits and potential risks associated with the research.

Study organization

This study used an experimental method with a One-Group Pretest-Posttest Design. Fourteen futsal athlete students will do TCDB+HIIT training for six weeks (Permana et al., 2022; Pettersen & Mathisen, 2012). Before and after being given treatment to determine the effect of the exercise, participants will be given an agility and futsal dribbling ability test. In measuring the agility of this study using the Illinois Agility Test and dribbling using the futsal dribbling test.

Statistical analysis

Data analysis in this study consisted of 2 parts: the prerequisite test using Shapiro-Wilk and hypothesis testing using the Paired Sample T-Test. This study uses a paired sample t-test hypothesis test. This test aims to analyze the differences in pretest and post-test results. Statistical analysis in this study used the IBM SPSS Statistics 29.0

Results

This research was conducted for one month and a half, with a total of 20 days of practice with details of one pretest, 18 treatments, and one post-test. The number of participants is as many as 14 players. The results of calculating agility and complete dribbling ability are obtained as follows.

Table 1 above describes the data resulting from increased dribbling speed and ability in this study. Based on the calculation of the pretest and posttest, get an average increase in agility of 0.99±0.57 and dribbling ability of 1.87±1.72.

Based on the results of table 2 above, the results of the normality test with the Shapiro-Wilk test instrument obtained the results from the pretest agility value 0.26>0.05, posttest agility value 0.86>0.05, pretest dribbling value 0.28>0.05, post test dribbling value 0.64>0.05, then all data the research results were normally distributed and continued to test the hypothesis using parametric statistics paired sample t-test.

Based on the results of Table 3 above, From the results of the hypothesis test with the Paired Sample T-Test test instrument, the agility data results obtained have a sig (2-tailed) value of 0.001<0.05, it can be concluded that there is a significant increase in agility through TCDB training +HIIT. The results of the dribbling data have a sig (2-tailed)

Table 1. Data Descriptive

Variable		N	Mean±SD	Min	Max	Mean±SD Pre-Post
Agility	Pretest	14	18.33±0.93	16.75	19.53	0.99±0.57
	Posttest	14	17.33±0.95	15.82	19.01	
Dribbling Ability	Pretest	14	15.13±2.34	12.07	20.87	1.87±1.72
	Posttest	14	13.25±1.38	10.91	15.29	

Table 2. Normality Test

Variable		Shapiro-Wilk		
		Statistic	Df	Sig.
Agility	Pretest	0.93	14	0.26
	Posttest	0.97	14	0.86
Dribbling Ability	Pretest	0.93	14	0.28
	Posttest	0.95	14	0.64

The data are presented by means ± SD and sig. value; In the Shapiro-Wilk test, the data is normally if the sig. ≥ 0.05

Tabel 3. Paired Sample T-Test

Variable	Paired Difference				t	df	Sig. (2-tailed)
	Mean±SD	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
Pre-Post Agility	0.99±0.57	0.15	0.66	1.32	6.5	13	0.001
Pre-Post Dribbling Ability	1.88±1.72	0.46	0.88	2.87	4.08	13	0.001

The data are presented by means ± SD; *statistically significant difference, mean scores at point comparisons from baseline: sig (2-tailed) value of ≤ 0.05.

value of 0.001<0.05, so it can be concluded that there is a significant increase in dribbling ability through TCDB+HIIT training.

Discussion

This study evaluates the effect of implementing TCDB+HIIT exercises on dribbling and agility abilities. The treatment was carried out for six weeks with a frequency of 3 times a week, with a total of 18-day training. This exercise is based on applying specific training principles using a ball and the overloading principle every two weeks. The results showed a significant increase in agility and dribbling ability through TCDB+HIIT training with an intensity of 80%-90%.

The selection of the TCDB+HIIT training program using a ball approach is an essential aspect of efforts to achieve the goals, in this context, to increase agility and dribbling skills (Sekulic et al., 2021). In the process, players must make quick movements with the ball and make sharp changes in direction. This can train and improve dribbling technical skills, speed, and eye and foot coordination. These specific drills allow the player to develop his dribbling skills in real-time in situations similar to those of a real match. Specific training can provide sufficient stimulus to improve coordination in soccer performance (Szabo et al., 2020; Tessitore et al., 2011). On the other hand based on literature studies, the HIIT approach can improve the physical performance of players (Arazi et al., 2017; Clemente et al., 2021).

The principle of overload, which is applied every two weeks, also improves dribbling ability and agility. Increasing training intensity gradually exposes players to more significant challenges, promoting physiological adaptation and increased performance (D'Isanto et al., 2022; Trecroci et al., 2022). Giving excess weight in training can stimulate muscle growth, increase muscle strength, and speed of muscle contraction (Plotkin et al., 2022). This is necessary because it can positively influence dribbling situations and actual futsal matches. Physiological adaptation is essential in improving dribbling ability and agility. During six weeks of practice, body adaptation involves various physiological aspects (Sharma & Kailashiya, 2018). Increased muscle strength can help players produce more substantial movements and optimal ball control. Increasing the speed of muscle contraction can also increase the responsiveness of players to changes in direction and fast movements (Chaabene et al., 2018). In addition, giving TCDB + HIIT exercises can make the muscles more elastic, and the range of motion for the joints will be much more optimal; this will make the joints very flexible and impact the swing of the legs when taking a step wider. In addition, the dynamic balance has also increased because, in this exercise, the athlete must be able to control the body's condition when making movements. In addition, having good agility will have a positive impact on aspects of muscle speed and explosive power (Herridge et al., 2020; Lockie et al., 2014). This adaptation gives players more optimal agility in overcoming challenges in futsal games.

Physiological adaptation, TCDB+HIIT training can also impact psychological. In the process, high-intensity training and a focus on technical skills can increase players' confidence in their dribbling and agility abilities (Nascimento et al., 2016). This can occur due to repeated exercises with a frequent frequency every week. In other words, this can also be a mental boost for players in increasing their agility and dribbling abilities. The significant increase in agility and dribbling ability in this study may also be influenced by motivational factors and the players' dedication to the training program (Garcia-Mas et al., 2010).

In this context, this study's results indicate that applying TCDB+HIIT exercises for six weeks with a frequency of 3 times a week, by applying the specific training principles using the ball and the principle of overload, significantly improves dribbling and agility abilities. The principle of specific training using a ball helps train and improve dribbling technical skills, while the principle of overload gradually increases training intensity and promotes physiological adaptation, especially agility (Thongnum & Phanpheng, 2022).

Conclusions

Based on the research results and discussion in this study, TCDB+HIIT training for six weeks with a frequency of 3 times a week can improve agility and dribbling student futsal athlete.

Conflict of interest

Authors do not receive endorsement from any organization for submitted work. The author has no relevant financial or non-financial interest to disclose.

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ВПЛИВ 6 ТИЖНІВ КОМБІНОВАНОГО ВИКОНАННЯ ВПРАВ НА БІГ ПОМІЖ ТРЬОМА КОНУСАМИ З ВИКОРИСТАННЯМ М'ЯЧА ТА ВИСОКОІНТЕНСИВНИХ ІНТЕРВАЛЬНИХ ТРЕНУВАНЬ НА СПРИТНІСТЬ І ЗДАТНІСТЬ ДО ВЕДЕННЯ М'ЯЧА УЧНІВ-ФУТЗАЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 3 табл., 2 рис., 40 джерел.

Мета дослідження. Високоінтенсивні інтервальні тренування (HIIT) з виконанням вправ на біг поміж трьома конусами з використанням м'яча (TCDB) – це вправа, яка вимагає від гравців виконання швидких рухів і різких змін напрямку, використовуючи м'яч, поміж трьома конусами з високою інтенсивністю. Ця вправа ґрунтується на застосуванні спеціальних тренувальних принципів з використанням м'яча та принципу перевантаження, що має на меті підвищення спритності та покращення навичок ведення м'яча. Метою цього дослідження було оцінити вплив комбінованого виконання TCDB+HIIT на спритність і здібність до ведення м'яча учнів-футзалістів.

Матеріали та методи. У цьому дослідженні використовували експериментальний метод за схемою попереднього та підсумкового тестування на одній групі. Учасниками дослідження стали учні-футзалісти, загалом 14 гравців віком 16,6±0,7 року, зріст 170,2±3,36 см, маса тіла 59±9,11 кг, ІМТ 20,4±3,25. Як інструменти дослідження використовували Іллінойський тест на спритність і тест на футзальне ведення м'яча. Для аналізу даних використовували t-критерій Стьюдента для парних вибірок за рівня значущості 0,05; як попередній критерій використовували критерій Шапіро-Вілка.

Результати. На підставі результатів тесту з використанням t-критерію Стьюдента для парних вибірок було встановлено, що значення рівня значущості (двостороннього) змінної швидкості становило 0,001 < 0,05 зі збільшенням на 0,99±0,57. У змінній ведення м'яча значення рівня значущості (двостороннього) становить 0,001 < 0,05 зі збільшенням на 1,88±1,722.

Висновки. Результати цього дослідження дозволяють дійти висновку, що вправи TCDB + HIIT ефективно застосовуються для підвищення спритності футзалістів і покращення їхніх здібностей до ведення м'яча.

Ключові слова: футзал, вправа на біг поміж трьома конусами з використанням м'яча, високоінтенсивне інтервальне тренування, спритність, здібність до ведення м'яча.

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ORIGINAL SCIENTIFIC ARTICLE

RELATION BETWEEN START REACTION TIME AND PERFORMANCE TIME AMONG WOMEN FINALIST SPRINTERS IN THE OLYMPIC GAMES 2000 TO 2020

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Abstract

Background. Success in sprinting events broadly depends on many factors. Among them, the reaction time at starting is one of the main factors that help sprinters get success by increasing their confidence and helping to avoid false starts.

Study purpose. The purpose of the study was to find out the relationship between reaction time and performance time among women finalist sprinters in six Olympic Games since 2000.

Materials and methods. Data were collected from 227 (n = 227) women finalist sprinters in the event of 100 m (n = 47), 200 m (46), 400 m (43), 100 m H (45), and 400 m H (46) in 6 Olympic Games from 2000 to 2020, based on published official reports on "worldathletics.org" and "www.olympedia.org" websites. Data were considered from 227 samples from a total of 240 finalist women, where 13 were excluded because of a false start, being disqualified for doping, or failing to finish. Descriptive statistics, the Pearson correlation coefficient and simple regression analysis were used to determine the relationship between reaction time and performance time of the finalist women sprinters. The significance level was set at 0.05. Further Gaval'a 5-point scale was used to categorize the women sprinters based on their reaction times in five sprint events.

Results. The results showed that there was a low positive correlation between reaction time and performance time among the sprinters in the 100 m ($r = 0.369$, $p < 0.05$) and 100m H ($r = 0.367$, $p < 0.05$) events, whereas no relation was confirmed in 200 m, 400 m and 400 m hurdles among women sprinters who participated in 2000-2020 Olympics. The 5-point scale revealed that 33.48% of sprinters belong to the average category, while 25.99% are in the unsatisfactory category, and only 1.32 % and 16.74% are in the excellent and very good categories, respectively.

Conclusions. The current analysis concludes that there was a low positive relationship between reaction time and performance time of the finalist women sprinters only in sprint events of 100 m and 100 m hurdles during 2000 to 2020 Olympics, and the majority of the finalists belonged to the 'Average' category as per Gaval'a 5-point scale.

Keywords: elite sprinters, Olympic sprint events, performance time, reaction time.

Introduction

'Track and field' is one of the most popular events in the highly competitive sports arena and embodies the spirit of mankind to challenge the limit and continue to make breakthroughs (Opar et al., 2015). Olympic sprinting is the particular focus of global audiences of all time (Geurin & Naraine, 2020). Sprint results (such as timing of the event) are approaching human limits on a daily basis as performance in sprint events improves over time (Haugen & Buchheit, 2016). For elite-level athletes in sprinting, the physical and technical gaps are shrinking day by day, and the differences in performance are sometimes narrowed down to only 0.001 second (Zhang et al., 2021). The reaction time of sprint runners is one of the key determinants that may affect their performance and success where hundredths or even thousandths of a second decide the winner (Zhang et al., 2021; Majumdar & Robergs, 2011). Therefore, the poor reaction ability of a sprinter can make them unsuccessful as well as out of the competition because of a false start.

In the sports field, reaction ability is of great importance because every sports action starts with a reaction to a known or unknown stimulus. The sprinters start their sports action with a reaction to a gun sound, i.e., a known stimulus. The

reaction time may be defined as the time elapsed between the sensory stimulus and subsequent responses (Spierer et al., 2010). Reaction time to sensory stimuli has been widely examined in the literature in various populations (Spierer et al., 2010; Spierer et al., 2011; Pramono et al., 2023). In sprinting events, the reaction time is influenced by factors like the time required for the start signal stimulus to reach the receptors, the time for the receptors to convert the stimulus into nerve signals, neurotransmission and processing, the activation of the concerned muscles, and soft tissue adaptability (Baker et al., 2015; Zhang et al., 2021).

Apart from reaction time, performance in sprint events depends on start acceleration, block clearance, maintenance or speed endurance, and deceleration phase. However, in sprint events, the two important components, i.e., Block clearance with a proper start and gaining optimum acceleration, substantially generate the end outcome. Previous research studies revealed that start and start acceleration play a significant role in achieving maximum results in sprint disciplines (Pavlovic et al., 2014; Pavlovic, 2015). According to the available information (Babic et al., 2011), the length of the initial acceleration depends on the morpho-motor potentials, the anaerobic-lactate system, and the intensity of the sprinter's CNS excitation (Pavlovic, 2021). In the first ten meters of a 100 m sprint event, sprinters develop up to 55% of their maximum speed, up to twenty meters, 70–80%; and up to thirty meters, it goes up to 85–95%. Between 50m and 80 m, sprinters reach their maximum speed (more than 11.5 m/s), and after 80-90 m, the achieved speed decreases (Pavlovic et al., 2014; Majumdar & Robergs, 2011; Morin et al., 2012). The drop in speed at the finish of the race is a consequence of lower speed endurance, i.e., weaker anaerobic capacity in sprinters.

Start acceleration is a complex cyclic motion determined primarily by the progression of frequency and step length, the duration of the contact phase and the phase of flight, the position of the body's center of gravity at the moment of ground contact, propulsion in the phase of flight, and the forces that are handled in the first step. But here, along with all this, the reaction time is also not avoided in any way (Majumdar & Robergs, 2011). However, these disparities are not always significant in 200 and 400-meter events, which contradict the idea that start acceleration and reaction time are more essential in shorter sprint events than in longer sprint events (Tonnessen et al., 2013; Pilianidis et al., 2012a).

Many researchers attempted to analyse biomechanically the block clearance and acceleration to explain the phenomenon of sprint speed and start acceleration based on the timing of the start reaction (Ille et al., 2013; Babic et al., 2011). Optimal coherence between sprint starts and acceleration indicates particular motor challenges that athletes must integrate in terms of time and spatial factors in the total running process (Babic et al., 2011). However, only a few researchers examined the relationship between start reaction time and total performance time.

Some researchers have focused mainly on reaction time and performance time which were mainly done on world-class athletes. Pilianidis et al. (2012b) reported no significant correlation between reaction time and performance time in sprint events among male sprinters except in the 110-meter Hurdles race in the World Athletic Championship between 1997 to 2009. Pavlovic (2021) also supported the above study in his research, where only the 100-meter race had a significant relationship between reaction time and performance time among male sprinters at the World Championships from 2001 to 2019. Paradisis (2013) observed a significant correlation between reaction time and sprint results in the 2004 Olympic Games in Athens in the 100-meter for females and the 100-meter for male sprinters. In high-level competitions (Olympic Games, World Championships), gender differences are noticed in the timing of the start reaction (Mitasik et al., 2020; Mirkov et al., 2020). Tonnessen et al. (2013) found significant differences in reaction time in the 100 m sprint event between male and female world-class sprinters during 2003 to 2009 World Championships.

In this perspective, the current study was conducted based on large amounts of data, i.e., on 240 female finalist sprinters from five sprint events since the 2000 Olympic Games, with the purpose of finding out the relationship between reaction time and performance time among female finalist sprinters.

Materials and methods

Sample Details

The current study included 240 elite female finalist athletes in Olympics sprint events from the 2000 Sydney Olympics to the 2020 Tokyo Olympic (held in 2021 due to the pandemic situation). Only 48 female finalist athletes from each sprint event, such as 100 m, 200 m, 400 m, 100 m hurdles, and 400 m Hurdles races were considered. Their starting reaction time and final results were obtained from the International Amateur Athletic Federation (IAAF) (from 2000 to 2016) and World Athletics (from October, 2019) official reports of the Olympic Games. On 227 samples of 100 m (n = 47), 200 m (n = 46), 400 m (n = 43), 100 m H (n = 45), and 400 m H (n = 46), data were gathered and finally calculated by the statistical method. Thirteen (n = 13) samples were excluded for various reasons, including false starts, being disqualified for doping, did not start (DNS), or did not finish (DNF).

Statistical Analysis

The descriptive statistics (Mean, SD, range) were calculated. The Anderson-Darling test was used to investigate the assumptions of normality and homogeneity in exported data. The Pearson correlation of coefficient was used to measure the strength of the link between reaction time and performance time with significance level at 0.05 ($p < 0.05$). For data sorting, statistical analysis, and graphical depiction, the IBM Statistical Package for Social Sciences (SPSS-free version) version 20 and Gnumeric Spreadsheet version 1.12.52 were used. A 5-point rating scale (according to Gaval'a, 2002; Mitasik et al., 2020) was used to determine the category of the reaction time of the female athletes in different sprint events.

Variables

In the present study, reaction time and total performance time were considered as variables, and data were obtained from published official reports on the "worldathletics.org" website and "www.olympedia.org".

Results

All finalists had to meet the entry standards of the championship, which were set by the IAAF and World Athletics; thus, familiarization with the competition procedure was ensured.

Table 1 highlighted the descriptive statistics of reaction time (Mean ± SD, Fastest and Slowest, Range) of the female Olympic finalist in 100 m, 200 m, 400 m, 100 m hurdles, and 400m hurdles events from 2000 to 2020 Olympic Games in seconds. Table 1 also presents the fastest reaction time which was seen in the 200 m event (0.104 seconds) in the year of 2016 and the slowest RT which was seen in the 400 m race (0.452 seconds) in the 2000 Olympic. But it was also observed that the RT of 100 m (0.108 s) and 400 m Hurdles (0.447 s) races were very close to the above events in 2020 and 2000 Olympics respectively. Another observation from Table 1 is that the average RT in 100 m (0.168 ± 0.033) and 100 m H (0.168 ± 0.032) were almost the same which was also the best average reaction time among the five events.

Table 1. Descriptive statistics of Reaction Time of female finalist in 100 m, 200 m, 400 m, 100 m H, and 400m H events from 2000 to 2020 Olympic Games and correlation between Reaction time and Performance Time

Events	Year	Total Athletes (no.)	Variables	Mean ± SD (s)	Fastest-Slowest (s)	Range (s)	Simple Regression analysis			
							R	R^2	F	Sig.
100 m	2000	7	RT	0.208±0.032	0.163-0.253	0.090				
	2004	8		0.185±0.020	0.154-0.212	0.058				
	2008	8		0.183±0.033	0.149-0.234	0.085				
	2012	8		0.156±0.015	0.128-0.176	0.048				
	2016	8		0.140±0.016	0.112-0.163	0.051				
	2020	8		0.140±0.016	0.108-0.158	0.050				
	2000-2020	47	RT	0.168±0.033	0.108-0.253	0.145	0.369	0.136	7.095	0.011*
			PT	11.001±0.199	10.610-11.800	1.190				
200 m	2000	7	RT	0.192±0.026	0.151-0.235	0.084				
	2004	8		0.199±0.031	0.162-0.259	0.097				
	2008	8		0.186±0.015	0.167-0.206	0.039				
	2012	7		0.168±0.007	0.157-0.176	0.019				
	2016	8		0.145±0.020	0.104-0.171	0.067				
	2020	8		0.156±0.012	0.141-0.173	0.032				
	2000-2020	46	RT	0.174±0.027	0.104-0.259	0.155	0.046	0.002	0.094	0.761
			PT	22.320±0.405	21.530-24.000	2.470				
400 m	2000	8	RT	0.250±0.090	0.174-0.452	0.278				
	2004	8		0.245±0.024	0.205-0.276	0.071				
	2008	6		0.227±0.042	0.181-0.299	0.118				
	2012	7		0.195±0.030	0.167-0.258	0.091				
	2016	7		0.167±0.028	0.133-0.219	0.086				
	2020	7		0.155±0.020	0.127-0.176	0.049				
	2000-2020	43	RT	0.208±0.058	0.127-0.452	0.325	-0.016	0.000	0.011	0.918
			PT	49.991±0.588	48.360-51.250	2.890				
100 mH	2000	8	RT	0.209±0.043	0.156-0.294	0.138				
	2004	6		0.161±0.019	0.145-0.195	0.050				
	2008	8		0.176±0.031	0.138-0.239	0.101				
	2012	7		0.149±0.010	0.137-0.163	0.026				
	2016	8		0.152±0.015	0.130-0.179	0.049				
	2020	8		0.158±0.009	0.144-0.172	0.028				
	2000-2020	45	RT	0.168±0.032	0.130-0.294	0.164	0.367	0.135	6.683	0.013*
			PT	12.705±0.228	12.350-13.490	1.140				
400 mH	2000	8	RT	0.282±0.115	0.169-0.447	0.278				
	2004	8		0.288±0.066	0.184-0.408	0.224				
	2008	8		0.205±0.024	0.184-0.248	0.064				
	2012	7		0.202±0.040	0.163-0.270	0.107				
	2016	8		0.173±0.031	0.140-0.226	0.086				
	2020	7		0.183±0.033	0.136-0.235	0.099				
	2000-2020	46	RT	0.224±0.074	0.136-0.447	0.311	0.035	0.001	0.053	0.819
			PT	53.971±1.106	51.460-57.550	6.090				

Note. *no = Number, s = Seconds, m = Meter; SD = Standard Deviation, H = Hurdles, RT = Reaction Time, PT = Performance Time, R = coefficient of correlation, R^2 = coefficient of determination, F = F-value, p = Level of significance, *$p < 0.05$

Table 2. Evaluation of reaction time of women finalist sprinter (event-wise) of Olympic (2000-2020) on a 5-points scale (according to Gaval'a, 2002; Mitasik et al., 2020)

Rating	Number of Female Finalists in Different Olympic Events						
	100 m	200 m	400 m	100 m H	400 m H	Total	%
Excellent (0.100-0.120 s)	2	1	0	0	0	3	1.32
Very Good (0.121-0.150 s)	13	7	4	11	3	38	16.74
Average (0.151-0.175 s)	15	20	9	22	10	76	33.48
Below Average (0.176-0.205 s)	9	11	12	7	12	51	22.47
Unsatisfactory(≥0.206 s)	8	7	18	5	21	59	25.99
Overall	47	46	43	45	46	227	100

Note. H = Hurdles, s = Seconds; m = Meter

Table 3. Analysis of reaction time and performance time of best three reaction time holders women finalist sprinters from 2000-2020

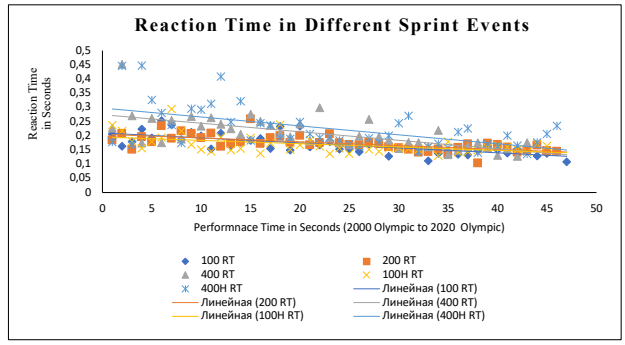
Events (Mean RT)	Total No. of Finalists	Best Three Reaction Times (s)	Performance Time of the event	Year	Year Wise Position	Rating Scale	Mean Differences of RT
100 m (0.168 s)	47	0.108	11.12	2020	8th	Excellent	0.060
		0.112	10.83	2016	2nd	Excellent	0.056
		0.128	10.94	2012	6th	Very Good	0.040
200 m (0.174 s)	46	0.104	22.69	2016	8th	Excellent	0.070
		0.135	22.31	2016	5th	Very Good	0.039
		0.141	21.88	2016	2nd	Very Good	0.033
400 m (0.208 s)	43	0.141	21.94	2020	4th	Very Good	0.033
		0.127	49.97	2020	6th	Very Good	0.081
		0.131	49.61	2020	4th	Very Good	0.077
		0.133	51.97	2016	6th	Very Good	0.075
100 m H (0.168 s)	45	0.130	12.74	2016	5th	Very Good	0.038
		0.137	12.35	2012	1st	Very Good	0.031
		0.137	12.48	2012	3rd	Very Good	0.031
400 m H (0.224 s)	46	0.138	12.64	2008	2nd	Very Good	0.030
		0.136	53.08	2020	4th	Very Good	0.088
		0.140	53.13	2016	7th	Very Good	0.084
		0.143	54.56	2016	1st	Very Good	0.081

Note. H = Hurdles, RT = Reaction Time, m = Meter

Based on the data of 227 women finalist sprinters across the last six Olympics (2000 to 2020), a 5-point scale was used to assess reaction times (Table 2). The majority of the women printers were classified as "Average" (33.48%), while the percentage of athletes classified as "excellent" was very low at only 1.32%, with the first and second-best timing holders in the 100 m event and the other one in the 200 m event, whereas the second largest part of the women sprinters belongs to the unsatisfactory (25.99%) category.

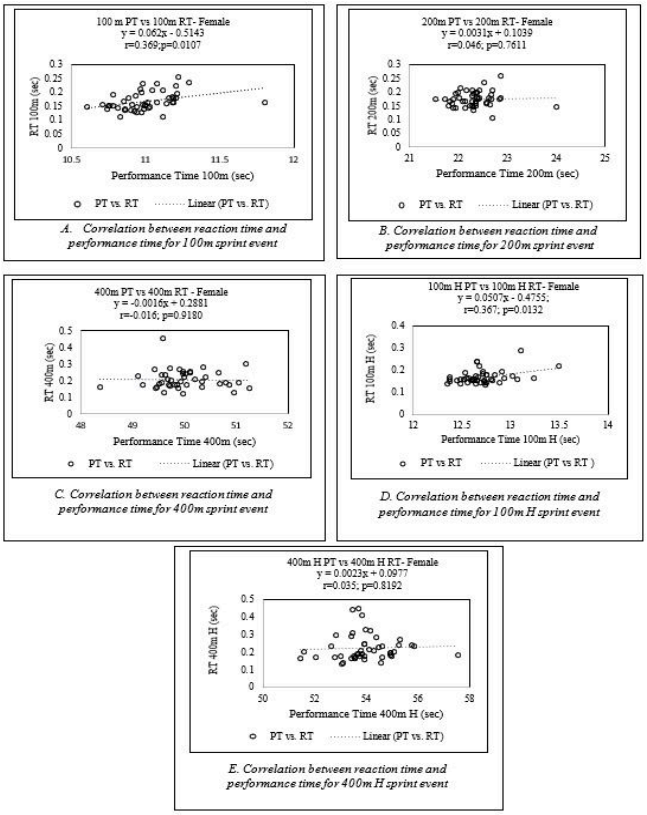
Table 3 highlighted that the top three reaction times of five different sprint events (100 m, 200 m, 400 m, 100 m H, and 400 m H) lie between 0.104 s (200 m) to 0.143 s (400 m H), where a total of 17 participants were placed, and two of them had the same timing in the same events (200 m and 100 m H) each. It is also noted that only six sprinters among them got positions (medal holders) between first and third in the events except the 400 m race, where only two got first place, three got second place, and one got third place. Except for only three in the Excellent category, the remaining 14 sprinters belong to the Very Good category, where the mean difference in reaction time (0.038 s to 0.030 s for the best three RT) is the lowest for the 100 m hurdles and the highest for the 400 m hurdles (0.088 s to 0.081 s).

Figure 1 presents the event-wise reaction time and performance time of all individual data with trend lines



Note. PT=Performance Time, RT=Reaction Time

Fig 1. Reaction Time in Different Sprint Events (100 m, 200 m, 400 m, 100 m H, 400 m H)



Note. PT = Performance Time, RT = Reaction Time, sec = Seconds, r = coefficient of correlation, p = Level of significance

Fig 2. Scatter plots (ABCDE) illustrate the relationship between Reaction time and Performance time in 100 m, 200 m, 400 m, 100 m H, and 400 m H events

since the 2000 Olympics. Here it is also seen that most of the data is spread between 0.1 to 0.3 seconds.

The results of a correlation analysis (Figure 2) were examined for each sprint event. The Pearson correlation coefficient and simple regression were calculated to determine the relationship between reaction time and sprint performance time. Figure 2 revealed that for most sprint events, there was no statistically significant correlation ($P<0.05$) between reaction time and sprint performance time. However, among female finalists, a significant correlation was observed between reaction time and sprint performance time in the 100 m flat ($R = 0.369$, $p < 0.05$) and 100 m hurdles ($R = 0.367$, $p < 0.05$), with a significance level of $p < 0.05$ (Figure 2).

Discussion

The top performance of sprinters is the result of the integration of several factors (genetic potential, training, health condition of the athlete, etc.). In athletics, the time of the (starting) reaction is becoming more and more significant in the result performance of sprint disciplines. The aim of the study was to observe and analyse the relationship between reaction time and performance time among female sprinters.

The current analysis examined 240 female finalists who qualified to participate in the Olympic Games from 2000 to 2020 across five different sprinting events. Finally, the data were collected from 227 participants for the data analysis.

The results showed that there was a linear increase in the average reaction time and average performance time as the length of the event increases (Table 1). There was a disparity in reaction time between events, indicating that athletes responded differently to various events. As the distance of the events increases, the reaction time also gradually increases in sprint events (Table 1). The current analysis demonstrated a total reaction time variation (100 m to 400 m H) of 0.056 s among the five selected events.

Pioneer researchers have shown in their analysis (Pilianidis et al., 2012b; Haugen et al., 2019; Pavlovic, 2021) that short-distance sprinting events, such as the 100 meters, women sprinters have a significantly better reaction time than other sprints event like 200 m and 400m. These studies support our findings, particularly in the 100 m ($r = 0.369$, $p<0.05$) and 100 m hurdles ($r = 0.367$, $p < 0.05$) events, with a correlation between the mean value of performance time and reaction time. Despite the weak correlation observed in our current analysis for 100 m and 100 m hurdles events, it may be said that reaction time has a significant impact on total performance time in 100 m flat sprint and 100 m hurdles.

Furthermore, it is worth mentioning that the least reaction time has a productive outcome on the first three-step movement, acceleration, maintenance of speed, and overall performance time, as supported by prior investigations (Haugen & Buchheit, 2016; Morin et al., 2012).

However, it has been argued that reaction time does not always have a significant impact on total performance time or the length of the event (Pilianidis et al., 2012a). It is also seen in our study that in the Tokyo 2020 Olympics, the mean reaction time in the 400 m race was lower (mean: 0.155 s; fastest: 0.127 s) compared to the 2020 Olympic Games in the 100 m H (mean: 0.158 s; fastest: 0.144 s), 200 m (mean: 0.156 s; fastest: 0.141 s), and 400 m H races (mean: 0.183 s; fastest: 0.136 s).

It is also important to note that other factors such as genetic potential, training, health condition of the athlete, movement time, CNS system, position of the center of gravity, initial acceleration, loco-motor phase, time of deceleration, and body's ability play a more active role in running and contribute to the improvement of total performance time (Haugen et al., 2012).

On the other hand, another finding from this study (Table 1) was that the reaction time of women finalists increased from 0.104 s (fastest by a sprinter in 200 m) to 0.452 s (longest by a sprinter in 400 m), which ranged 0.348 s in where event-wise average reaction time variation was quite low, only 0.056 s (see Table 1). Particularly this occurs when an athlete has differences in their ability, race technique, motivation during the race, recovery phase, etc., and this affects their performance (Haugen et al., 2019; Tonnessen et al., 2013). Another fact that was highlighted in Table 2 was that most of the data was spread in the "Average" category (33.48). However, out of this, 75% of this category data was available on 100 m, 200 m, and 100 m H races, and only 25% was from 400 m and 400 m H races. This type of similarity is also seen in the "Very good" category (16.74%), where only 18.42% of athletes belong to the 400 m and 400 m H races. But the opposite scenario has been

seen in the "Unsatisfactory" category, where most of the data (66.10%) lies in the above-mentioned two events. The prediction behind this phenomenon is that reaction time plays a more important role in short-distance running than in long-distance events as we see in the above finding.

Reaction time is considered one of the most complex issues in sprinting, and it cannot be ignored, particularly in elite athletes' performance and top international circuits where recovering from a poor start is challenging (Haugen et al., 2019; Tonnessen et al., 2013). However, there are exceptional athletes like Usain Bolt, Justin Gatlin, and Veronica Campbell-Brown who have achieved remarkable results despite having poor reaction times in the last two decades. Usain Bolt, for instance, consistently secured first position in the 100 m and 200 m events in the Olympics, with reaction times of ≤160 milliseconds (five times) and ≤180 milliseconds (six times), respectively (Pavlovic, 2021; Mitasik et al., 2020). Besides that, Justin Gatlin secured a position 12 times with an average reaction time of 159 milliseconds, and Veronica Campbell-Brown won medal for 15 times with an average reaction time of 165 milliseconds at the World Championship (Mitasik et al., 2020; Pavlovic, 2021; worldathletics.org). This kind of performance is only possible by working properly and doing it together with other factors.

Therefore, it can be concluded that reaction time is not always the sole predictor of performance in longer-distance running events, such as the 400 m or 400 m hurdles. However, apart from reaction time, other factors and aspects play a significant role in overall performance, such as correct block clearance technique, speed endurance, start acceleration, confidence level, race strategy, ability to fight back, perception, and pacing skills (Pilianidis et al., 2012a; Pilianidis et al., 2012b; Majumdar & Robergs, 2011). An example of Wayde van Niekerk's performance in the men's 400 m race at the 2016 Olympic Games, where his reaction time (0.181) ranked fifth among the finalists, but there was no difficulty in setting the World Record with a timing of 43.03 seconds(worldathletics.org). Also in this study it was found that, while the push-off phase from the blocks is vital for the athletes competing in the 200 m, 400 m, and 400m hurdles events, but the other factors (technique, stride length, stride frequency, maintaining phase, deceleration phase) can compensate this drawback. Apart from this, the curve of the track during the start is one of the valid reasons behind the reaction time deterioration that is seen in the above-said events.

Although here in Table 3, it is reflected that, despite the athletes' reaction timing being quite good (first, second, and third best reaction time holders in five different events), about 65% of the athletes failed to win medals over the years. The above-mentioned results indicate that RT is not only the primary indicator of winning a medal in different sprint events. So, despite the limitations of the RT as a performance indicator, still it is an advantageous issue to improve performance in sprints for developing confidence and avoiding false start.

Conclusions

The findings of this study, based on a thorough analysis and persuasive arguments, lead to the conclusion that starts reaction time does not provide any additional advantages and plays a negligible role in sprinting performance, with the exception of the 100 m ($r = 0.369$, $p < 0.05$) and 100 m H ($r = 0.367$, $p < 0.05$) races. These results indicate that having a faster start reaction time does not necessarily correspond into improved overall performance times in Olympic women's sprint events. It is important to note that while reaction time alone cannot guarantee exceptional performance at an elite level, as exemplified earlier, other factors such as a combination of supportive tools and areas also contribute to enhancing overall performance time. Nevertheless, it is worth mentioning that athletes and coaches can still strive to enhance their performance by focusing on improving their response time through effective training. By correctly employing strategies to improve reaction time, athletes can potentially see an improvement in their overall performance. Therefore, this study can provide valuable insights to coaches, performance analysts, sports scientists, and even active athletes, facilitating a better understanding of the role of start reaction time and enabling further analysis and exploration of performance enhancement strategies.

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Conflict of interest

The authors declare that there was no conflict of interest.

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ЗВ'ЯЗОК МІЖ ЧАСОМ РЕАКЦІЇ НА СТАРТ І ЧАСОМ ВИКОНАННЯ ЗАБІГУ СЕРЕД ЖІНОК-ФІНАЛІСТОК У СПРИНТІ НА ОЛІМПІЙСЬКИХ ІГРАХ 2000–2020 РОКІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 3 табл., 2 рис., 25 джерел.

Історія питання. Успіх у спринтерських змаганнях багато в чому залежить від багатьох факторів. Серед них час реакції в момент старту є одним із головних факторів, які допомагають спринтерам досягати успіху, підвищуючи їхню впевненість і допомагаючи уникати фальстартів.

Мета дослідження. Метою дослідження було з'ясування зв'язку між часом реакції та часом виконання забігу серед жінок-фіналісток у спринті на шести Олімпійських іграх із 2000 року.

Матеріали та методи. Дані збирали з показників 227 (n = 227) жінок-фіналісток у спринті в забігах на 100 м (n = 47), 200 м (46), 400 м (43), 100 м із бар'єрами (45) і 400 м із бар'єрами (46) на 6 Олімпійських іграх із 2000 по 2020 рік на основі опублікованих офіційних звітів на веб-сайтах "worldathletics.org" і "www.olympedia.org". Дані були враховані з 227 вибірок із загалом 240 жінок-фіналісток, із яких 13 були виключені через фальстарт, дискваліфікацію через допінг або неспроможність добігти до фінішу. Для визначення зв'язку між часом реакції та часом виконання забігу жінок-фіналісток у спринті використовували описову статистику, коефіцієнт кореляції Пірсона та аналіз простої регресії. Рівень значущості був заданий на рівні 0,05. Далі використовували 5-бальну шкалу Ґавалья для класифікації жінок-спринтерів за їхнім часом реакції в п'яти спринтерських змаганнях.

Результати. Результати показали низьку позитивну кореляцію між часом реакції та часом виконання забігу серед спринтерів у забігах на 100 м ($r = 0,369$; $p < 0,05$) і 100 м із бар'єрами ($r = 0,367$; $p < 0,05$), тоді як на дистанціях 200, 400 та 400 метрів із бар'єрами серед жінок-спринтерів, які брали участь в Олімпійських іграх 2000-2020 років, зв'язок не підтверджено. За 5-бальною шкалою виявилося, що до середньої категорії належать 33,48% спринтерів, тоді як 25,99% належать до незадовільної, і лише 1,32% і 16,74% належать до відмінної та дуже доброї категорій відповідно.

Висновки. Даний аналіз дозволяє дійти висновку, що під час Олімпійських ігор 2000-2020 років низький позитивний зв'язок між часом реакції та часом виконання забігу жінок-фіналісток у спринті спостерігався лише в спринтерських забігах на 100 м та 100 м із бар'єрами, при цьому за 5-бальною шкалою Ґавалья більшість фіналісток належали до «Середньої» категорії.

Ключові слова: елітні спринтери, Олімпійські спринтерські змагання, час виконання забігу, час реакції.

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ORIGINAL SCIENTIFIC ARTICLE

CHIMNEY JUMP AND STANDING LEG EXTENSION TRAINING INCREASES THE LOWER EXTREMITY POWER OF VOLLEYBALL ATHLETES

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Abstract

Background. The Covid-19 pandemic has caused various adaptations in the world of sports. One form of adaptation that is carried out is training at home or known as training from home (TFH).

Study purpose. This study aims to see the effectiveness of the chimney jump and standing leg extension exercises carried out by volleyball athletes during training at home or training from home (TFH).

Materials and methods. A total of 36 volleyball athletes with an age range of 19-20 years were selected by purposive sampling and divided into the chimney jump (KCJ) group, the standing leg extension (KSE) group, and the control group (KKL). This research is quantitative research with a quasi-experimental research design with one group pretest posttest design.

The three variables used as the dependent variable are agility, balance, and athlete's leg power which were measured before TFH and after the athlete carried out TFH for 3 months. The results of the exercise were analyzed descriptively and continued to be analyzed using the Independent Samples T-test and One-Way ANOVA.

Results. There was a significant difference in the results of the leg power posttest of the three groups (<.05) with KCJ having the highest average leg power (77.76 ± 9.38). Furthermore, KSE has the highest average in agility (56.83 ± 11.93) and balance (38.75 ± 3.02).

Conclusions. Based on the results of this study, it can be concluded that the chimney jump has a significant impact on increasing leg power. On the other hand, the standing leg extension has a positive impact on increasing agility and balance.

Keywords: chimney jump, standing leg extension, agility, balance, leg power.

Introduction

Volleyball is one of the most popular sports in the world (Briner & Kacmar, 1997). This sport is also a favorite sport in Indonesia (Maliki, 2017). Various training methods were developed rapidly to support the training to be more efficient (Munir & Muhammad, 2018). Various coaching programs have been implemented to maximize the athletes' best performance in volleyball (Oliinyk et al., 2021). There are variations of technical training models have also been studied to increase athlete motivation in training (Pranopik, 2017).

The physical component is an important factor in volleyball achievements (Prasetyo, 2020). Good physical condition can support athletes in performing techniques and tactics optimally to bring a positive impact on athlete achievement (Firmansyah, 2017). In basic passing techniques, the physical components of eye coordination, arm muscle strength, and balance are of key importance for an athlete (Ikadarny & Karim, 2020). Conversely, poor athlete performance is often caused by a decrease in the ability of the physical component (N. Saputra & Aziz, 2020). Furthermore, the achievements of a team are also determined by the physical condition of the players (Maizan & Umar, 2020).

The physical components that play an important role in volleyball are the explosive power of the arm muscles, leg muscles, agility, flexibility, and endurance (Guscahyati & Shin, 2019). Each physical component is closely related to the techniques and tactics used in volleyball. The role of the leg muscles is very important in defending or blocking (P. Saputra et al., 2016) and attacking or smashing (Pratomo & Iqbal, 2020). As a result, the training model to improve the leg muscle explosive power is the most frequently chosen by volleyball coaches in preparing physical training programs (Utamayasa, 2020).

Leg muscle is very important to train for volleyball athletes (Nasrulloh et al., 2021). The leg muscle is not only important to improve the athlete's performance, but also to prevent the occurrence of injuries that are often experienced by volleyball on the limbs such as ankle sprains (Briner & Kacmar, 1997) and Achilles tendon rupture (Al Ardha et al., 2020). These injuries can be avoided by training leg muscle strength which is important in performing various volleyball basic techniques related to vertical jump (da Cunha et al., 2020). Models of physical exercise can also be developed to support movements or techniques to overcome injuries involving the legs (Briner & Kacmar, 1997).

Various training models have also been developed to improve athletes' abilities (Maliki, 2017). The training model that can be used to increase the explosive power of the leg muscles is the drill box exercise (Widiantari & Indrawathi, 2018), plyometric exercises (P. Saputra et al., 2016), practice multiple box jumps (Utamayasa, 2020), skipping exercises (Hidayat et al., 2020), reactive jump over hurdles exercise (Nasri et al., 2017). As well as 1:3 interval ratio method exercises with skipping rope media (Hariyanto & Pramono, 2020). However, during covid-19 pandemic, it is necessary to modify the training model that can be applied independently at home (Irdiani, 2020).

The training model known as training from home (TFH), is carried out independently at home during the Covid-19 pandemic. Athletes use the facilities and infrastructure available in the home environment to practice. However, the training load and recovery model are important to maintain and improve athlete performance (Berriel et al., 2020). It is also necessary to consider the mental condition and anxiety of athletes when training during a pandemic (Herdyanto et al., 2020). Furthermore, the Chimney jump and Standing Leg Extension were selected as treatment in this study to increase agility, balance, and leg power in volleyball athletes.

Chimney Jump is a training model with a media agility ladder. The jump is done by bending both knees and assisted by the movement of the two arms swinging forward so that there is balance when making a forward jump, after that all leg muscles contract to jump forward as high as possible by lifting the thighs parallel to the horizontal line and landing both legs on the second box with followed by swinging both arms back so as to maintain balance when landing, after both feet land on the second box, immediately proceed with the same movement procedure to jump to the fourth box with a distance of one box to the end of the agility ladder toolbox. The series of chimney jump movements can be modified, and the level of difficulty can be adjusted. This is done to provide a challenge and make the exercise more interesting. This chimney jump training model is effective for increasing the ability of the leg muscles and agility of an athlete (Herdyanto et al., 2019).

Standing Leg Extension is a training model using additional equipment in the form of resistance bands or rubber weights attached to the ankles. The movement begins by lifting the leg that is given a load until the thigh and calf form a 90-degree angle. After that, just do the swing of the calf forward until it is straight with the thigh and then return to its original position. This is done repeatedly according to the prescribed dose. Single leg stands can help improve balance (Munawwarah & Rahmani, 2015). Similar exercises can also be used to improve mobility (Widayanto et al., 2017). Based on the background that has been presented, this study aims to determine the effectiveness of the Chimney Jump and Standing Leg Extension Exercise programs carried out independently at home (TFH) during the Covid-19 pandemic on agility, balance, and leg power in volleyball athletes.

This study aimed to analyze the result of the Chimney jump and Standing Leg Extension which were selected as treatment in this study to increase agility, balance, and leg power in volleyball athletes.

Materials and methods

Study participants

Based on the problems and research objectives that have been described previously, this type of research is a quasi-experiment with a one-group pretest-posttest research design. A total of 36 male volleyball athletes with an age range of 19-20 years were selected by purposive sampling method. All of the research samples were explained the research procedure and have agreed to participate by filling the informed concern. The group division was based on the z-score ranking of the pre-test scores which were then divided into three groups using the ordinal pairing technique, namely: the chimney jump (KCJ) group, the standing leg extension (KSE) group, and the control group (KKL). Treatment in the chimney jump (KCJ) group and the standing leg extension (KSE) group was carried out 4 days/week with a training duration of 20 minutes for 3 months of training from home (TFH). The research design was evaluated and approved by Universitas Negeri Surabaya Ethical Board Members No. B/12483/UN38/HK.01.01/2021.

Study organization

Agility in sports movements is needed for sudden changes in direction of motion. It requires movement speed and good balance. In this study, the ability of agility will be measured by a side-step test for 20 seconds. Records of automatic test results are visible on the monitor based on the number of athletes' steps through the right and left sensors.

Fig. 1. Agility Test Documentation

Balance is the ability to stay upright or keep control of body movements both while moving and still. In this study, balance was measured by a balance beam test. The athlete stands on one leg with his hands on his hips and eyes closed. The timing will be stopped when the pedestal foot shifts. This test will be carried out three times and the best time will be taken.

Fig. 2. Balance Beam Test Balance Test Equipment

Leg Power is a combination of two elements of physical condition, namely the strength of leg muscle contraction and the speed of movement of the leg muscles which are carried out simultaneously. In this study, leg power ability was measured by accu power or force plates with vertical jump movements. The test was carried out three times and the best leg power data was taken in Watt units.

Fig. 3. Limb Power Test Documentation with Accu Power

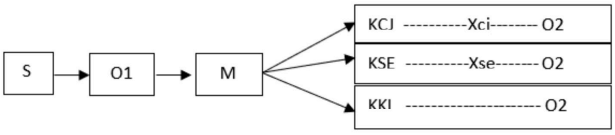

Fig. 4. Research design

Information:

S : Samples	KKL : Control Group
O1 : Pretest	O2 : Posttest
M : Matching Ordinal Pairing	X : Treatment
KCJ : Chimney Jump Group	Xcj : Chimney Jump Treatment
KSE : Standing Leg Group Extension	Xse : Standing Leg Treatment Extension

Statistical analysis

Data from the pre-test and post-test results were tested for normality with the Kolmogorov-Smirnov Test. If the results of the normality test show that the results of the data distribution are normal, then the data is continued with analysis using the one sample t-test to see differences in the results of the pre-test and post-test in each group (Figure 4). Furthermore, one-way ANOVA and post hoc tests were also carried out by comparing the results of the post test with all sample groups. All statistical tests were performed with SPSS 26 computer software.

Results

The results of the normality test using the Kolmogorov-Smirnov test showed that the data were normally distributed for each variable (α>0.05). The one sample t-test was conducted to compare the pre-test and post-test data in each group (Table 1).

The results of the one sample t-test analysis showed that there was a significant difference between the pre-test and post-test results in each group and variable (sig <0.05). However, in the control group, there was a decrease in leg power from the pre test results (68.89 ± 7.79) to (67.60 ± 6.75) on the post test results. One way ANOVA analysis was applied to see differences in pre-test and post-test results between sample groups (Table 2).

Based on the results of the one way ANOVA analysis applied, it can be seen that there is only one difference between the three sample groups, especially in the value of the leg power post-test. So that a post hoc analysis needs to be done to see the comparison of leg power post-test

Table 1. Results of the One Sample T-Test Analysis (Mean ± SD)

Group	Number of Samples (N)	Agility			Balance			Power Limbs		
		Pre-test	Post test	Sig	Pre-test	Post test	Sig	Pre-test	Post test	Sig
KCJ	12	35.33 ± 3.20	37.67 ± 3.77	0.00*	45.00 ± 10.88	54.33 ± 8.91	0.00*	68.07 ± 8.21	77.76 ± 9.38	0.00*
KSE	12	35.75 ± 4.09	38.75 ± 3.02	0.00*	46.58 ± 11.51	56.83 ± 11.93	0.00*	68.60 ± 6.65	76.15 ± 7.12	0.00*
KKL	12	35.75 ± 4.88	36.25 ± 4.53	0.00*	45.08 ± 15.90	46.41 ± 15.17	0.00*	68.89 ± 7.79	67.60 ± 6.75	0.00*

*sig. <0.05

Table 2. Analysis Results One Way Anova Test (Mean ± SD)

Group	Number of Samples (N)	Agility		Balance		Power Limbs	
		Pre-test	Post test	Pre-test	Post test	Pre-test	Post test
KCJ	12	35.33 ± 3.20	37.67 ± 3.77	45.00 ± 10.88	54.33 ± 8.91	68.07 ± 8.21	77.76 ± 9.38
KSE	12	35.75 ± 4.09	38.75 ± 3.02	46.58 ± 11.51	56.83 ± 11.93	68.60 ± 6.65	76.15 ± 7.12
KKL	12	35.75 ± 4.88	36.25 ± 4.53	45.08 ± 15.90	46.41 ± 15.17	68.89 ± 7.79	67.60 ± 6.75
Sig	36	0.96	0.289	0.945	0.109	0.964	0.07*

*sig <0.05

Table 3. Analysis Results of Post Hoc (Significant Value)

Group		Bonferroni	Tukey	Scheffe
		Sig	Sig	Sig
KCJ	KSE	1	0.869	0.881
	KKL	0.010*	0.009*	0.012*
KSE	KJC	1	0.869	0.881
	KKL	0.035*	0.031*	0.040*
KKL	KJC	0.010*	0.009*	0.012*
	KSE	0.035*	0.031*	0.040*

*sig. <0.05

values among the three sample groups. The post hoc analysis applied using Bonferroni, Tukey, and Scheffe showed the following results (Table 3).

There was a significant difference between the control group (KKL) and the other two groups (sig <0.05) based on the results of the post hoc analysis applied using Bonferroni, Tukey, and Scheffe. When compared with the average value, the control group (KKL) has the lowest leg power when compared to the chimney jump (KCJ) and standing leg extension (KSE) groups.

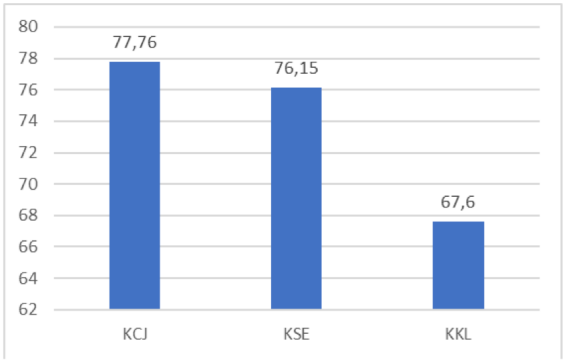

Fig. 5. Comparison of Limb Power Average of Each Group

Discussion

Based on the results of the data analysis that had been carried out, all groups experienced a significant increase in the results of the agility and balance post test. However, it should be noted that the increase in the balance score in the control group (KKL) was not as good as the increase in the chimney jump (KCJ) and standing leg extension (KSE) groups. However, the difference in the results of the post test balance score was not significant in one way ANOVA (sig. 0.109), but the average of KKL (46.41 ± 15.17) was the lowest when compared to KCJ (54.33 ± 8.91) and KSE which had the average value of the highest balance (56.83 ± 11.93).

Furthermore, on the results of the leg power post test, KCJ obtained the highest average score (77.76 ± 9.38) and the increase in leg power values was also followed by KSE (76.15 ± 7.12). However, KKL experienced a decrease in leg power in the post test (67.60 ± 6.75). The KKL power post test results decreased significantly when compared to the pre test results (68.89 ± 7.79). The one way ANOVA analysis also revealed that there was a significant difference (α <0.05) in the results of the leg power post test of the three groups, where KKL had the smallest average score compared to the other two groups.

Athletes who train using chimney jump and standing leg extension exercises experience improvements in agility, balance, and leg power. This provides another perspective on understanding strength training using heavy training loads and certain repetitions (Lacerda et al., 2021). The process of activating large muscles such as the Quadriceps is indeed easier to implement and train using weight training (Jakobsen et al., 2019). In contrast to weight training, chimney jump and standing leg extension exercises provide a movement experience that can be adjusted to the technique in volleyball. This is not only useful for training large muscles, but can also train the coordination of muscles, joints and tendons in performing movement techniques (Markowitz & Herr, 2016).

The chimney jump training model with an agility ladder helps improve the leg muscles and agility of an athlete through a variety of explosive movements (Herdyanto et al., 2019). In addition, the use of agility ladders in training programs can strengthen the athlete's leg muscles and agility (Hidayat, 2019). Various variations of the agility ladder exercise can also be combined with speed training for athletes (Fatchurrahman et al., 2019) as well as specific exercises related to skills in certain sports (Irfan & Umansyah, 2019). In volleyball, the chimney jump training model can be combined with blocking or smashing techniques through a variety of steps and movements.

The standing leg extension exercise model involves movements that include knee flexion, knee extension, knee medial rotation, knee lateral rotation, ankle plantarflexion, and ankle dorsiflexion (Belli et al., 2015). Standing leg

extension exercises with elastic band media can be combined with other exercise models according to the training program (Wu et al., 2018). In volleyball, the use of elastic bands can be combined with basic technical training movements such as receiving, passing, blocking, and also smashing. Movements that are also very influential in a volleyball match such as serving, receiving, and blocking can also be trained (Silva et al., 2014).

This study has several limitations, including the homogeneity of the selected sample, namely male volleyball athletes aged 19-20 years. This of course can be developed using various sample backgrounds to obtain broader data. Furthermore, the limitations experienced by researchers are the forms of treatment given. Chimney jump and standing leg extension exercises are additional training programs provided in addition to the routine training programs provided by the coach. So that several factors that affect aspects of measurement such as the training program provided by the trainer and the athlete's weight gain cannot be controlled and have the potential to affect the measurement results.

Conclusions

The chimney jumps and standing leg extension training models are effective for increasing agility, balance, and leg power in volleyball athletes. This is evidenced by the significant increase in post-test scores from the aspects of agility, balance, and leg power in the group that received the chimney jump and standing leg extension exercises. Furthermore, it was also found that there were significant differences in the results of the leg power post-test from the three groups. In general, the chimney jump group had the highest average score in the post-test of leg power, and the standing leg extension (KSE) group had the highest average score in the post-test of agility and balance.

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Conflict of interests

The authors declare that there is no conflict of interest.

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ТРЕНУВАННЯ ЗІ СТРИБКІВ ІЗ МІСЦЯ НА КООРДИНАЦІЙНІЙ ДРАБИНІ ТА РОЗГИНАННЯ НІГ СТОЯЧИ ЗБІЛЬШУЄ ПОТУЖНІСТЬ НИЖНІХ КІНЦІВОК СПОРТСМЕНІВ-ВОЛЕЙБОЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 3 табл., 5 рис., 36 джерел.

Історія питання. Пандемія Covid-19 спричинила різноманітні адаптації у світі спорту. Однією з форм адаптації, яка здійснюється, є тренування вдома, також відоме як тренування з дому (TFH).

Мета дослідження. Метою цього дослідження є побачити ефективність вправ «стрибки з місця на координаційній драбині» та «розгинання ніг стоячи», які спортсмени-волейболісти виконують під час тренування вдома або тренування з дому (TFH).

Матеріали та методи. Загалом 36 волейболістів віком 19–20 років були відібрані шляхом цілеспрямованої вибірки та розділені на групу стрибків із місця на координаційній драбині (KCJ), групу розгинання ніг стоячи (KSE) та контрольну групу (KKL). Це дослідження є кількісним дослідженням із квазіекспериментальним планом дослідження за схемою попереднього та підсумкового тестування на одній групі.

Трьома змінними, які використовують як залежну змінну, є спритність, рівновага та потужність ніг спортсмена, які вимірювали до TFH та після того, як спортсмен проводив TFH протягом 3 місяців. Результати вправи аналізували описово та продовжували аналізувати з використанням t-критерію Стьюдента для незалежних вибірок та однофакторного дисперсійного аналізу.

Результати. Спостерігалася статистично значуща різниця в результатах підсумкового тестування потужності ніг у трьох групах (<0,05), причому група KCJ мала найвищу середню потужність ніг (77,76 ± 9,38). Крім того, група KSE має найвищий середній показник спритності (56,83 ± 11,93) і рівноваги (38,75 ± 3,02).

Висновки. На підставі результатів цього дослідження можна дійти висновку, що стрибок із місця на координаційній драбині значно впливає на збільшення потужності ніг. З другого боку, розгинання ніг стоячи позитивно впливає на підвищення спритності та рівноваги.

Ключові слова: стрибок із місця на координаційній драбині, розгинання ніг стоячи, спритність, рівновага, потужність ніг.

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EFFECTS OF FITBALL EXERCISE ON BODY COMPOSITION, FLEXIBILITY, MUSCULAR STRENGTH-ENDURANCE AND AEROBIC CAPACITY IN OBESE WORKING-AGE WOMEN

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Abstract

The study purpose was to examine and compare the effects of fitball exercise on body composition, flexibility, muscular strength-endurance and maximum oxygen consumption (VO_2 max) in obese working-age women.

Materials and methods. Twenty-six working-age women with obesity (BMI ≥ 25.0 kg/m^2) aged between 40 to 50 years were divided into 2 groups: 1) fitball exercise group (FEG) and 2) control group (CG). The training lasted 12 weeks with sessions of 60 min/day and 3 days per week. All parameters were measured at 1 day prior to (PRE; pre-training), 1 day after 6 weeks (MID; middle-training) and within 1 day after 12 weeks (POST; post-training) of the training period.

Results. After the 6-week training, the FEG showed substantial improvement in body weight, BMI, back extension, leg strength, 60 second chair stand (60SCST) and VO_2max (-0.92%, -1.34%, 12.74%, 27.19%, 25.79% and 10.75%, respectively, $p < 0.05$) when compared to the CG. Similarly, after the 12-week training, the FEG showed a significantly larger improvement in body weight, BMI, fat mass, sit and reach, back extension, leg strength, 60SCST and VO_2max (-1.14%, -2.19%, -1.92%, 54.31%, 27.31%, 33.50%, 37.02% and 24.05%, respectively, $p < 0.05$) compared to the CG.

Conclusions. Fitball exercise training is effective in improving body composition, flexibility and muscular strength-endurance as well as increasing the aerobic capacity in female workers with obesity.

Keywords: fitball exercise, body composition, flexibility, muscular strength-endurance, exercise capacity, obese, female workers.

Introduction

Obesity can lead to numerous health problems, such as cardiovascular diseases (heart disease and stroke), type 2 diabetes, certain types of cancer, musculoskeletal disorders, and respiratory issues (Lam et al., 2023). It also places a considerable burden on healthcare systems due to the increased risk of chronic diseases and the need for medical treatment. Several factors contribute to the higher prevalence of obesity in adults, especially among working-age women (Harris, et al., 2021). These factors can include changes in lifestyle and dietary habits, reduced physical activity due to sedentary jobs and stress (González et al., 2017). Addressing the issue of obesity in working-age women requires a comprehensive approach that considers both individual behavior and broader environmental and policy changes. Encouraging physical activity, promoting healthy eating habits, and providing supportive workplace environments can all contribute to combating obesity in this population.

Aerobic exercises using a fitball (swiss ball) is an effective and safe form for working-aged women (Josaphat et al., 2019). This is beneficial because working-age women often experience limited body movement and reduced physical activity, these exercises are a valuable way to

counteract sedentary lifestyles and enhance overall health and fitness (Dunsky, 2019). The movements causing impact load on the weight-bearing joints may result in excessive strain on the joints, causing injury to ligaments, joints and muscles (Howley, 2001). Previous studies revealed that exercising with fitball can improved various parameters in overweight and obese working-age women including body composition, especially body weight, body mass index and fat mass (Buttichak et al., 2022), flexibility, muscle strength and endurance, maximum oxygen consumption (Ayudthaya & Kritpet, 2015) and lower back flexibility (Sekendiz et al., 2010). In addition, fitball has incorporated into other forms of exercise such as yoga (Buttichak et al., 2022; Na Nongkhai et al., 2021), low-impact aerobic dance (Ayudthaya & Kritpet, 2015), resistance training and body weight exercise (Escamilla et al., 2016; Liu et al., 2022; Multani et al., 2019). It was also used with other equipment such as kettle bell (Wasim et al., 2023) to develop overall physical fitness including body composition, flexibility, muscular strength-endurance and maximum oxygen consumption with different testing strategies. However, other factors should be considered, such as session duration, intensity, frequency, repetitions, training time per repetition, rest times, diet and sleep to benefit health and well-being significantly.

Therefore, this study aimed to examine and compare the effects of 12-week fitball exercise training model on body composition, flexibility, muscular strength-endurance and maximum oxygen consumption in working-age subjects with obese women as an alternative treatment option to prevent and treat obesity.

Materials and methods

Study participants

Twenty-six working-age subjects with obese women (aged 45.81 ± 3.39 years) from Ubon Ratchathani University volunteered for this study. The inclusion criteria were as follows: (a) measured and reported as obese (BMI ≥ 25.0 kg/m^2), (b) passing a health examination by the doctor at the government hospital only and having a medical certificate allowing for participation in a fitball exercise research project and (c) getting at least 2 doses of COVID-19 vaccination. The exclusion criteria included (a) having muscle, bone, ligament and joint injuries or other complications such as heart disease and high blood pressure and (b) participating in the research project less than 80% of the training. Before participating in this study, all participants were informed of the experimental protocol. Written consent was obtained after explaining the objectives, risks and potential of fitball exercise program in the study. The consent form was approved by Ubon Ratchathani University Human Ethics Committee (UBU-REC-95/2022).

Study organization

The participants were randomly divided into two groups: control group (CG, n = 13) and fitball exercise group (FEG, n = 13). The study duration was 12 weeks of training. All outcome variables were measured at 3 times points consisting of pre-tests (PRE; pre-training or week 0), middle-tests (MID; middle-training or week 6) and post-tests (POST; post-training or week 12) of the 12-week of the intervention period, as shown in Fig. 1.

Training program

The fitball exercise program was used as a medium for teaching exercises. The total experimental period was 60 min/day, 3 days/week for 12 weeks, every Monday, Wednesday, and Friday from 5:00 p.m. to 6:00 p.m. at the activity field of the ILC 204 exercise room, Faculty of Liberal Arts, Ubon Ratchathani University. The instruments were 4 fitball exercise plans with a rest period of 2 seconds per pose changing. The fitball exercise program consisted of 4 phases (a) 1st to 3rd week: the familiarization phase; (b) 4th to 6th week: the skill development phase; (c) 7th to 9th week: the progression phase; and (d) 10th to 12th week: the final phase. The 20 fitball poses training protocol consisted of 3 phases: (a) 10-minute warm-up phase, (b) 40-minute fitball exercise training phase and (c) 10-minute cool-down phase (a total of 120 minutes/week or 1,440 minutes over 12 weeks) (Table 1).

Measures

Body composition measurement

Body composition (body weight, body mass index, fat mass and skeletal muscle mass) was measured by using the bioelectrical impedance analysis machine (TANITA model; MC-980 MA, Japan).

Sit and reach test

Sit and reach test was measured the flexibility of the hamstring and lower back muscles using a standing trunk

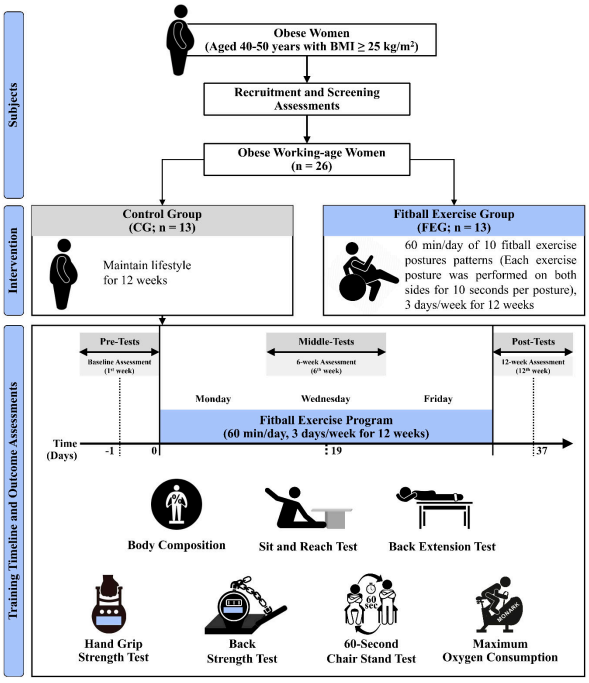

Fig. 1. Outline of training and testing schedule. Abbreviations: CG, control group; FEG, fitball exercise group

Table 1. Fitball exercise training protocol

(a) Warm up phase:
Methods: 10-min walk (easy pace) and 4 fitball poses for static stretching of major muscle groups. (2 × 10 sec)

(A) Moon salutation | (B) Downward facing dog | (C) Cat pose | (D) Matsyasan

Note: The fitball exercise training program at warm up phase; 3 days per week: for 1st to 3rd week (2 sets of 2 repetitions), 4th to 6th week (2 sets of 3 repetitions), 7th to 9th week (2 sets of 4 repetitions) and 10th to 12th week (2 sets of 5 repetitions).

(b) Fitball exercise phase:
Methods: 40-min fitball exercise postures consisted of 12 fitball poses, focusing on tensing muscles in a fixed position. Each pose must be held for 10 seconds and the rest time after each pose was 10 seconds. The body must be moved slowly in a continuous rhythm. It consisted of the following fitball poses.

(E) Mountain pose | (F) Pigeon pose | (G) Cobra's pose | (H) Bow pose

(I) Cobra pose | (J) Camel pose | (K) Bridge pose | (L) Crescent lunge

(M) Lizard pose | (N) Upward facing dog pose | (O) Rabbit pose | (P) Chair pose

Note: The fitball exercise training program at fitball exercise phase; 3 days per week: for 1st to 3rd week (2 sets of 2 repetitions), 4th to 6th week (2 sets of 3 repetitions), 7th to 9th week (3 sets of 3 repetitions) and 10th to 12th week (3 sets of 4 repetitions).

(c) Cool-down phase:
Methods: 10-min walk (easy pace) and 4 fitball poses for static stretching of major muscle groups (2 × 10 sec). It was the practice of the basic and simple fitball postures (2 × 10 sec).

(Q) Child's pose | (R) Standing forward fold | (S) Downward facing dog | (T) Dolphin pose

Note: The fitball exercise training program at cool-down phase; 3 days per week: for 1st to 3rd week (2 sets of 2 repetitions), 4th to 6th week (2 sets of 3 repetitions), 7th to 9th week (2 sets of 4 repetitions) and 10th to 12th week (2 sets of 5 repetitions).

flexion meter (Flexion-D Takei physical fitness test; T.K.K. 5403, Japan). The subject was asked to sit with the legs straight and put the feet under the meter with both feet flat to the floor and close together. The soles of the feet must be placed flat against the box. Then the subject had to slowly bend forward so that the hands were on the meter until it was unable to continue bending and hold that position for 2 seconds or more while the distance in cm was recorded. The test was performed twice. The best value was used.

Back extension test

Back extension test was conducted to measure the flexibility in the trunk muscles using a trunk extension meter (Extension-D Takei physical fitness test; T.K.K. 5404, Japan). The subject stretched the trunk and back muscles and lied down on the floor with two arms crossed at the back at the waist. If the arms or hands cannot be crossed, try to keep the arms as close as possible to the back. The test assistant grasped the subject' ankle or thigh, depending on suitability. After that, the subject had to lift the upper body as high as possible and hold the head up for about 3 seconds. Distance was recorded in cm. The test was performed twice. The best value was used.

Hand grip strength test

Hand grip strength test was administered to measure the strength of the arm muscles using a grip strength dynamometer (Grip-D Takei physical fitness test; T.K.K. 5401, Japan). The handle of the dynamometer must be adjusted to fit the subject' hand to be measured. The subject

held the dynamometer in the hand to be tested with the arm at right angles and the elbow by the side of the body and squeezed the dynamometer with all possible force. The test was performed twice. The best value was used. The test results were recorded in kilograms and divided by the subject's body weight.

Leg strength test

Leg strength test was done to measure the muscular strength of the leg muscles using a back strength dynamometer (Back-A Takei physical fitness test; T.K.K. 5002, Japan). The dial must be reset to zero. The subject had to stand on the dynamometer, bend the knees while grasping the handle of the dynamometer, adjust the angle of the knees to the ready position and pull as hard as possible on the chain until the maximum value was obtained. The test was performed twice. The best value was used. The test results were recorded in kilograms and divided by the subject's body weight.

60 seconds chair stand test (60SCST)

It was administered to measure the muscular strength and endurance of the leg muscles. A chair for the standing-sitting test must be placed against a smooth wall to prevent it from moving. The subject must be seated in the middle of the chair (not close to the backrest to make it easier to stand up) with both feet placed on the floor approximately shoulder-width apart at an angle slightly back from the knees and back straight. Arms were crossed at the wrists and held against the chest. When hearing the "Start" signal, the subject had to stand up from the chair, stand straight with legs stretched, and then sit down in the starting position. This was counted as 1 repetition. The number of repetitions was recorded for 60 seconds, the participants stood up and sat down correctly on a chair as many times as possible.

Maximum oxygen consumption assessment

It was performed to measure cardiorespiratory endurance or aerobic capacity (maximum oxygen consumption; VO_2max) following the Astrand-Rhyming test method, using a mechanically braked cycle ergometer (Monark Ergomedic 828E, Vansbro, Sweden). The subject sat in the saddle. The saddle must be adjusted to the level that the legs can be fully stretched with the knees slightly bent. The rhyme was set at 50 rpm with constant speed. The counterweight must be adjusted to 1 kp. The timer was started when the subject rides with the specified counterweight and constant speed. The heart rate was counted every 1 minute (from the 45th to the 60th second by using a stethoscope (Stethoscope professional; CK-MA601CP, Taiwan) to measure the heart rate 30 times and then compare to the table. The heart rate at the carotid artery should also be recorded for 6 minutes. If at the second minute, the heart rate is still lower than 120 beats per minute, add another 0.5 kp of weight, and add another

Table 2. Baseline characteristics of cardiovascular parameters in the control and fitball exercise group

Parameters	CG (n = 13)	FEG (n = 13)
Age (y)	45.46 ± 3.23	46.15 ± 3.65
Weight (kg)	68.75 ± 10.01	70.09 ± 7.48
Height (cm)	156.54 ± 6.62	158.77 ± 5.83
BMI (kg/m^2)	28.00 ± 2.20	27.66 ± 2.85
Resting heart rate (b/m)	77.54 ± 6.39	78.31 ± 5.82
SBP (mm Hg)	127.54 ± 4.48	129.08 ± 5.01
DBP (mm Hg)	86.62 ± 5.62	81.38 ± 8.06

Description: CG; control group and FEG; fitball exercise group; BMI; body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure. Values are mean ± SD. No significant difference was found between the two groups for any variable

Table 3. Mean changes in body composition parameters in all two groups after 6-week (MID) and after 12-week (POST) of the training period

Parameters	Time	CG (n = 13)	FEG (n = 13)	p-value
Weight (kg)	PRE (week 0)	68.64 ± 10.55	70.09 ± 7.48	
	MID (week 6)	68.60 ± 10.49	69.45 ± 7.41	
	POST (week 12)	70.01 ± 10.23	69.29 ± 7.42	
	%Changes (MID vs. PRE)	-0.06 ± 1.10	-0.92 ± 0.70*	0.019†
	%Changes (POST vs. PRE)	2.00 ± 1.38	-1.14 ± 1.60#	0.001‡
Body mass index (kg/m^2)	PRE (week 0)	28.00 ± 2.20	27.66 ± 2.85	
	MID (week 6)	28.01 ± 1.99	27.28 ± 3.05	
	POST (week 12)	28.28 ± 2.07	27.05 ± 3.23	
	%Changes (MID vs. PRE)	0.03 ± 2.54	-1.34 ± 1.59*	0.040†
	%Changes (POST vs. PRE)	1.02 ± 2.39	-2.19 ± 2.18#	0.001‡
Fat mass (%)	PRE (week 0)	39.31 ± 4.95	37.11 ± 3.96	
	MID (week 6)	39.24 ± 4.95	36.69 ± 3.79	
	POST (week 12)	39.97 ± 4.68	36.40 ± 3.94	
	%Changes (MID vs. PRE)	-0.19 ± 1.20	-1.15 ± 1.19*	0.058
	%Changes (POST vs. PRE)	1.68 ± 2.58	-1.92 ± 2.25#	0.002‡
Skeletal muscle mass (kg)	PRE (week 0)	37.61 ± 4.12	39.26 ± 2.46	
	MID (week 6)	37.65 ± 4.08	39.13 ± 2.57	
	POST (week 12)	37.53 ± 4.31	39.58 ± 2.52	
	%Changes (MID vs. PRE)	0.10 ± 1.06	-0.33 ± 0.74	0.135
	%Changes (POST vs. PRE)	-0.21 ± 1.87	0.82 ± 0.55#	0.050

Description: *Significant p<0.05 (PRE vs. MID), #Significant p<0.05 (PRE vs. POST), †Significant p<0.05 (%Changes MID vs. PRE), ‡Significant p<0.05 (%Changes POST vs. PRE)

1 minute of testing time, and measure it every minute. The average heart rate for the last 2 minutes was taken (provided that the heart rate is stable, or the difference does not exceed ± 5 bpm). The obtained heart rate was recorded, and the table was used to find the maximum oxygen consumption from heart rate and weight (in ml/kg/min).

Statistical analysis

Statistical calculations were performed using SPSS 26 (IBM Corp. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp). Descriptive data were shown as means and standard deviation (SD). Data normality was evaluated by using the Shapiro-Wilk test. Paired t-tests (comparisons between values obtained before, after 6-week and after 12-week training) and independent t-tests (comparisons of differences to baseline between groups) were completed. The one-way analysis of variance with repeated measures followed by the Bonferroni post-hoc test was used to evaluate differences in body composition, flexibility, muscular strength-endurance and maximum oxygen consumption between groups. P values < 0.05 was considered to be statistically significant.

Results

The baseline characteristics of cardiovascular parameters in the control group (CG) and fitball exercise group (FEG) group are presented in Table 1. No significant differences existed among the two groups for any variables. After 6-week, the body weight and body mass index were reduced in FEG by 0.92 % and -1.34%, respectively, p < 0.05) when compared to CG. Likewise, after the 12-wks, the FEG

Table 4. Mean changes in flexibility, muscular strength-endurance, and maximum oxygen consumption parameters in all two groups after 6-week (MID) and after 12-week (POST) of training period

Parameters	Time	CG (n = 13)	FEG (n = 13)	p-value
		Flexibility		
Sit and reach test (cm)	PRE (week 0)	10.89 ± 4.99	11.69 ± 4.42	
	MID (week 6)	12.18 ± 4.85	16.15 ± 4.99	
	POST (week 12)	12.07 ± 5.02	18.04 ± 4.75	
	%Changes (MID vs. PRE)	11.88 ± 31.26	38.17 ± 24.32*	0.063
	%Changes (POST vs. PRE)	10.88 ± 19.87	54.31 ± 20.64#	0.001‡
Back extension test (cm)	PRE (week 0)	36.21 ± 6.82	37.38 ± 6.50	
	MID (week 6)	37.49 ± 6.59	42.83 ± 6.15	
	POST (week 12)	39.66 ± 7.13	47.58 ± 6.83	
	%Changes (MID vs. PRE)	3.53 ± 8.58	12.74 ± 8.83*	0.014†
	%Changes (POST vs. PRE)	9.53 ± 10.57#	27.31 ± 17.09#	0.003‡
		Muscular strength-endurance		
Hand grip strength of right hand (kg/weight)	PRE (week 0)	0.35 ± 0.06	0.39 ± 0.09	
	MID (week 6)	0.39 ± 0.05	0.43 ± 0.10	
	POST (week 12)	0.39 ± 0.05	0.45 ± 0.10	
	%Changes (MID vs. PRE)	10.20 ± 10.14*	11.71 ± 8.15*	0.448
	%Changes (POST vs. PRE)	10.44 ± 15.47#	15.93 ± 8.18#	0.209
Hand grip strength of left hand (kg/weight)	PRE (week 0)	0.32 ± 0.06	0.36 ± 0.09	
	MID (week 6)	0.35 ± 0.05	0.40 ± 0.09	
	POST (week 12)	0.39 ± 0.05	0.42 ± 0.10	
	%Changes (MID vs. PRE)	8.75 ± 11.91	10.44 ± 7.40*	0.370
	%Changes (POST vs. PRE)	0.32 ± 33.39	16.29 ± 10.20#	0.061
Leg strength (kg/weight)	PRE (week 0)	1.30 ± 0.31	1.37 ± 0.40	
	MID (week 6)	1.38 ± 0.31	1.74 ± 0.41	
	POST (week 12)	1.33 ± 0.33	1.82 ± 0.51	
	%Changes (MID vs. PRE)	5.96 ± 11.30	27.19 ± 27.60*	0.006†
	%Changes (POST vs. PRE)	2.61 ± 16.43	33.50 ± 31.15#	0.002‡
60 seconds chair strand test (reps)	PRE (week 0)	41.77 ± 6.81	43.85 ± 9.65	
	MID (week 6)	47.46 ± 8.99	55.15 ± 5.29	
	POST (week 12)	45.38 ± 9.46	60.08 ± 5.82	
	%Changes (MID vs. PRE)	2.72 ± 1.08*	25.79 ± 26.43*	0.001†
	%Changes (POST vs. PRE)	8.66 ± 31.38	37.02 ± 31.52#	0.009‡
		Cardiorespiratory endurance		
VO_2 max (ml/kg/min)	PRE (week 0)	24.73 ± 2.40	21.71 ± 3.95	
	MID (week 6)	24.77 ± 2.75	24.04 ± 3.92	
	POST (week 12)	25.34 ± 3.23	26.93 ± 4.16	
	%Changes (MID vs. PRE)	0.15 ± 10.69	10.75 ± 11.80*	0.015†
	%Changes (POST vs. PRE)	2.44 ± 13.16	24.05 ± 20.84#	0.003‡

Description: *Significant p<0.05 (PRE vs. MID), #Significant p<0.05 (PRE vs. POST), †Significant p<0.05 (%Changes MID vs. PRE), ‡Significant p<0.05 (%Changes POST vs. PRE)

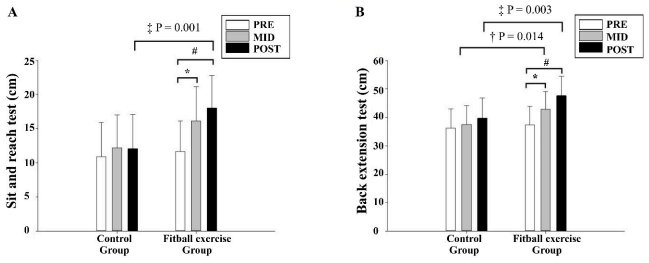

Fig. 2. Changes in flexibility (A; Sit and reach test and B; Back extension test) before (PRE), after 6-week (MID) and after 12-week (POST) of the training period. Values are present as mean ± SD. *Significant p<0.05 (PRE vs. MID), #Significant p<0.05 (PRE vs. POST), †Significant p<0.05 (%Changes MID vs. PRE), ‡Significant p<0.05 (%Changes POST vs. PRE)

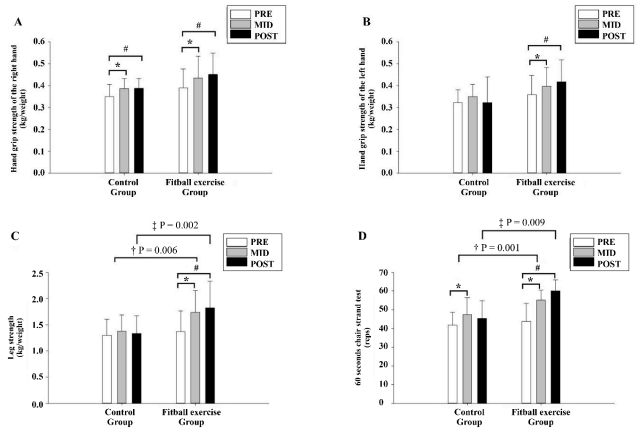

Fig. 3. Changes in muscular strength-endurance (A; Handgrip strength of right hand, B; Handgrip strength of left hand, C; Leg strength and D; 60 seconds chair stand test) before (PRE), after 6-week (MID) and after 12-week (POST) of the training period. Values are present as mean ± SD. *Significant p<0.05 (PRE vs. MID), #Significant p<0.05 (PRE vs. POST), †Significant p<0.05 (%Changes MID vs. PRE), ‡Significant p<0.05 (%Changes POST vs. PRE)

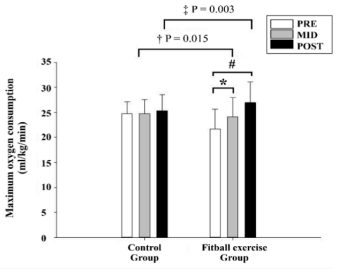

Fig. 4. Changes in maximum oxygen consumption before (PRE), after 6-week (MID) and after 12-week (POST) of the training period. Values were presented as mean ± SD. *Significant p<0.05 (PRE vs. MID), #Significant p<0.05 (PRE vs. POST), †Significant p<0.05 (%Changes MID vs. PRE), ‡Significant p<0.05 (%Changes POST vs. PRE)

showed a significantly larger improvement in body weight, BMI and fat mass (-1.14%, -2.19% and -1.92% respectively, $p < 0.05$) compared to the CG Table 3.

Table 4 shows the mean values of flexibility before and after 6 weeks of training. It was found that the FEG showed substantially improvement in back extension when compared to the CG ($P = 0.014$). Similarly, after 12 weeks of training, the sit and reach and back extension of the FEG were significantly improved ($P = 0.001$ and $P = 0.003$ respectively, $p < 0.05$) (Fig. 2), compared to the CG. Moreover, after the 6-week training, the FEG showed significant improvement in leg strength, 60 second chair stand test (60SCST) and ($P = 0.006$, $P = 0.001$ and $P = 0.015$ respectively, $p < 0.05$) when compared to the CG. In addition, the leg strength, 60SCST and VO_2max were significantly improvement in the FEG after 12 weeks of the training program ($P = 0.002$, $P = 0.009$ and $P = 0.003$ respectively, $p < 0.05$), when compared to the CG.

In general, after 6 weeks of training, the left-hand grip strength, leg strength, 60SCST and VO_2max were significantly improvement in the FEG (10.44%, 27.19%, 25.79% and 10.75% respectively, $p < 0.05$), compared to their baseline. In particular, after 12 weeks of training, the left-hand grip strength, leg strength, 60SCST and VO_2max were significantly improvement in the FEG (16.29%, 33.50%, 37.02% and 24.05% respectively, $p < 0.05$), compared to the before training (Fig. 3 and Fig. 4).

Discussion

This research supports the concept of fitness training with fitball to improve body composition. The results after 6 weeks of training revealed changes in body weight and body mass index. It is consistent with the study of Buttichak et al. (2019) studying the effects of a yoga training program with fitball. It was revealed that this training program can promote changes in body composition in terms of body weight, body mass index and fat mass after 8 weeks of training (Buttichak et al., 2019). Based on this present study, after 12 weeks of training, there were prominent changes in body composition compared to the PRE and MID of the training period. In the intervention group, there were showed significant improvements in body weight, body mass index and fat mass. This is consistent with previous studies by Buttichak et al. (2019) and Na Nongkhai et al. (2021) which found changes in muscle mass after 8 weeks of training or more (Buttichak et al., 2019; Na Nongkhai et al., 2021). Liu et al. (2021) also conducted a systematic review and meta-analysis of different forms of resistance training. It was revealed that weight training exercise (fitball exercise is considered weight training exercise) can increase muscle mass. It may be because fitball exercise uses muscle sharing to stabilize body balance with body weight as resistance, causing muscles to work. Fitball exercise also tends to use stabilizer muscles more than other types of training (Liu et al., 2022). Escamilla et al. (2016) compared the training with different fitball positions to body weight training to examine muscle contractions. Fitball exercises were found to produce better muscle contractions than resistance training, especially rectus abdominis muscle and stabilizer muscles (lower-rectus abdominis, external oblique, internal oblique, etc.). Because the muscles are stimulated, their strength and size can be increased (Escamilla et al., 2016). Besides, training with fitball for a long period of time continuously can affect the metabolic process since the body will use fat as a fuel source for energy supply during exercise. This is in accordance with the study indicating that continuous exercise training on a regular basis can affect the metabolic system during aerobic training. The energy obtained from cellular metabolism is mainly

the breakdown of fat in the exercising muscles. As a result, the amount of fat mass in the body of obese women decreases (Tan et al., 2012). However, recent studies support the idea that training with fitball can help improve body composition and increase muscle mass although it takes a long time to see the changes. Therefore, to achieve maximum efficiency, further study of the effects of exercise and food intake should be investigated to reduce the BMI level, and the percentage of body fat in people with obesity (Voulgari et al., 2013).

The flexibility was significantly increased in the FEG. Women were more likely to improve flexibility than men. Meanwhile, Kumar (2023) conducted a study of fitball exercises among male college students, which revealed changes in muscle flexibility. It is apparent that fitball exercise can increase the flexibility of the body in all genders and ages. This may be due to continuous fitball exercise fucuses on full-range of motion, combined with tightness and holding (Kumar, 2023). Likewise, Buttichak et al. (2022) reported that 8 weeks of yoga exercise can improved flexibility (back scratch test) in overweight elderly women (Buttichak et al., 2022). It is consistent with the study of Judy and Tamilarasi (2023) which found that fitball exercise affected the improvement of flexibility. After 12 weeks of fitball exercise, sit and reach test and back extension test were used to measure flexibility. The results of the present study, fitball exercise can improve both anterior and posterior muscle flexibility in these participants. This may be due to the similarity of the test and the training form. That is, with fitball exercises in different positions, the muscles of the shoulders, back, hips and legs are mainly stretched (Judy & Tamilarasi, 2023). Sekendiz et al. (2010) conducted a study on fitball exercise among working-age women. Significant changes in lower back flexibility were observed. This was because the exercise focused on the shoulders, back, hips and legs using different fitball exercise poses, e.g., cobra's pose, bow pose, bridge pose and downward facing dog (Sekendiz et al., 2010).

In terms of muscular strength-endurance performance, the muscular strength and muscular endurance of the FEG could improved because the training postures were in sets and reps, considered as the basis of the resistance training. In addition, in this study, the principle of overload was applied to stimulate muscle development each week in order to improve both muscular strength and size. A study by Kumar (2023) revealed that incorporating fitball into a training program can improve muscular strength. However, when compared to the group trained with the aerobic exercise program, there was no difference in the development of muscle strength. It is probably because fitball exercise can improve strength, but it may not be the best exercise compared to other forms of training (Kumar, 2023). Kamatchi et al. (2020) studied the effects of swiss ball exercise and pilates exercise on core muscle strengthening in college cricketers. It was found that both forms of training can improve muscle strength after 6 weeks of training (Kamatchi et al., 2020). In addition, a study by Wasim et al. (2023) compared fitball exercises with kettle bells. It is suggested that to develop muscular strength, fitball exercise with kettle bells works best. The samples of the study were teenagers. Compared to this research, the samples were working-age women, so they tend to have less physical activity (Wasim et al., 2023). Thus, fitball exercise may be a physical activity that can promote good health. It is also safe and suitable for obese working-age women.

The maximum oxygen consumption that refers to the exercise capacity or exercise tolerance was improved in the FEG after 6 (MID) and 12 weeks (POST) of the intervention period, compared to the CG. As working-age women in this generation tend to decrease in physical activity, fitball exercise is another good option to improve the cardiovascular system. There will be a greater exchange of oxygen in the blood and muscle cells as a result of aerobic exercise. As a result, the cardiac muscle is stronger. The heart can better pump blood to different parts of the body and cardiorespiratory system is also improved. However, it depends on the frequency, intensity, duration and type of exercise. Another factor that may increase maximum oxygen consumption in obese working-age women is fitball exercise in the form of sets and reps by focusing on total muscle use, contraction and increasing intensity by shortening rest periods. This is consistent with a study by Ayudthaya & Kritpet (2015), which found that low-impact aerobic training combined with fitball can increase maximum oxygen consumption among working-age women, similar to this present study (Ayudthaya & Kritpet, 2015). Multani et al. (2019) studied the resistance training combined with fitball at a low-weight and high-repetition. This training form can also improve maximum oxygen consumption. The main factors enabling the improvement of cardiorespiratory endurance in this study may be the intensity and the continuity of the training, that is 45 minutes or more of training, compared to the appropriate intensity for those doing exercise, so it may result in the effective improvement of VO_2max (Multani et al., 2019).

Conclusions

The 6-week (MID) fitball exercise affects the overall change of body composition, flexibility, muscular strength-endurance and maximum oxygen consumption in working-age subjects with obese women. In particular, it is more effective when continuously training for 12 weeks (POST). Therefore, it should be supported as another option to promote health and wellness that does not negatively affect tendons, joints and muscles. It is also safe and suitable for working-aged women population.

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Conflict of interest

The authors declare that they have no conflict of interest.

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ВПЛИВ ВПРАВ НА ФІТБОЛІ НА СКЛАД ТІЛА, ГНУЧКІСТЬ, М'ЯЗОВУ СИЛУ-ВИТРИВАЛІСТЬ ТА АЕРОБНУ ЗДАТНІСТЬ У ЖІНОК ПРАЦЕЗДАТНОГО ВІКУ З ОЖИРІННЯМ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 4 табл., 4 рис., 20 джерел.

Метою дослідження було вивчити та порівняти вплив вправ на фітболі на склад тіла, гнучкість, м'язову силу-витривалість і максимальне споживання кисню (VO_2max) у жінок працездатного віку з ожирінням.

Матеріали та методи. Двадцять шість жінок працездатного віку з ожирінням (ІМТ ≥ 25,0 кг/м^2) віком від 40 до 50 років були розподілені на 2 групи: 1) група вправ на фітболі (ГВФ) та 2) контрольна група (КГ). Тренування тривало 12 тижнів із заняттями по 60 хв/день і 3 дні на тиждень. Усі параметри вимірювали за 1 день до (ПЕРЕД; до початку тренування), через 1 день після 6 тижнів (СЕРЕД; посередині тренування) і протягом 1 дня після 12 тижнів (ПІСЛЯ; після завершення тренування) періоду тренування.

Результати. Після 6-тижневого тренування ГВФ продемонструвала значне покращення показників маси тіла, ІМТ, розгинання спини, сили ніг, тесту на повторні вставання з крісла та сідання в крісло протягом 60 секунд (60SCST) та VO_2max (-0,92%, -1,34%, 12,74%, 27,19%, 25,79% та 10,75% відповідно, $p < 0,05$) порівняно з КГ. Аналогічно, після 12-тижневого тренування ГВФ продемонструвала значно більше покращення показників маси тіла, ІМТ, відсоткового вмісту жиру в організмі, тесту на нахили тулуба вперед із положення сидячи, розгинання спини, сили ніг, тесту 60SCST та VO_2max (-1,14%, -2,19%, -1,92%, 54,31 %, 27,31 %, 33,50 %, 37,02 % та 24,05 % відповідно, $p < 0,05$) порівняно з КГ.

Висновки. Тренування з виконанням вправ на фітболі є ефективним для покращення складу тіла, гнучкості та м'язової сили-витривалості, а також для підвищення аеробної здатності працівниць з ожирінням.

Ключові слова: вправа на фітболі, склад тіла, гнучкість, м'язова сила-витривалість, здатність до фізичного навантаження, з ожирінням, працівниці.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF PERIODIZED INTERVAL TRAINING IN COMBINATION WITH EXPLOSIVE STRENGTH AND SPEED IN GAME-LIKE SITUATION ON AGILITY AND HIGH INTENSITY AEROBIC CAPACITY OF YOUTH SOCCER PLAYERS

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Abstract

Study purpose. High-intensity aerobic capacity (HIAC) is essential for soccer players because they have to perform sprints of short duration in the shortest possible time. At the same time, they need to quickly change direction with and without the ball, which requires agility. The purpose of the study was to investigate the effect of a periodized (8-week) training plan that combines interval training (IT), explosive strength (ES), speed, and game-like situations on agility and HIAC in youth soccer players.

Materials and methods. This research is an experimental study in which the population was male youth soccer players (N = 23) (aged 16.7±2.1). The Arrowhead Agility Test and the HIAC Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) have taken the pre- and post-data of agility. By using the formula for YYIR1 test: VO_2max (mL kg^{-1} min^{-1}) = IR1 distance (m) × 0.0084 + 36.4, we get an estimation of the volume of maximum oxygen consumption (VO_2max). The data analysis used a t-test at 0.05% as the significance level.

Results. Based on the results, the mean of the pre-tests in agility, YO-YO IR1, and VO_2max showed 17.911, 14.8100, and 55.25510. After training for eight weeks, there was an improvement: the mean showed 16.667, 15.9750, and 60.06960. As per the results of the data on the hypothesis in the study, it was found that there was a significant effect of periodized IT in combination with ES and speed on agility performance and HIAC of the youth soccer players.

Conclusions. There was a significant effect of periodized IT in combination with ES and speed on improving youth soccer players' agility performance and HIAC.

Keywords: interval training, explosive strength, high intensity aerobic capacity, agility and VO_2max.

Introduction

Soccer is a high-intensity intermittent exercise based on repeated short sprints within short breaks. It also comprises ES, useful for executing actions like jumping, kicking, and sprinting. Modern soccer is an energy-demanding sport, with the ability of players to repeat high-intensity actions during the game likely being of paramount importance for success (Helgerud et al., 2001). Training sessions in modern soccer are done in game-like situations, from simple to complex, so that players get the same amount of load that they get in the competition. This form of training can be used as a substitute for common running fitness drills because of the similarity of its effect on aerobic capacity levels (Hill-Haas et al., 2009). Developing skills and tactics are as essential as raising physical capacity levels. Therefore, young soccer players should use this form of practice. Games with a greater number of players and a larger surface area are applied to develop soccer-specific skills, which involve high-precision performance. The intensity of the training session depends upon the pitch area, number of players, coach encouragement, and rule modification (Rampinini et al., 2007).

Soccer includes intermittent loads from high to lower intensities (Aguiar et al., 2008). The varying nature of the sports gives rise to rapid changes in oxygen uptake during the training and the match (Helgerud et al., 2001), averaging 70–80% of VO_2max with a covered distance of about 10-12 km (Aguiar et al., 2008) at a mean intensity close to the

anaerobic threshold. Within this context, recent studies have verified the importance of intensive aerobic training in soccer players in improving the VO_2max, considered the most important parameter of HIAC.

Decision-making and change of direction require good physical and perceptual abilities (Gabbett & Benton, 2009). The ability to change direction quickly is called agility; measuring basic and sports-specific physical ability is important in recreation and sport (Hribernik et al., 2021). Physical coordination, speed, and balance skills are called agility (João et al., 2014). A good football player requires ES and speed to change direction quickly and efficiently.

Periodization is a superior method for developing an athlete's peak performance. The training for soccer players should be periodized as per game-like situation training sessions, with appropriate recovery in between the sessions. The game-like situation drills are mainly small-sided games (SSGs). For physiological and motor enhancement, SSG can be used as a daily training tool (Santos, 2021). Coaches can improvise the SSGs according to their requirements in the training session. Several studies (Köklü, 2012), (Little & Williams, 2007) have confirmed that during SSGs within a 3vs3 form, the highest intensity can be achieved when the player's pitch area ranges from 60 to 125m^2. The important aspect of playing SSGs is that power and anaerobic endurance in soccer players can be developed in addition to HIAC. These benefits are allotted to the repetitions of short and long runs alternating with recovery, which could be active or passive in soccer (Nédélec et al., 2013). For planning the training of the youth players, there is a need to pay specific attention at this age so that significant improvement can be attained within a short period of time. Few studies have analyzed the influence of ES, SSGs, or interval-running training on sports-specific skills in soccer players (Owen Adam et al., 2004).

Soccer players need more ES and speed to execute the skills and to overcome the load (ball or opponent) in the shortest possible time; at the same time, they must execute them in the condition of fatigue, which arises from quickly changing directions (agility) and continuous sprints with skill execution; for that, they require more HIAC. Therefore, the study's main aim was to determine the effect of periodized IT in combination with ES and speed in a game-like situation on agility and HIAC in youth soccer players. It was hypothesized that IT, combined with ES and speed in a game-like situation, would significantly improve agility performance and HIAC in youth soccer players.

Materials and methods

Study participants

A total of 23 players participated in the experiment. Three players were excluded from the study because of health problems and absences during training. Consequently, 20 players were analyzed (Table 1). All the players belong to the same team and have at least five years of playing experience. In the sample selection process, participants were randomly selected for the treatment group in which the pre- and post-effects of the experiment were recorded. Before the implementation of the experiment, written consent was received from all participants and guardians.

Table 1. Physical Characteristics of the subjects

Characteristic	Mean ± SD	N
Age (y)	16.7±2.1	20
Mass (Kg)	62.7±8.69	20
Height (cm)	170.0±6.23	20

Study organization

The experiment was conducted during the mid-season of a one-year periodization cycle. Weather: moderate winter (October–November). The experimental program's training was integrated with the standard regime of the team. The group underwent weekly high-intensity interval training, then ES, speed, technical, and tactical training in game-like scenarios. On the last day of the week, a match was organized. After the completion of a warmup by participants, which lasted for 20 minutes per session and was followed by 5 minutes of passive stretching, the interval training was performed for 40 m in a 6" run for 6 times 18" rest, and after rest for 2 min SSGs of 8 vs. 8 (80×50 m) 2 games 8 min play 2 min rest. The character of the SSGs was two touches per player so that player had to move quickly after the ball was passed for support. Each week, the load progressed through SSGs and interval training (Table 2). Moreover, coaches motivated the players to engage maximally during the SSGs.

Table 2. Proposed training plan of 8-week exercise intervention for selected participants

Monday	Endurance – 40 m in 6" run for 6 times 18" rest and 8 vs 8 (80 m × 50 m) 2 games 8 min play 2 min rest.
Tuesday	Passing and receiving technique-break the wall, cross the water and 1 vs 1 with 2 goals.
Wednesday	Explosive strength-jump squats, alternating lunge jumps 4-6 sets of 20-25 reps,1vs1 body covering.
Thursday	Speed – Sprints, Backpedal Repeats, Lean Fall and Sprint, with the ball catching the opponent.
Friday	Passing receiving and turning technique- cross the water, 3 vs 3 with 2 goals.
Saturday	Match
Sunday	Rest

The progression of the load was done after each week in Interval training, ES, Speed training

Because of the high intensity of the test, participants were asked to rest properly before the pre-data collection. A proper warmup was done, and all necessary information was conveyed to participants about the Arrowhead Agility and Yo-Yo Intermittent Recovery Test Level 1 (YYIR1). During the day, a test was conducted, and after that, those participants participated in 60 minutes of low-intensity skill training.

The Arrowhead Agility Test measured speed, explosion, body control, and the ability to change direction at various angles and directions. Before starting the test, participants completed their warmup and stretching. The test was conducted on artificial turf. Each participant was allowed to complete two paths; one left and one right, with a minimum of two minutes' rest. The test result is how long it

takes to complete the test for the left and right (Arrowhead Agility Test: Right + Left = Result). If a participant steps on the cone, it is considered invalid; participants must run around the cones.

The YYIR1 Yo-Yo intermittent recovery test measured the participant's ability to perform high-intensity aerobic work. Before the start of the test, participants completed their warmup and stretching. The test was conducted on artificial turf. Each participant was allowed to make only two consecutive failed attempts before they were withdrawn from the test. Once withdrawn from the test, the individual's score was recorded. The VO_2max was calculated by using the formula: YYIR 1 test: VO_2max (mL kg^{-1} min^{-1}) = IR1 distance (m) × 0.0084 + 36. VO_2max is considered to be the most important parameter of HIAC.

Statistical Analysis

Basic results are presented as descriptive statistics' mean and standard deviation (M±SD). The 20th version of SPSS was used for all types of statistical analysis. All the data sets were processed through SPSS for normality assessment using the Shapiro-Wilk test (table 1). A paired t-test was applied (because the data were found to be normally distributed) to analyze the post-effect of periodization; IT combined with ES and speed training. The level of significance was set at 0.05.

Results

Periodized IT combined with ES and speed significantly increased agility and HIAC in youth soccer players. Table 3 shows that the group mean of agility, IR1, and VO_2max pre- and post-data are significantly different ($p<0.05$). The percentage increase in pre- and post-difference in mean in the Agility, IR1, and VO_2max groups was recorded as 7.19%, 7.86%, and 8.71%, respectively, reflecting the enhancement of Agility performance from 17.911 to 16.667 and the increase in IR1 from 14.8100 to 15.9150 and VO_2max from 55.25510 ml × kg^{-1} × min^{-1} to 60.0690 ml × kg^{-1} × min^{-1}. HIAC-YYIR1 has been seen as a valid and reliable predictor of HIAC and VO_2max.

Table 3. Shapiro-Wilk test of normality for all pre and post data sets

Indicator	Statistic	df	Sig.
Pre data YO YO IR1	0.889	20	0.066
Post data YO YO IR1	0.908	20	0.059
Pre VO_2max	0.848	20	0.055
Post VO_2max	0.913	20	0.074
Pre Arrow Head agility test	0.948	20	0.331
Post Arrow Head agility test	0.926	20	0.067

Concerning Table 3, the normality assumption is thoroughly satisfied for the given data set as indicated $p>0.05$. As per the common agreement, the p-value obtained for test statistics should be higher than 0.05 if the significance level is set at 0.05. In this case, the Shapiro-Wilk test statistics of all concerned data are equal to or greater than 0.05. Thus, the given data is appropriate for further processing and is normally distributed.

In Table 4, the basic output of the concerned variables has been reported systematically. Mean, SD, minimum, maximum, skewness, and kurtosis have been presented. In particular, the recognized rule of thumb for a data set to be considered normal is that the associated test statistics should not be greater than twice its standard error in cases of skewness and kurtosis; the present dataset satisfies this assumption too.

Table 5 presents the results of two t-tests in the 2nd and 3rd rows. The first test compares the pre- and post-data of the Yo-Yo IR1 test. This output confirms that the mean of the pre-data differs significantly from the mean of the post-data

Table 4. Descriptive Statistics showcasing basic information regarding participants score in YOYO IR1 and VO_2max tests

Indicator	N	Min	Max	Mean	SD	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Pre data YO YO IR1	20	13.40	16.60	14.8100	0.84909	0.898	0.512	0.381	0.992
Post data YO YO IR1	20	14.80	17.40	15.9750	0.73619	0.447	0.512	-0.886	0.992
Pre_VO_2max	20	51.284	63.252	55.25510	3.591699	1.002	0.512	0.583	0.992
Post_VO_2max	20	55.636	66.516	60.06960	2.949532	0.604	0.512	-0.444	0.992
Pre Arrow Head	20	16.63	19.23	17.911	0.711	-0.293	0.512	-0.657	0.992
Post Arrow Head	20	16.12	17.89	16.667	0.435	1.002	0.512	1.630	0.992
Valid N (listwise)	20								

Table 5. Output of t-test showcasing proof of observed mean differences

		Paired Differences				
S.N	Pair name	Mean	SD	Std. error of mean	t	Sig. (2-tailed)
Pair 1	Pre data YO YO IR1 – Post data YO YO IR1	-1.165	0.382	0.085	-13.607	0.000
Pair 2	Pre_VO_2max – Post_VO_2max	-4.814	2.836	0.634	-7.591	0.000
Pair 3	Pre data Arrow Head Agility – Post Data Arrow Head Agility Test	1.24	0.460	0.103	12.065	0.000

Table 6. Paired Samples Statistics

	Indicator	N	Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre data YO YO IR1	20	14.8100	0.84909	0.18986
	Post data YO YO IR1	20	15.9750	0.73619	0.16462
Pair 2	Pre VO_2max	20	55.25510	3.591699	0.803128
	Post VO_2max	20	60.06960	2.949532	0.659535
Pair 3	Pre Arrow Head	20	17.9110	0.71144	0.15908
	Post Arrow Head	20	16.6675	0.43510	0.09729

(p.000<0.05). The second row is concerned with observing the effect of training on the VO_2max capacity of soccer players. In Table 5, it is evident that, due to the following of the training program, both means differ significantly from each other. The third row is concerned with observing the effect of training on the agility performance of soccer players. In Table 5, it is evident that, due to the following of the training program, both means significantly differ from each other.

In Table 6, it is visible that the mean of the pre-data in both pairs is less than the mean of the post-data. Thus, the selected training program is effective in both pairs as long as the results of Table 3 are valid.

Discussion

The study aimed to compare the pre- and post-effects of eight weeks of periodized IT in combination with ES and speed in game-like situations (SSG) on agility and HIAC in youth soccer players. It was concluded that high-intensity interval training, realized in two forms (running and SSGs) in combination with ES and speed, would significantly improve the agility and HIAC of youth soccer players. Moreover, we hypothesized that periodized IT in combination with ES and speed in a game-like situation would improve the agility and HIAC of youth soccer players. The result of the present study supports this hypothesis with p.000>0.05.

The two most important factors influencing the effectiveness of the performance of the soccer players were noted as the load and recovery during and after the training session. However, these factors are difficult to measure in soccer because of the limited form of individualization during and after training. Thus, periodization is useful in determining the appropriate load and recovery, and weight training is more effective. Table b shows the proposed plan for one-week microcycle periodization for youth soccer players. (Balsom P, Lindholm T, Nilsson J, Ekblom B. Precision Football. Kempele, Finland: Polar Electro Oy. 1999., n.d.) Revealed that continuous exercise without a ball (intermittent exercise at 100% VO_2max) and 4 vs. 4 SSG will have a similar effect on HIAC.

Moreover, (Dupont & Berthoin, 2004) contemplates that for developing VO_2max, intermittent exercise at 120% of VO_2max for 15–15 sec is the most effective form of IT. The training load applied to the players during the 6–6 sec and increased after each week in combination with ES and speed in our study turned out to be significantly improving HIAC. (Dellal et al., 2008) Assert that if there is appropriate load application, it plays a crucial role in aerobic capacity development. Appropriate loads can be given through periodization.

It has been examined in several studies that IT, in combination with ES and speed, is effective in developing the agility performance of youth soccer players. (Mathisen & Pettersen, 2015) has concluded that the agility performance of 10-year-old soccer players is increased through short bursts of high-intensity IT. Training ES and speed helps a player develop the ability to execute a quick takeoff from a stationary or slow-moving position, a quick change in direction, and cover the distance in the minimum possible time. ES training, or plyometric training, considerably increases the agility of elite basketball players (Huang et al., 2023). (Fajrin et al., 2018) It has been concluded that agility performance can be improved by high-intensity IT.

Several studies have examined this phenomenon. However, no consensus existed regarding the effectiveness of different forms of SSG or IT on physical capacity. Some coaches prefer SSG, but others practice both forms equally, as in our study. We believe this split results more from the coach's philosophy and experience than from scientific reasons.

Using other explosive and speed exercises in the IT periodic program is very convenient and effective in improving agility and HIAC. (Michailidis, 2022) This study agrees that a short-term IT program can improve sprint and repeated sprint ability performance, i.e., HIAC, in soccer players. The results are consistent with previous studies such as (Naimo et al., 2015), which called IT in combination with ES has a positive effect on performance in Ice hockey players reveals the same thing that IT is able to provide a significant improvement to the HIAC of athletes. (Astorino et al., 2012) Concluded that IT workouts can improve endurance and increase agility and speed in athletes.

Conclusions

The current study suggested that IT, combined with ES and speed, enhanced youth soccer players' agility performance and HIAC. The study proves that the preparation of a good periodized program has a significant effect on improving the performance of players. Coaches may use a combination of both without the ball and with the ball IT in game-like situations in combination with ES and speed in their periodic training plan to develop agility, HIAC, and soccer-specific skill development. To maximize external validity, more experiments need to be conducted in which participants from different regions of the world are encouraged to participate. The present study encourages future researchers to conduct related studies with a larger sample size using precise tools for measuring data.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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ВПЛИВ ПЕРІОДИЗОВАНИХ ІНТЕРВАЛЬНИХ ТРЕНУВАНЬ У ПОЄДНАННІ З ВИБУХОВОЮ СИЛОЮ ТА ШВИДКІСТЮ В ІГРОВІЙ СИТУАЦІЇ НА СПРИТНІСТЬ ТА ВИСОКОІНТЕНСИВНІ АЕРОБНІ МОЖЛИВОСТІ ЮНИХ ФУТБОЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 4 табл., 4 рис., 20 джерел.

Мета дослідження. Високоінтенсивна аеробна здатність (ВІАЗ) є важливою для футболістів, оскільки вони мають виконувати короткі спринт-забіги за найкоротший час. При цьому їм потрібно швидко змінювати напрямок із м'ячем і без нього, що вимагає спритності. Метою дослідження було вивчити вплив періодизованого (8-тижневого) плану тренувань, який поєднує інтервальні тренування (ІТ), вибухову силу (ВС), швидкість та ігрові ситуації на спритність і ВІАЗ у юних футболістів.

Матеріали та методи. Це дослідження є експериментальним дослідженням, у якому вибірку складали юні футболісти чоловічої статі (N = 23) (віком 16,7±2,1 року). Дані про показники спритності були зібрані на етапах попереднього та підсумкового тестування в тесті на спритність під час бігу зі зміною напрямків за стрілоподібною траєкторією та в тесті Йо-йо з переміжним відпочинком (рівень 1) (YYIR1) на ВІАЗ. Використовуючи формулу для тесту YYIR1: VO_2max (мл кг$^{-1}$ хв$^{-1}$) = відстань переміжного відпочинку IR1 (м) × 0,0084 + 36,4, ми отримуємо оцінку об'єму максимального споживання кисню (VO_2max). Для аналізу даних використовували t-критерій Стьюдента за рівня значущості 0,05%.

Результати. На підставі одержаних результатів, середні значення попередніх тестів на спритність, YYIR1 на ВІАЗ та VO2max становили 17,911, 14,8100 та 55,25510. Після тренувань протягом восьми тижнів спостерігалося покращення: середні значення становили 16,667, 15,9750 та 60,06960. Відповідно до результатів даних щодо гіпотези, висунутої в дослідженні, було встановлено наявність статистично значущого впливу періодизованих ІТ у поєднанні з ВС та швидкістю на показники спритності та ВІАЗ юних футболістів.

Висновки. Спостерігався статистично значущий вплив періодизованих ІТ у поєднанні з ВС і швидкістю на покращення показників спритності та ВІАЗ юних футболістів.

Ключові слова: інтервальні тренування, вибухова сила, високоінтенсивна аеробна здатність, спритність та максимальне споживання кисню (VO_2max).

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ORIGINAL SCIENTIFIC ARTICLE

THE IMPACT OF JAVANESE DANCE ON IMPROVING RHYTHMIC SKILLS AND CRITICAL THINKING

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Abstract

Study purpose. The low rhythmic skills of students are caused by the complexity of rhythmic movements. This study aims to determine the impact of Javanese dance on rhythmic skills and critical thinking.

Materials and methods. The study used a one group pretest-posttest experimental design. Fourth grade students of 66 people were used as research subjects who were taken through cluster random sampling. Rhythmic skill data collection was using Rhythmic Test and critical thinking data collection was using a questionnaire. Data analysis was used to determine the impact of Javanese dance using paired samples t-tests, while proving the difference in impact was using independent samples t-tests.

Results. The results show that the paired samples t-test in rhythmic skills is known to have t-test > t-table or 7.540 > 1.980, p = 0.00. In critical thinking t-test > t-table or 4.631 > 1.980, p = 0.00. That is, there is an impact of Javanese dance on improving students' rhythmic skills and critical thinking (t = 6.575, p = 0.00 < 0.005).

Conclusions. The applied Javanese dance has an impact on improving rhythmic skills (psychomotor aspects) and critical thinking (cognitive aspects).

Keywords: rhythmic skills, physical education, critical thinking, traditional, Javanese dance.

Introduction

Rhythmic activity has the meaning of human movement with rhythmic patterns that are adapted to body expressions that follow musical accompaniment or beats other than music. The function of rhythmic activity is to increase rhythm sensitivity and provide the experience of dance movements as a means of expression (Vazou et al., 2020). In addition, the function of rhythmic activity is also as a means of training critical thinking skills through memorizing movements, collaboratively through togetherness movements, and discipline through seriousness in carrying out movements (Ismail et al., 2021). Rhythmic activity is part of the art of rhythmic movement as well as developing relevant aspects of positive values for students such as sincerity, discipline, collaboration, creativity, and critical thinking (Asmawi, 2020). In the context of the learning process, this is called rhythmic learning, namely learning that focuses on the process of mastering movement including the suitability and accuracy between movement and rhythm. The development of rhythmic learning in elementary schools can be grouped into two main activities, namely standard structured and free structured rhythmic activities (Prima et al., 2018).

One of the rhythmic learning developed as a vehicle to help students learn rhythmic activities more easily is the Javanese dance, which is a rhythmic activity based on the Angguk dance. The Angguk dance is a traditional dance from Kulonprogo which has the same characteristics as rhythmic activity (Alfianti et al., 2019). This dance has been developed and successfully implemented in several elementary schools in Kulonprogo. Rhythmic learning in elementary schools aims to improve rhythmic skills in addition to training students' discipline and critical thinking (Zhao et al., 2021). The elements contained in rhythmic learning are flexibility, continuity of movement, flexibility, accuracy of movement with the rhythm of music (Ardiansyah, 2018).

However, the results of previous studies showed that many teachers still had difficulties in implementing rhythmic learning, even some of them annulled the rhythmic activity material because it was too difficult to teach (Utami & Utina, 2019). Another fact shows that the ability of teachers to develop learning is relatively low. There are several learning obstacles; 1) incomplete rhythmic equipment, 2) rhythmic activities in the form of general dance so that students find it difficult to imitate the movement, 3) Rhythmic learning in schools does not contain elements of art, culture and students' critical thinking skills.

Rhythmic activity has characteristics as a creative movement that is closer to the art of dance (Kurniawan et al., 2020). Rhythmic activities in elementary schools aim to increase the accuracy of rhythm and provide flexibility of movement as a means of self-expression, as well as the experience of dance movements (Brakel-Papenhuijzen, 2021). Dance is a rhythmic activity performed with musical accompaniment. Sometimes seen as a tool to express a particular culture. In its development it is also used as entertainment and pleasure. Another function of dance is as a form of social communication and as a cultural activity. There are at least three forms of dance that can be given by teachers in learning to students, namely, singing dances, folk dances, and creative dances (Farida et al., 2022). Where each of these dance forms has different challenges for students. Song dances and folk dances provide a less expressive experience of rhythmic movement, while creative dances provide a more expressive experience of rhythmic movement (Singh & Devi, 2021).

Fun rhythmic learning in elementary schools can involve several approaches that involve students actively and incorporate elements of play. Moreover, there are some rhythmic learning whose movements are based on elements of regional culture. The culture that develops in Java is rich in various kinds of traditional dances (Mujriah et al., 2022). Dance is the art of combining body movements with music to match. Through a combination of movements coordinated with the rhythm of the music, dance creates beautiful harmony and expresses emotions and stories. Javanese Dance has characteristics as a rhythmic activity as well as cultural preservation that is often encountered, especially in Kulonprogo (Supeni & Harini, 2021). In order for Javanese dance to remain sustainable, modifications are needed in the form of rhythmic learning in schools. This is intended to anticipate the phenomenon of today's society which prefers modern things and tries to leave traditional culture (Susanto et al., 2023). Dance can contain various meanings and purposes, such as expressing traditions and culture, depicting stories or narratives, expressing feelings, or providing entertainment to the audience. In some cultures, dance is also used in religious ceremonies, celebrations or social rituals.

Javanese dance grows and develops in the Javanese tribe which is a cultural property and is still maintained today. In other words, the dance is still appropriate and recognized by the population (Nurindiyani et al., 2019). Angguk, Gambyong, Jathilan, and Bedaya dance are some of the traditional dances that were born as folk dances as a result of processing various aspects, namely, social, cultural, and historical aspects that grew in Javanese society (Ismail et al., 2021; Brakel-Papenhuijzen, 2021). Dance can communicate messages and tell stories without using words. Body movements that match the music can create a powerful and engaging artistic experience for the audience. It was also born as a response to various elements that existed at that time, so that a folk dance was formed as one of Javanese cultural identities (Alfianti et al., 2019).

Javanese dance is a type of traditional dance originating from Java, Indonesia. Javanese dance is an important part of Javanese culture and is usually performed in various events and celebrations, such as traditional ceremonies, weddings, festivals and art performances. This dance can be performed by anyone who has interest and skills in the dance. Javanese dance is also suitable for elementary school students based on the characteristics of easy, simple and happy movements (Nurindiyani et al., 2019; Healy, 2019). Rhythmic skills in Javanese dance can be considered as a multidimensional skill set, which can explore relationships in school children aged 6-11 years (Ismail et al., 2021). Javanese dance can be a valuable source of learning, both for individuals and groups. Javanese dance involves coordinated and precise body movements. In the process of learning to dance Javanese dance, students can develop their motor skills, such as balance, strength and flexibility. In the Javanese dance, messages from the community are implied in the form of knowledge, ideas, beliefs, values, and norms (Davidson, 2021). Javanese dance also provides opportunities for students to express themselves through body movements and facial expressions. This can help them develop creativity, confidence and the ability to communicate nonverbally. Javanese dance can be integrated into the school curriculum as part of art, history, or culture lessons.

Characteristics of students at the age of 6-11 years is the phase of the body experiencing very rapid growth and development both in the physical, cognitive, emotional and social aspects that determine further development (Susanto et al., 2021). Teachers should provide good physical activity facilities. The growth and development experienced by elementary school students includes physical development, cognitive development, language development, moral development, emotional development, and social development (Bhaskar et al., 2021). Therefore, teachers can develop learning that contains elements of moving or moving, learning in groups, and providing opportunities to be directly involved so that learning can take place in an interesting and not boring way (Sawitri, 2016).

In learning movement especially rhythmic movement, a component of thinking is needed including lower order thinking and higher order thinking skills. Critical thinking is one of the higher-order thinking processes that can be used in the formation of students' conceptual systems (Huang & Ning, 2021). Critical thinking is reasonable and reflective thinking that focuses on deciding what students should believe or do (Uzunöz & Demirhan, 2017). In reasoning, critical thinking skills are needed or in other words, critical thinking skills are part of reasoning. Schools should teach children the right way of thinking because it plays a very important role in mastering rhythmic movements. Critical thinking also means considering carefully about a knowledge received from various angles of reasons that support and conclude it (Noviyanti, 2020). In the context of learning motion or learning rhythmic activities, critical thinking skills are very helpful in mastering rhythmic movements

that require memorizing movements and accuracy of movements (Fajari & Chumdari, 2021).

Materials and methods

Participants

The sample of this study was fourth grade with a total of 66 students selected by cluster random sampling. They are elementary school students spread across Kulonprogo Regency. Subject selection is based on the availability of students who carry out rhythmic learning on a regular basis.

Research design

This research is using experimental method. The independent variable (X1) is the Javanese dance and the dependent variable is rhythmic skills (X2) and critical thinking (X3). This study used the One-Group Pretest Posttest design. The technique of collecting data on the rhythmic skill variable is by using a rhythmic skill test. The aspects of motion that are assessed are sequence, accuracy, flexibility, and sincerity. Collecting critical thinking data using a critical thinking questionnaire. The number of critical thinking questionnaire items is 28 items (validity 0.57, reliability 0.93).

Data Collection

The research on the impact of Javanese dance was carried out for 12 sessions. Table 1 below shows the practice schedule for Javanese dance which was used as a treatment in finding out its impact on students' rhythmic and critical thinking skills. The treatment intervention given focused on aspects of sequence, accuracy, flexibility, and sincerity. The treatment begins with a pretest and post-test of rhythmic skills and critical thinking skills.

Data analysis

The data analysis used was paired sample t-test to find out the difference between the initial score and the final score. The significance value is expressed by t-test. Prerequisite test in the form of normality test, homogeneity and hypothesis.

Results

The results of both the independent and dependent variables were taken based on the pretest and posttest. The results of the pre-test calculation show that the average impact of Javanese dance is 2.378 and the standard deviation is 0.632. The average post test result for the impact of Javanese dance is 2.931 and the standard deviation is 0.597. The difference between the average pretest and posttest is 0.553, and the standard deviation is 0.271 (Table 2). To find out the impact of Javanese dance, a paired sample t test was carried out, while to prove differences in the impact of treatments, an independent sample t test was carried out.

Table 2. Differences in pretest and posttest scores

Pretest score	Posttest score	Differences Pretest-posttest
$\bar{x}$ = 2.378	$\bar{x}$ = 2.931	$\bar{x}$ = 0.553
N = 66	N = 66	N = 66
SD = 0.632	SD = 0.597	SD = 0.271

The data analysis used was a paired sample t-test to prove the impact of Javanese dance on improving critical thinking and rhythmic skills. The analysis used a two-tailed test and a significance level of 0,05. A two-tailed test was used with a significance level of 0.05. The results of data analysis showed that there was a significant impact of Javanese dance on improving students' rhythmic skills and critical thinking ($t = 6.575$, $p = 0.00 < 0.005$), so that Javanese dance was said to be effective in improving rhythmic skills and critical thinking skills (Table 3).

Table 3. Impact value of Javanese Dance

Variable	t	Sig. (2-tailed)	df
Javanese Dance	6.575	0.000	65

Tabel 1. Content Listing and Schedule

Session	Schedule	Javanese Dance Material	Activity
1		Pre-test	
2	Practice 1	Basic Javanese Dance	Movement of arm without rhytm
3	Practice 2	Basic Javanese Dance	Movement of feet without rhytm
4	Practice 3	Basic Javanese Dance	Change Movement without rhytm
5	Practice 4	Basic Javanese Dance	Movement of arm with rhytm
6	Practice 5	Basic Javanese Dance	Movement of feet with rhytm
7	Practice 6	Basic Javanese Dance	Change Movement with rhytm
8	Practice 7	Advance Javanese Dance	Warming-up
9	Practice 8	Advance Javanese Dance	Main Training
10	Practice 9	Advance Javanese Dance	Main Training
11	Practice 10	Advance Javanese Dance	Cooling-down
12		Post-test	

Prerequisite Test

To determine the normality and homogeneity, a prerequisite test was carried out. The prerequisite test is used to determine the normal distribution of the data. Based on the normality test, it is known that the results of the pretest and posttest of the variables of rhythmic skills and critical thinking are normally distributed (Table 4). Homogeneity test is needed to see the level of data homogeneity. The results show that the pretest and posttest of rhythmic skills and critical thinking show a homogeneous distribution.

Table 4. Results of Normality and Homogeneity Test Data Processing

Experimental Data Group		Kolmogorov Smirnov	Distribution	P-value
Rhythmic Skills	Pretest	0.437	Normal	> 0.05
	Posttest	0.450	Normal	> 0.05
Critical Thinking	Pretest	0.726	Normal	> 0.05
	Posttest	0.981	Normal	> 0.05
Experimental Data Group		**Levene**	**Distribution**	**P-value**
Rhythmic Skills	Pretest	0.424	Homogeneous	> 0.05
	Posttest	0.349	Homogeneous	> 0.05
Critical Thinking	Pretest	0.628	Homogeneous	> 0.05
	Posttest	0.914	Homogeneous	> 0.05

Hypothesis testing

After carrying out the pretest and posttest tests of the two variables, it is known that the results of the hypothesis testing (Table 5).

Table 5. Hypothesis Test Results for Rhythmic & Critical Thinking Skills

Variable		Pair Diff.			t	df	Sig. (2-tailed)
		Mean	SD	SEM			
Pair 1	Pretest-posttest Rhythmic Skills	7.248	5.385	0.983	6.372	65	0.000
Pair 1	Pretest-posttest Critical Thinking	8.432	9.352	1.707	5.754	65	0.000

Notes: SD = Standard Deviasi, SEM = Standard Error of Mean

The Impact of Javanese Dance on Rhythmic Skills

Based on the results of the paired sample t-test on the rhythmic skill variable, the t test (6.372) is greater than t-table (1.980) with a significance level of 0.05 (Table 5). There is a significant difference between the pretest and posttest average scores for the rhythmic skill variable. The mean t-test value is 7.248. Thus, the average value of the posttest (after being treated with Javanese dance) is higher than the average value of the pretest (before being treated with Javanese dance). Based on the number of male students who took the rhythmic skills test, it was found that there were 6 highly skilled, 10 skilled, 12 moderately skilled, 5 less skilled, and 3 unskilled. For female students, it is known that there are 8 highly skilled, 10 skilled, 8 moderately skilled, 3 less skilled, and 1 unskilled. Therefore, the conclusion is that Javanese dance has a significant impact on rhythmic skills. The impact of the Javanese dance is seen in changes in student skills in aspects of sequence, accuracy, flexibility, and sincerity.

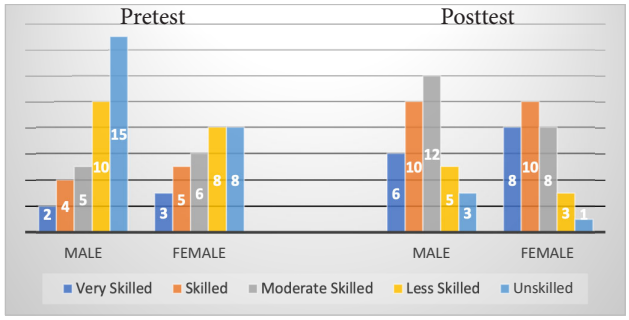

Fig. 1. Number of students with rhythmic skill level pretest-posttest treatment

The Impact of Javanese Dance on Critical Thinking

Based on the results of the paired sample t-test for critical thinking variables, the t-count (5.754) is greater than t-table (1.980) with a significance level of 0.05. These results indicate that there is a difference between the pretest and posttest scores on critical thinking skills. This result is supported by a t-test score of 8.432. This shows that the posttest average score (after being given critical thinking treatment) is higher than the pretest average score (before critical thinking treatment). Based on male respondents who have filled out a critical thinking questionnaire after receiving Javanese dance treatment, it was found that there were 8 students who were very critical, 8 students were critical, 10 students were moderate critical, 6 students were less critical, and 4 students were not critical. For female students, it is known that there are 9 students who are very critical, 10 students are critical, 6 students are moderate critical, 4 students are less critical, and 1 student is not critical. So it can be concluded that Javanese dance has a strong impact on critical thinking skills. The measurement of critical thinking skills that is applied consists of aspects of basic clarification, basic decision making, conclusions, further clarification, and strategies & tactics.

Observation of the rhythmic learning process through Javanese dance is carried out as supporting evidence for the results of the research that has been done. The Javanese

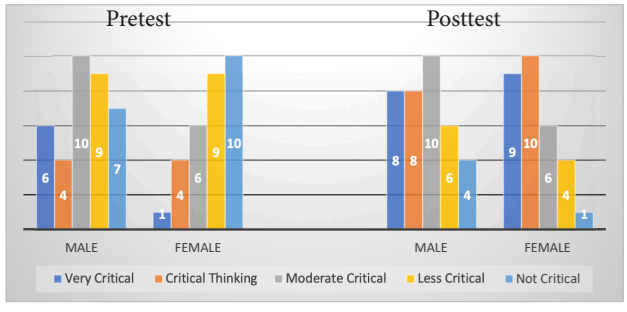

Fig. 2. Number of students with critical thinking level after treatment

dance intervention used in the experimental group showed an increase in rhythmic skills which could be seen from the elements of movement learned. In the intervention process, students showed significant skill changes. There was an increase in skills during tests and treatments which showed that students memorized more, had precise movements, were more flexible, and were more serious in their movements. Another indicator is that students show discipline, are actively involved in the rhythmic learning process, and help each other in difficult movements. This shows that rhythmic activities based on the Javanese dance are easy to do in rhythmic learning for elementary school students.

Discussion

The results mentioned earlier by looking at the characteristics of rhythmic learning through Javanese dance show that students participating in rhythmic learning are less active, have difficulty moving, are not happy, lack attention and more than half experience obstacles in rhythmic skills. Teachers need a rhythmic learning model with the aim of improving rhythmic skills and critical thinking skills. The Javanese dance used as a research treatment showed a large influence on the results of students' rhythmic and critical thinking skills. This is in accordance with several theories which state that there is a relationship between rhythmic activity and critical thinking skills in students (Taghinezhad & Javad, 2020; Kurniawan, 2020; Noviyanti, 2020).

The Impact of Javanese Dance on Rhythmic Skills

From the results found it is known that Javanese dance has an impact on rhythmic skills. This can happen because this model contains rhythmic activities based on the Javanese dance which are close in characteristics to rhythmic skills. According to the results of previous studies, rhythmic skills are influenced by rhythmic components, both in the form of dance and rhythmic movements (Cicchella, 2009; Ismail et al., 2021; Kurniawan, 2020). When participating in rhythmic activities, students must be required to think for themselves about developing their skills. It is undeniable that critical thinking skills can be improved through regular practice of rhythmic skills. Learning rhythmic skills makes a huge contribution in improving rhythmic skills. This can happen because rhythmic activities provide many experiences where students are able to control their bodies with confidence and a high success rate, thus enabling them to help form positive concepts (Botti & Nascimento, 2011).

The importance of rhythmic movements such as singing, dancing, and playing musical instruments are activities that are expected in learning rhythmic movements (Prima et al., 2018). While the concept of rhythmic motion comes from one of the components in the Dalcroze Eurhythmics approach (Daly, 2022; van der Merwe & Habron, 2020). The rhythmic philosophy put forward by Dalcroze has an emphasis on providing rhythmic activities so that students feel the elements of rhythm, music, tone and melody. Dalcroze's idea of using movement in musical activities can stimulate students' mental strength to learn skills (Wentink & Van der Merwe, 2020).

There are two basic elements used to connect movement and rhythm. Rhythmic movement is naturally embedded in a person which makes it the strongest and closest musical element in human life, meaning that movement and rhythm must be in harmony (Daly, 2022). Movement is also reflected in other fields, including the association and degree of conformity with the movement of the human body, which is expressed by the flexibility of motion (de Oliveira et al., 2021). In rhythm, the interaction between the body and the brain can be increased more optimally. The function of the brain is to receive information and analyze stimuli which then give instructions to the body to move. Students tend to repeat the same movement because they feel comfortable with the movement (Cicchella, 2009).

Rhythmic activity is a gymnastic movement performed using music, or free exercise performed rhythmically (Farida et al., 2022). Gymnastics that use music must be matched between movements and the type of music. The stresses given to rhythmic gymnastics are rhythm, flexibility of the body in movement, and uninterrupted continuity of movement (Ivanov & Bardina, 2021). Thus, it can be concluded that rhythmic skills for elementary school are categorized into 3 domains, namely cognitive, psychomotor, and affective. Motion memorization is included in critical thinking skills which is a cognitive aspect, while the accuracy of rhythm with movement and flexibility of motion is a psychomotor aspect, and the affective aspect can be seen from the enthusiasm and discipline of students in performing rhythmic movements (Terekhina et al., 2021). In order for rhythmic activities to be carried out properly, students must have good motor skills (Irmansyah et al., 2021). The motor process is a movement that directly involves the muscles to move and the innervation process that is able to move the limbs (Prima et al., 2018). The process of motion maturity which involves the muscles to move makes a person able to move his limbs well. In this context, motor learning is realized through muscle responses that are expressed in a specific body movement or body part to improve the quality of body movement (Šrám & Velemínský, 2018).

In developing the Javanese dance, it is necessary to pay attention to the creativity of children in performing rhythmic movements (Ismail et al., 2021). Moreover, the Angguk dance, which is the basis of this model, has a strong characteristic of movement which is a reflection of everyday life such as walking, sitting, squatting, turning, twisting, and nodding (Supeni & Harini, 2021). In this context students should be able to utilize motion skills to improve critical thinking skills. The rhythmic activities in the Javanese dance provide many experiences where students are able to control their bodies with confidence and a high level of success, allowing them to help form positive concepts (Sawitri et al., 2016).

The Javanese dance is a rhythmic activity which in its expression uses the Angguk dance or traditional dance from Java. To be a good dancer, a dancer is required to master the aspects of wiraga, wirama, and wirasa (Utami & Utina, 2019). Angguk Dance is a form of cultural performance art. The Angguk dance which was adopted as Javanese dance can be understood as a form of rhythmic motion as well as a combination of artistic and cultural elements in society (Mursih, 2018). The dance that has become Javanese dance is a beautiful movement and is born from a body that moves to the accompaniment of the rhythm of music. Some opinions state that Javanese dance is a rhythmic activity that conveys

messages through body language accompanied by music or rhythm.

The Impact of Javanese Dance on Critical Thinking

According to the results, it is found that Javanese dance has an impact on critical thinking skills. This can happen considering that in the Javanese dance there are movements that must be memorized and understood well by students. This is why students are required to have critical thinking skills in mastering rhythmic skills (Terekhina et al., 2021; Zhao et al., 2021). This Javanese dance is an activity based on the Angguk dance which consists of elements of sequence, accuracy, flexibility, and sincerity. It takes critical thinking skills in mastering it. Rhythmic and dance activities have something in common, namely both activities that combine movement with music (Darwati et al., 2021). Javanese dance contains messages about ideas, knowledge, beliefs, values and norms. In terms of movement, clothing and accompaniment, it shows that this dance work is simple but full of values. Dance skills or techniques are not difficult but the expression of the soul is really prioritized to maximize the message that will be conveyed. For rhythmic activities, students are required to have good critical thinking skills (Ardiansyah, 2018). Given this ability is very supportive of the mastery of rhythmic skills which include memorization of movements, accuracy of movements, flexibility of movements, and seriousness of movements.

For fourth grade students, the Javanese dance, apart from being a free rhythmic activity according to the wishes of the students, can also be used as a vehicle for teaching critical thinking skills, meaning that rhythmic activity movements train students to think critically (Vieira & Tenreiro, 2016). Age between 7 to 12 years is often considered as an important period in seeking knowledge as much as possible. At this stage, children are usually at the primary level of education, such as elementary school or junior high school. This period is considered crucial because at this age children have high cognitive abilities and comprehension. Children at this age are very curious and very easy to absorb new knowledge. Apart from formal education at school, children can also broaden their knowledge through extracurricular activities, such as sports, art, music or community activities. In a supportive environment, they can develop their interests and talents in various fields. However, it is also important to strike a balance between learning and play. Children at this age also need time for social interaction, play, and outdoor exploration. Through play, they can develop social skills, creativity and problem solving. Upper class students are individuals who are very active in doing physical activities and filling their spare time (Rollings & Wells, 2018). Age 7 to 12 years is an important period in seeking knowledge as much as possible. Formal education in schools and activities outside of school can provide opportunities for children to broaden their knowledge and develop interests and talents in various fields.

One of the growth experienced by elementary school students is the ability to think. The ability to think is characterized by mental activities such as remembering, understanding, and solving problems (Susanto et al., 2022). This is in accordance with the concept that physical education including rhythmic learning can help students practice critical thinking skills (Ramos & Gómez, 2021). Students are able to group different objects. As stated by Piaget that cognitive development of students is a period that is at the stage of concrete operations, which is characterized by the ability to classify objects based on similar characteristics, associate numbers, and solve simple problems (Barrouillet, 2015). To develop the power of reasoning and creativity, students need to be given the opportunity to ask questions, have opinions and assess various things related to their environment. This characteristic is in accordance with the theory of rhythmic motion learning that leads to critical thinking skills (Trigueros & Navarro, 2019).

The problem encountered at the beginning of conducting the experiment was finally proven, namely the lack of teacher ability in providing learning rhythmic activities in the learning process in elementary schools (Hastuti et al., 2020). Teacher courage is needed in applying learning models with rhythmic activities. One way is by providing appropriate training and support for teachers, including training in implementing learning models that involve rhythmic activities. The results of the treatment in the experiment also confirmed that there were not many physical education teachers who used local traditional dances as a vehicle for learning rhythmic activities (Saregar, 2021). This is reflected in the absence of traditional dance as a local curriculum that needs to be developed (Rahmadhani et al., 2020).

The results of the treatment of this model also confirm that the Javanese dance in addition to having an impact on critical thinking skills also has an impact on high social values. These social values are in accordance with social cognitive theory, which is a theory that emphasizes the idea that most human learning occurs in a social environment (Sun et al., 2022). By observing other people, humans acquire knowledge, rules, skills, beliefs, and attitudes (Sapsağlam & Ömeroğlu, 2016). Individuals also look at models or examples to study the usefulness and appropriateness of behaviors as a result of the behavior being modeled, then they act according to beliefs about their abilities and the expected results of their actions (Stewart & Krivan, 2021). Another distinctive characteristic is that critical thinking is a major role in the function of self-regulation. Most of their behavior is motivated and governed by internal standards and reactions to their own actions related to self-assessment (Escriva-Boulley, 2018).

Dance-based learning models or rhythmic activities can be an interesting alternative in learning. Including proven to improve rhythmic skills and critical thinking. There are several learning models to develop rhythmic skills (Lasma & Rachman, 2019). Generally, rhythmic activity models are used in game or dance type materials that promote teamwork between teams so that it is easy to assess rhythmic and critical thinking skills (Eun, 2019). In implementing Javanese dance it is important to consider the needs and characteristics of students, as well as provide a safe space and appropriate support. Teachers can combine elements of dance with a variety of other learning strategies to create diverse learning experiences for students. Thus, critical thinking in rhythmic activities is a way of thinking for students to respond by analyzing facts to form an assessment of the rhythmic motion function performed. Javanese dances often contain complex messages and stories. Students are faced with the task of interpreting dance movements, symbolic meanings,

and the cultural context behind them. This process involves analytical abilities and interpretation skills, which are important components of critical thinking.

Conclusion

The conclusions from the results and discussion above are the Javanese dance treatment had an impact on rhythmic skills and critical thinking. The influence of the Javanese dance on rhythmic skills is seen in changes in the skills of sequence, accuracy, flexibility, and sincerity. The influence of the Javanese dance on critical thinking can be seen in aspects of basic clarification, basic decision making, conclusions, further clarification, and strategies & tactics as outlined in rhythmic motion. With Javanese dance showing the impact in improving rhythmic skills and critical thinking. This is in accordance with previous research that rhythmic learning models can improve rhythmic skills and critical thinking.

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Conflict of interest

No conflict of interest was reported by the authors.

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ВПЛИВ ЯВАНСЬКОГО ТАНЦЮ НА ВДОСКОНАЛЕННЯ РИТМІЧНИХ НАВИЧОК І КРИТИЧНОГО МИСЛЕННЯ

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Реферат. Стаття: 9 с., 4 табл., 4 рис., 20 джерел.

Мета дослідження. Низький рівень розвитку ритмічних навичок учнів зумовлений складністю ритмічних рухів. Метою цього дослідження є визначення впливу яванського танцю на ритмічні навички та критичне мислення.

Матеріали та методи. У цьому дослідженні використовували експериментальний план із попереднім і підсумковим тестуванням на одній групі. Учасниками дослідження стали 66 учнів четвертих класів, які були відібрані шляхом кластерної випадкової вибірки. Збір даних про ритмічні навички здійснювали за допомогою Ритмічного тесту, а збір даних про критичне мислення здійснювали за допомогою анкети. Аналіз даних для визначення впливу яванського танцю проводили за допомогою t-критеріїв Стьюдента для парних вибірок, а для підтвердження різниці у впливі використовували t-критерії Стьюдента для незалежних вибірок.

Результати. Результати показують, що t-критерій для парних вибірок у тестуванні ритмічних навичок має значення t-критерію > табличне значення t-критерію, або 7,540 > 1,980, p = 0,00. У тестуванні критичного мислення значення t-критерію > табличне значення t-критерію, або 4,631 > 1,980, p = 0,00. Тобто спостерігається вплив яванського танцю на вдосконалення ритмічних навичок і критичного мислення учнів (t = 6,575, p = 0,00 < 0,005).

Висновки. Прикладний яванський танець впливає на вдосконалення ритмічних навичок (психомоторні аспекти) і критичного мислення (когнітивні аспекти).

Ключові слова: ритмічні навички, фізичне виховання, критичне мислення, традиційний, яванський танець.

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ORIGINAL SCIENTIFIC ARTICLE

INTERLIMB ASYMMETRY OF MAXIMAL HANDGRIP STRENGTH AND WRIST CIRCUMFERENCE IN ELITE INTERNATIONAL MALE BOXERS

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Abstract

The purpose of the study was to examine interlimb maximal handgrip strength asymmetry and wrist circumference asymmetry in amateur boxing across three weight classes and two different stances.

Materials and methods. The study sample comprised 12 (flyweight: 4; bantamweight: 4; featherweight: 4) amateur elite international boxers of India. Both limbs were tested for maximal handgrip strength and wrist circumference. For both tests, interlimb asymmetry was calculated using the interlimb asymmetry equation validated by Bishop et al. (2018). One-way ANOVA was used to compare asymmetries in three different weight classes, and an independent samples t-test was used to compare asymmetries in two different boxing stances.

Results. The average wrist circumference asymmetry in different weight classes was 2.85±1.97 for flyweight, 1.29±0.75 for bantamweight, and 2.44±1.23 for featherweight, whereas the average maximal handgrip strength asymmetry was 4.91±3.75 for flyweight, 7.69±1.89 for bantamweight, and 5.80±2.89 for featherweight. Non-significant differences in interlimb asymmetry for wrist circumference and maximal handgrip strength in three different weight classes and two different stances were obtained ($p > 0.05$).

Conclusions. The maximal handgrip strength asymmetry and wrist circumference asymmetry in elite international boxers were found to be less than 10 percent and observed non-significant differences in weight classes as well as stances indicate elite amateur international boxers to be less prone to interlimb asymmetry-related injuries and have favourable conditions for high performance.

Keywords: flyweight, bantamweight, featherweight, southpaw, orthodox, boxing.

Introduction

Boxing is one of the oldest combat sports in human history and is historically referred to as the "noble art" and pugilism. The International Boxing Association has stated that the first proof of this was found in Egypt around 3000 B.C. Boxing probably started in Ethiopia around 6000 B.C., and in 688 B.C., at the first Olympic Games, boxing made its historical debut as an Olympic sport (Chaabène et al., 2014). In order to be successful in boxing, a person must possess a wide range of skills, knowledge, and traits that can be measured, analyzed, and ultimately improved through the use of the right tools and techniques throughout their athletic career (Kapo et al., 2021). Boxers choose between the orthodox or southpaw stance. The term "orthodox stance" describes how the boxer should stand, with the left foot and hand forward and the right foot and hand back. The term "southpaw," which comes naturally to left-handers, describes having one's right foot and right hand in the front (Sorokowski et al., 2014). What we call the difference between one limb in relation to the other is known as inter-limb asymmetry (also known as bilateral asymmetry or bilateral difference) (Bishop et al., 2018). Öktem et al. (2017) has determined a highly positive correlation between hand grip strength and upper extremity parameters. Specific sports practice also affects the morphological differences of the body sides. Additionally, participating in sports activities that primarily use one side of the body results in asymmetrical changes to some tissues, and martial arts may be an example of a discipline in which one side of the body is emphasized over the other (Burdukiewicz et al., 2020a). The most popular way to evaluate the strength of the muscles in the upper extremities is by measuring hand grip strength, which also serves as a key performance indicator for athletes (Fry et al., n.d.). Using magnetic resonance imaging, Ducher et al. (2005) and Daly

et al. (2004) have determined in tennis players that the radius, ulna and humerus have a larger diameter compared to the non-dominant upper limb, in the dominant upper limb. Simenko et al. (2017) determined significant differences between right and left body pairs in -73 kg youth judo players. Krzykała and Leszczyński (2015) uncovered a significant increase in muscle mass and bone mineral density on the left side of the bodies of both male and female professional field hockey players. Guidetti et al. (2002) has established that the isometric muscle contraction, especially that of the upper limb (i.e., the dominant arm), is closely associated with boxing competition ranking. The boxer's hand-grip isometric strength is a significant physical fitness indicator. Indian National Boxers' morphological, physiological, and biochemical characteristics between Senior and Junior levels (Khanna & Manna, 2006). Hand-grip strength performance of the main hand correlates with both the power of the straight and the side blow (Chaabène et al., 2015). Sporrong et al. (1996) and Guidetti et al. (2002) suggested that hand-grip strength is one of the most important medical control indicators in boxing training. The performance of left and right hand-grip isometric strength by weight category was examined, and it was found that there is a substantial difference between the lightweight, middleweight, and heavyweight categories (Ramírez-García et al., 2010). However, scientific literature related to interlimb grip strength and wrist circumference asymmetry in elite international boxers is scarce. During an amateur boxing bout, a pugilist executes combination of punches from dominant as well as non-dominant hand. Therefore, reduction in interlimb asymmetry may be an influential factor to determine outcome of a bout as well as prevention of injuries during the course of a bout. By identifying any significant differences in handgrip strength and wrist circumference between the dominant and non-dominant limbs, coaches can customise exercises and routines to promote symmetrical development, potentially reducing the risk of injuries and optimising sports performance. The investigation of elite boxers' handgrip strength and wrist circumference asymmetry can contribute to the development of injury prevention strategies and could aid in talent identification and selection process. The research may shed light on the biomechanical aspects of boxing as well as the possible effects of specific stances on handgrip strength and wrist circumference. Understanding these biomechanical differences can aid in the refinement of boxing techniques, the optimisation of movement patterns, and the improvement of boxing performance as a whole. The findings of study may serve as a basis for comparing interlimb asymmetry in athletes from other combat sports or even athletes from other sports to differentiate the asymmetry patterns in boxing.

The aim of this study was to compare the wrist circumference asymmetry and interlimb hand grip strength asymmetry in three different weight classes and two different stances. On the basis of findings of previous studies, we hypothesized that there would be no significant difference in wrist circumference asymmetry and interlimb hand grip strength asymmetry in three different weight classes and two different stances. However, interlimb handgrip strength asymmetry and wrist circumference asymmetry would be less than 10 percentage in all the three-weight classes and two different stances.

Materials and Methods

Experimental Approach to the Problem

Indian elite international male boxers were the focus of this descriptive cross-sectional study. Anthropometric profiles were established, and interlimb asymmetry for hand grip strength and wrist circumference was compared among three different weight classes: flyweight (48-51 kg), bantamweight (51-54 kg), and featherweight (54-57 kg) (International Boxing Association, 2023). The National Boxing Training Center, situated in the Netaji Subhash National Institute of Sports in Patiala, served as the testing site. All athletes didn't need any special introductions or familiarisation since they had already taken part in the ensuing tests. Prior to their regular morning boxing training, the athletes underwent anthropometric and hand grip strength evaluations by an ISAK level 1 anthropometrist who was also a national boxing coach.

Study participants

Twelve (7 southpaw + 5 orthodox) of the best male boxers in India from three different weight classes (flyweight (48–51 kg), bantamweight (51–54 kg), and featherweight (54–57 kg)) were chosen for the study. Data from all available boxers in specified weight classes in national camp was collected and limited resources were the key factor in determining the size of the sample the researchers were able to gather. The participants were international boxers from India who were also a part of either the Olympic Games, the World Championships medal winners, the Commonwealth Games medal winners, the Asian Championship medal winners, or the Senior National Champions. After the goals and steps of the experiment were explained to each participant, they all signed an informed consent form. The Lakshmibai National Institute of Physical Education in Gwalior's Ethics Review Committee gave its approval for this study, which was carried out in compliance with the Helsinki Declaration. During the time leading up to the Asian Boxing Championship, the assessment was done. A survey was used to find out the participants' birth dates, their preferred boxing stances (Southpaw or Orthodox), and any injuries they might have

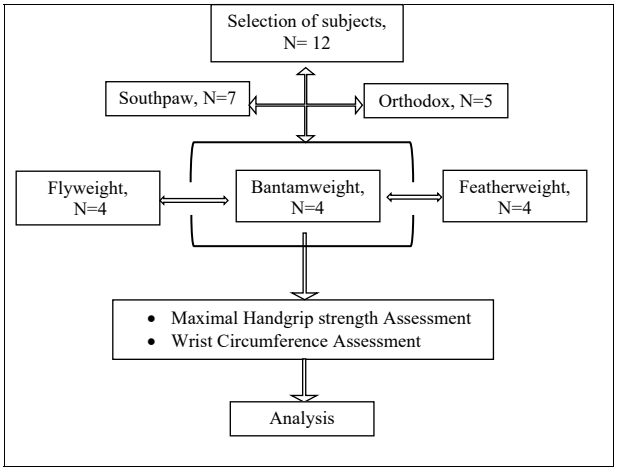

Fig. 1. Cross sectional design of the study

had in the past six months. None of the athletes have reported any injuries.

Procedure of data collection

Anthropometrics:

Height was measured using a stadiometer and the standard ISAK procedure for stretch stature to reduce the effect of diurnal variations. The subjects were instructed to stand with their feet together and their heels, buttocks, and upper back touching the scale. The measurer placed the hands along the jaw of the subject and gently lifted the subject's head upward through the mastoid processes. The recorder tightly compressed the hair and made sure that the head remained in the Frankfort plane and that the feet did not leave the ground. At the end of a deep inspiratory manoeuvre, the measurement was made (Norton, 2018). An electronic weighing scale made for professional boxers (Ohaus SD200L Boxing Scale) was used to measure body mass. The subjects were directed to put on the bare essentials of clothing, verify the zero, and then position themselves at the centre of the scale with their weight evenly distributed on both feet, heads held up, and eyes fixed forward. The wrist circumference was measured as the minimal girth distal to the radial styloid process. Non-elastic tape was used to measure the circumference of both wrists (left and right). The subject sat back with his non measuring arm at his side in a comfortable state. The measuring forearm was supinated, the hand was relaxed, and the elbow was slightly extended. It was necessary to manipulate the tape measure to get the minimal girth without compressing the tissues with too much tape tension. The measurement was recorded to the nearest 0.1 cm (Rogowski et al., 2008).

Maximal Handgrip Strength Test

The Takei T.K.K.5401 GRIP-D handgrip dynamometer (Takei Scientific Instruments Co., Ltd., Tokyo, Japan) was used for all data collection to measure the maximum isometric handgrip strength of the dominant and non-dominant hand (Gatt et al., 2018). Prior to the test, the athletes performed a warm-up consisting of two sets of five submaximal grip strength exercises. The participants were told to do the test for 5 seconds while standing with their elbows fully extended and their shoulders bent 90 degrees (Bonitch-Góngora et al., 2012). The interval between attempts was between 30 and 60 seconds. For further analysis, the average of three handgrip strength attempts was used.

Wrist Circumference Measurement

The cescorf anthropometric tape with 2 meter range and 6 millimeter width was used. The subject assumesd a relaxed pose, with the left arm hanging at the body's side. The right elbow was slightly extended, the forearm was supinated, and the hand was relaxed. The measurer stood infront of the subject. It was necessary to use the tape measure to ensure that the minimum circumference was reached, and the tissues were not compressed by excessive tape tension. The measurement was recored in centimeter (Norton, 2018).

Fig. 2. Cescorf anthropometric tape

Fig. 3. Takei T.K.K.5401 GRIP-D handgrip dynamometer

Interlimb Asymmetry

Interlimb asymmetry was calculated using the equation validated by Bishop et al. (2018)

Interlimb asymmetry = (Max (left or right) – Min (left or right)) ÷ Max (left or right) × 100

Statistical Analysis

Analyses were conducted using jamovi version 2.3 (2022). Shapiro Wilk normality test was run which indicated no evidence of non-normality in the data set for wrist circumference asymmetry (W=0.97, p=0.91) and maximal hand grip strength asymmetry (W= 0.89, p= 0.12). In case of homogeneity of variances, Levene's test indicated variances of all the groups to be equal (p=0.27) for wrist circumference asymmetry. However, variances of the all the groups were unequal for maximal handgrip strength asymmetry (p=0.02). Therefore, ANOVA (Fisher's) test was carried out for wrist circumference asymmetry and Welch's test was used for maximal handgrip strength asymmetry. For WC_A and MHGS_A comparison between orthodox and southpaw stance independent t test was employed after verification of normality and homogeneity of the data.

Results

The values of mean, standard deviation and standard error of mean are reported in Table 1. The mean and standard deviation values reported by the researchers for wrist circumference asymmetry in different weight classes was (flyweight: 2.85±1.97; bantamweight: 1.29±0.75; and featherweight: 2.44±1.23), whereas for maximal handgrip strength asymmetry was (flyweight: 4.91±3.75; bantamweight: 7.69±1.89; featherweight: 5.80±2.89). The mean and SD values for wrist circumference asymmetry in different stances was (orthodox: 2.39±0.96; and southpaw: 2.05±1.78), whereas for maximal handgrip strength asymmetry was (orthodox: 6.92±3.00 and southpaw: 5.57±2.97).

Fisher's one-way ANOVA was used to compare the difference in interlimb wrist circumference asymmetry (WC_A) in three different weight classes. The researchers found that there was no significant difference between flyweight, bantamweight, and featherweight boxers in terms of WC_A; ($F_{(2, 9)} = 1.32$, $p = 0.315$). Welch's one-way ANOVA was used to compare the maximal handgrip strength asymmetry (MHGS_A) of boxers in three different weight classes and insignificant difference was obtained; $F_{(2, 5.55)} = 1.05$, $p = 0.410$. From Table 2, it is evident that the t value for WC_A obtained was 0.39, and its associated p value

Table 1. Descriptive Statistics for wrist circumference asymmetry and maximal handgrip strength asymmetry in different stances and weight classes

Variable(s)	Stance	Weight Class	N	Mean	SD	SE
WC_A		Flyweight	4	2.85	1.98	0.98
		Bantamweight	4	1.29	0.76	0.37
		Featherweight	4	2.44	1.23	0.61
	Orthodox		5	2.39	0.96	0.43
	Southpaw		7	2.05	1.78	0.67
MHGS_A		Flyweight	4	4.91	3.75	1.87
		Bantamweight	4	7.69	1.89	0.94
		Featherweight	4	5.80	2.89	1.44
	Orthodox		5	6.92	3.00	1.34
	Southpaw		7	5.57	2.97	1.12

Table 2. One way ANOVA for wrist circumference asymmetry and maximal handgrip strength asymmetry in three different weight classes and two different stances in boxing

Statistical technique	Variable	t	F	MD	SED	df	df1	df2	p
Fisher's ANOVA	WC_A		1.32				2	9	0.32
Welch's ANOVA	MHGS_A		1.05				2	5.55	0.41
Independent t test	WC_A	0.39		0.35	0.88	10			0.71
	MHGS_A	0.77		1.35	1.75	10			0.46

Note. Hα $\mu_{Orthodx} \neq \mu_{Southpaw}$. Abbreviations: WC_A- wrist circumference asymmetry; MHGS_A- maximal handgrip strength asymmetry; MD- mean difference; SED- standard error difference

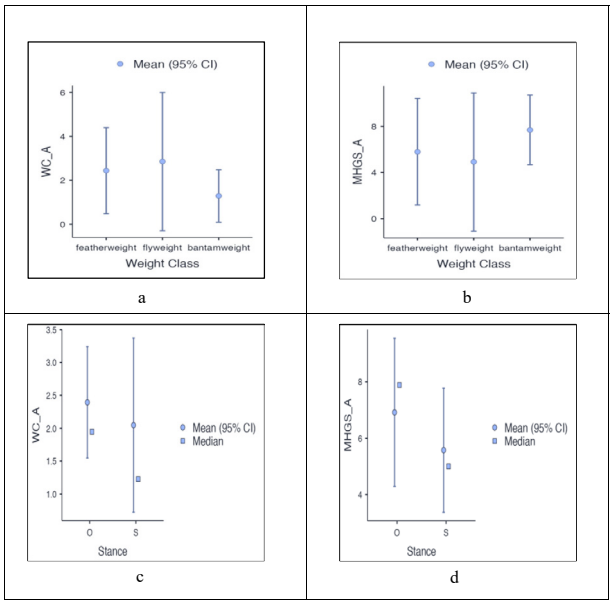

Fig. 4. Mean and median of different weight classes and stances (O: Orthodox; S: Southpaw) for wrist circumference asymmetry (WC_A) and maximal handgrip strength asymmetry (MHGS_A) in elite amateur international boxers.

was 0.71. Since the p value was greater than 0.05, it may be concluded that the null hypothesis was not rejected at the 5% level. Hence, it may be inferred that there was no significant difference between orthodox and southpaw boxers in wrist circumference asymmetry. In the case of MHGS_A, the t value was 0.77 and the corresponding p value was 0.46. Since the p value was higher than 0.05, there were no statistically significant difference between the two boxing stances in MHGS_A as well.

Discussion

The aim of the study was to compare the interlimb wrist circumference asymmetry and hand grip strength asymmetry in three different weight classes and two different stances in boxing. Results revealed no significant difference in physical attributes (WC_A and MHGS_A) in three different weight classes (flyweight, bantamweight, and featherweight) as well as two different stances (Orthodox and southpaw) in boxing. Different weight classes and stances of boxers may have training adaptations that produce similar asymmetries in wrist size and handgrip strength. Previous studies have demonstrated that regardless of weight class or stance, boxers' handgrip strength significantly increases with training (Ramírez-García et al., 2010). Cronin et al. (2017) and Guidetti et al. (2002) have mentioned a strong positive relationship between handgrip strength and boxing competition ranking. India is ranked third in the latest AIBA world rankings (IBA, 2023) and indian boxers, regardless of their weight classes, are precisely adjusted in terms of physical qualities.

However, mean values for WC_A and MHGS_A were less than 10 percentage in all three weight classes as well as both stances. Previous studies have reported maximal handgrip strength asymmetry of less than 10 percentage in Turkish athletes (Ziyagil et al., 2015), bodybuilders and martial artists (Burdukiewicz et al., 2020b). Asymmetry less than 10 percentage is an indicator of readiness for training and being less prone to injuries (Kyritsis et al., 2016; Rohman et

al., 2015). Inter-limb asymmetries higher than 15 percentage have been linked to higher injury rates in athletes and non-athletes (Grindem et al., 2011; Impellizzeri et al., 2007; Barber et al., 1990). The findings of previous studies were in line with the current study, wrist circumference asymmetry reported by Rogowski et al. (2016) was less than 3 percentage whereas Kannus et al. (1995) reported less than 5 percentage bilateral differences in wrist girth.

Our study demonstrates that stance is not a predictor of asymmetries and when boxers are performing at their highest level, asymmetries do not differ between lighter weight classes. While the present study provides novel insights into interlimb asymmetry, it is equally important to acknowledge the study's limitations. Due to possible differences in fitness level, gender, and playing level, the results cannot be extrapolated to female boxers or boxers competing at lower levels. Second, the study lacked useful lower limb asymmetry parameters, precluding definitive lower limb asymmetry details for international boxers. However, future research on this subject should include the middleweight and heavyweight divisions, female boxers, and lower limb asymmetry parameters at various playing levels.

Conclusion

In conclusion, the results of this study indicate that there were no significant differences in wrist circumference asymmetry (WC_A) and maximal handgrip strength asymmetry (MHGS_A) between orthodox and southpaw stances among elite international male boxers. These findings contribute to our comprehension of interlimb asymmetry in boxers and may be useful for optimising the training and performance of boxers. The maximal handgrip strength asymmetry and wrist circumference asymmetry in elite international boxers were found to be less than 10 percent, and observed non-significant differences in weight classes as well as stances indicate elite amateur international boxers to be less prone to inter-limb asymmetry-related injuries and have favourable conditions for high performance. MHGS_A & WC_A does not depend on boxing stance in elite amateur international boxers. However, additional research is encouraged to investigate other factors that may influence asymmetry in handgrip strength and wrist circumference among boxers and other athletes.

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Conflict of Interest

The authors state that no commercial or financial ties that might be considered a possible conflict of interest existed during the conduct of the study.

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АСИМЕТРІЯ КІНЦІВОК ЗА ПОКАЗНИКАМИ МАКСИМАЛЬНОЇ СИЛИ СТИСКАННЯ РУКИ ТА ОБХВАТУ ЗАП'ЯСТКА В ЕЛІТНИХ БОКСЕРІВ-ЧОЛОВІКІВ МІЖНАРОДНОГО КЛАСУ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 4 рис., 30 джерел.

Метою дослідження було вивчення асиметрії максимальної сили стискання руки між кінцівками та асиметрії обхвату зап'ястка в любительському боксі в трьох вагових категоріях і двох різних стійках.

Матеріали та методи. Вибірка дослідження складалася з 12 (найлегша вага: 4; легка вага: 4; напівлегка вага: 4) елітних міжнародних боксерів-любителів з Індії. Обидві кінцівки тестували на максимальну силу стискання руки та обхват зап'ястка. Для обох тестів асиметрію між кінцівками розраховували за допомогою рівняння асиметрії між кінцівками, валідність якого підтверджена в дослідженні Bishop et al. (2018). Для порівняння асиметрій у трьох різних вагових категоріях використовували однофакторний дисперсійний аналіз, а для порівняння асиметрій у двох різних боксерських стійках використовували t-критерій Стьюдента для незалежних вибірок.

Результати. Середня асиметрія обхвату зап'ястка в різних вагових категоріях становила 2,85±1,97 для найлегшої ваги, 1,29±0,75 для легкої ваги та 2,44±1,23 для напівлегкої ваги, тоді як середня асиметрія максимальної сили стискання руки становила 4,91±3,75 для найлегшої ваги, 7,69±1,89 для легкої ваги та 5,80±2,89 для напівлегкої ваги. Були одержані незначущі відмінності в асиметрії між кінцівками для показників обхвату зап'ястка та максимальної сили стискання руки в трьох різних вагових категоріях і двох різних стійках ($p > 0,05$).

Висновки. Асиметрія максимальної сили стискання руки та асиметрія обхвату зап'ястка в елітних міжнародних боксерів виявилася меншою за 10 відсотків, а спостережувані незначущі відмінності у вагових категоріях, а також у стійках вказують на те, що елітні міжнародні боксери-любителі менше схильні до травм, пов'язаних з асиметрією кінцівок, і мають сприятливі умови для високої результативності.

Ключові слова: найлегша вага, легка вага, напівлегка вага, боксер-ліва, боксер-права, бокс.

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ORIGINAL SCIENTIFIC ARTICLE

SMALL-SIDE GAMES 5V5: IMPROVING AEROBIC ENDURANCE OF YOUTH FOOTBALL PLAYERS

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Abstract

The purpose of this study was to determine the effect of small-sided games 5v5 on increasing aerobic endurance in football players.

Materials and methods. This type of study is a quasi-experiment with a one-group pretest-posttest design. The population of this study was Gama Muda Football School (SSB) players in Pasaman Regency (Indonesia), totaling 60 persons. Sampling was performed using a targeted sampling technique, so the sample was determined to be a maximum of 20 individuals. The players' endurance capacity was determined by measuring their VO_2max capacity. The study used the Yo-Yo Intermittent Recovery Test (Yo-Yo IR Test) as an instrument to obtain research data. Data analysis in this study used the mean difference test (t-test) statistical method. Before testing our hypothesis, we first performed a normality test using the Lilliefors test.

Results. After hypothesis testing, the results obtained show the value of t-count (10.15) > t-table (1.729), indicating that small-sided games 5v5 training effectively improves the aerobic endurance ability of young football players.

Conclusions. The results of this study demonstrate that small-sided games 5v5 training can improve the aerobic endurance of young football players.

Keywords: small-sided games, aerobic endurance, football.

Introduction

Football today is developing very rapidly in terms of technique, physical, and tactics. In recent years the rhythm of football games is faster. Players are able to execute techniques and make good tactical decisions even when running fast (Rago et al., 2017). In order to avoid pressure from opponents, players must have high technical, physical, and skill abilities. In modern football, achieving the best results is determined by three main factors: technique, tactics, and the overall condition of each player (physical, moral, psychological, etc.) (Bolotin & Bakayev, 2017). Physiological, technical, and tactical skills are all important to soccer performance (Hoff et al., 2002; Dio Juliandri & Sukarmin, 2019). Football is a sport that requires intermittent aerobic and anaerobic abilities according to the fundamental characteristics of the game (Evangelos et al., 2012; Reinhardt et al., 2020; Sulaiman et al., 2022). To be a great football player, players must have good performance components (physical, technical, tactical, and psychological). (Menegassi et al., 2018; Ade et al., 2014; Forsman et al., 2016; Anam et al., 2022). Soccer requires its players to train in various physical conditioning components, including strength, speed, jumping, and aerobic capacity (Altavilla et al., 2017; Oone et al., 2012; Joo, 2018).

The game of football has the idea of scoring as many goals as possible and guarding your own goal so you don't concede. Based on this idea, the game of football becomes even more interesting. In the modern football era, football games are played at a fast and high tempo (Jozef et al., 2018; Dost et al., 2016). The movements made by players during the match cover a considerable distance. A player runs 8-12 km during a match. The distance traveled by players in one match ranges from 10-12 km (Taylor, 2016; Emmonds et al., 2016; Najafi et al., 2015). The distance covered by a football player during the game is 10-14 km (Theocharis et al., 2022). In high-level football games, the total distance traveled is between 10-13 km (Michailidis, 2022).

In the distance of 10-14 km, many actions are performed by football players. The activities performed by players while

on the field are 1) walking at 3.1 km, 2) low-speed running at 1.5 km, 3) moderate-run speed at 1.2 km, 4) high-speed running at 0.2 km, 5) sprinting (100% speed) 250 m, 6) running backward 800 m (Taylor, 2016). During the 90 minutes, the players covered a distance of over 11 km, with 3% running and 5% running at high intensity (Rodríguez-Fernández et al., 2019). In a high level of effort, football players perform 150-200 short, powerful actions during a match; for example, sprinting, changing speed and direction, tackling, acceleration, deceleration, and jumping (Ferraz et al., 2017). According to (Afyon et al., 2015) at a higher level, football players are very fast runners for 90 minutes of matches. They frequently run 2500 to 3500 m and average anaerobic thresholds of 1500 to 2500 m and 600 to 1200 m.

The range and activity are quite a lot and to support high performance during the above-mentioned actions requires good physical condition. According to (Bahtra et al., 2022) one of the factors that determine the improvement of sports performance is physical condition. One of the key physical requirements for soccer players to have endurance. The body's ability to carry out activities as long as possible without experiencing fatigue is called endurance (Scheunemann, 2012; Wiguna, 2017). Endurance is the body's capacity to carry out activities for a long time without experiencing fatigue and accompanied by rapid recovery (Sidik et al., 2019; Emral, 2017). Aerobic endurance is the body's ability to take, transport and use oxygen (Hardiansyah et al., 2020; Zarwan et al., 2020).

Football matches that have high mobility and so long, namely 2×45 minutes require good endurance. The problem that we often see in training to improve endurance is boredom of players during the training process. This is because endurance training has a long duration of time. In addition, the activities carried out are very monotonous. Lack of variety in training methods is only in the form of long-distance running to train the physically applied so that training becomes boring and less effective for improving the ability of students (Prakoso & Sugiyanto, 2017). Fatigue contained in physical exercise and training programs that are not yet appropriate is thought to be a trigger for not achieving training goals so the right training method is needed to increase VO_2max capacity (aerobic endurance) (Hostrup & Bangsbo, 2017; Rago et al., 2017). This is sometimes what makes the increase in player endurance slow and even tends to stagnate. If the player's aerobic endurance is not at a good level, it will interfere with the player's performance in the match.

Responding to this problem requires a breakthrough in choosing or finding the right training method. According to (A. U. K. Putra et al., 2016) Many training methods can be used to increase aerobic endurance such as interval training, fartlek, continuous running and SSG. To increase aerobic endurance, several training programs have been carried out, including aerobic exercise and small sided games (SSG) (Los Arcos et al., 2015). Meanwhile, according to (Strudwick, 2016) The football team uses a variety of training methods to improve players' physical conditioning, general training (e.g. continuous, circuits, intervals, repeated sprints) and specific training (e.g. small side games, soccer technique drills, special drill positions with the ball). Many methods can be used to improve the aerobic endurance of football players. Both the general (without the ball) and the specific (with the ball). The choice of method depends on the situation and the needs of the coach.

From the description described above, the small side games method was chosen to improve the aerobic endurance of players. SSG is a drill designed with fewer players and a smaller field size compared to 11vs11 games (Bergkamp et al., 2020). SSG are a form of exercise carried out in the form of playing that adopts the actual game so that players can master technical, tactical, and physical skills simultaneously (A. N. Putra et al., 2022; Setyadi, 2016; Praniata et al., 2019). This type of training is often played with modified games on a reduced field area, using adapted rules and involving fewer players than traditional games (Hammami et al., 2018). Small Side Games are one of the exercises that can be used by coaches to improve endurance and develop technical skills (Moran et al., 2019). Intense training with SSG for 4 weeks can increase endurance performance by 8.2% in soccer players (Paul et al., 2019). Small side games training is effective and efficient to increase the endurance of beginner female futsal players (Wenly et al., 2021).

Although there have been many studies on this model but more on small-side games in general. In this study, researchers modified and improvised with a focus on 5v5 small-sided games. The research results (Gaudino et al., 2014) explain in SSG 5v5 the player's mileage is higher, acceleration and deceleration are large, and the speed distance is very high and maximum. High mileage will indirectly be able to increase aerobic endurance. In addition, modifications were also made to the training variables, namely training intensity, duration, and set. The intensity of the exercise is between 75-85%, and the duration of the exercise is long. Taylor (2016) explains training for aerobic capacity (VO_2max) is most often referred to as basic endurance training. In terms of exercise intensity level, it is recommended to train in intensity zones 1 and 2 (60-80 to 85% of HRmax) and duration between 30-60 minutes. The modification of this form of training is different from previous studies.

Research related to this method is expected to increase the awareness of coaches that the small-side game's method can improve various aspects of football such as physical condition (especially aerobic endurance), technical skills, and tactical abilities. The urgency of this research has an impact on training methods in football so that later coaches use the small-side game's method to improve endurance in football games. The aim of this study was to determine the effect of small side-game 5v5 training on improving aerobic endurance in young football players.

Material and Methods

Study Participants

The study is classified as a type of quasi-experiment with a one-group pre-test post-test design. The subject in this study were SSB Gama Muda Pasaman players with a total of 60 people. Samples were taken by means of purposive sampling in order to obtain a sample of 20 U-15 players. The distribution of selected players is goalkeeper 2 people, defender 8 people, midfielder 6 people, and strikers 4 people.

Study organization

This study modifies small side games to increase aerobic endurance. Modifications made to player count focused

Table 1. Small-side Game Training Program

Training Sections	Pitch Dimension (m)	Intensity	Duration	Set	Recovery
1-3	45 × 35	75%-85%	6 minutes	3	2 minutes/set
4-6	45 × 35	75%-85%	7 minutes	3	2 minutes/set
7-9	45 × 35	75%-85%	9 minutes	3	2 minutes/set
10-12	45 × 35	75%-85%	11 minutes	3	2 minutes/set
13-15	45 × 35	75%-85%	13 minutes	3	2 minutes/set
16-18	45 × 35	75%-85%	15 minutes	3	2 minutes/set

on SSG 5v5. Exercises are carried out for 16 sessions with a frequency of 3 times a week. The training program is structured in such a way as to achieve an increase in the aerobic endurance of players. The size of the field is designed 45×35 m by adjusting the number of players. The training load in this study was adjusted to the training load to increase aerobic endurance. Training intensity 75-85%, set 3 times per session, rest 2 minutes between sets and duration of 20-50 minutes. The duration of the training is increased every week (training program in table 1).

Measurement & Statistical Analysis

The test used in this study is the Yo-Yo Test (Bangsbo & Mohr, 2015). After the data is collected then the data is compiled, then data processing is carried out with the t-test analysis technique with the following calculation steps: 1) Normality test using Liliefors. The normality test aims to determine whether the data obtained are normally distributed or not, 2) To see the difference between the two forms of exercise, the t-test is used.

Results

The study process was conducted for 18 meetings, with details of one session for pre-test, 16 sessions for treatment, and one session for post-test. The results of the study will be described by the objectives of the previously proposed hypothesis. Starting with aerobic endurance data, normality test, and t-test. Table 3 is the frequency distribution of aerobic endurance tests.

The table above explains that in the pre-test the aerobic endurance ability of the dominant players is in the good category (15 people) and there is no very good category. whereas during the post-test there was an increase in aerobic

Table 2. Aerobic Endurance Result

Interval Class	Category	Pre-test		Post-test	
		Fr	Fa	Fr	Fa
>55	Excellent	0	0	0	0
51-55	Very Good	0	0	1	5
45-50	Good	15	75	16	80
38-44	Moderate	5	25	3	15
35-37	Low	0	0	0	0
<35	Poor	0	0	0	0
Total		20	100	20	100

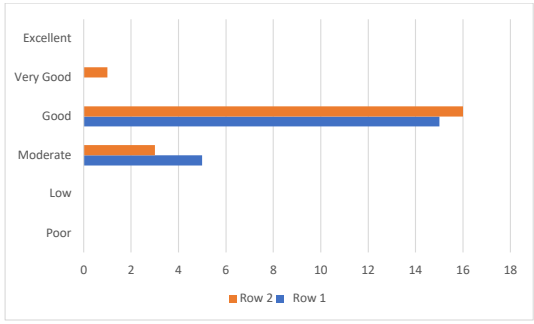

Fig. 1. Histogram of Pre-test and Post-test

endurance ability, where the category became 16 people and the very good category was 1 person. For more clarity, it can be seen in the histogram below:

After the data description, hypothesis testing was carried out to answer the hypothesis that had been proposed. Before hypothesis testing, a normality test was conducted. A summary of the results of the data normality test can be seen in the following table:

Table 3. Normality Test Results

Group	Mean	SD	L0	Lt	Ket
Pre-Test	46.24	2.02	0.074	0.190	Normal
Post-Test	47.52	2.46	0.052	0.190	Normal

Based on the table above, it can be seen that all data are normally distributed, where Lt > L0. So, the next step is to test the data hypothesis. The results of the hypothesis test can be seen in the table below:

Table 4. Hypothesis Test Results

Aerobic Endurance	Mean	SD	t_{count}	α	t_{table}
Pre-test	46.24	2.02	10.15	0.05	1.729
Post-test	47.52	2.46			

Based on the summary of the table above, after hypothesis testing, the results obtained the value of t_{count} (10,15) > t_{tabel} (1,729), indicating that small side games training effectively improves the aerobic endurance ability of football players.

Discussion

Results of this study reveal that training in small side-games can improve endurance in football players. This is consistent with multiple studies and literature stating that small side game training can improve endurance. SSG train-

ing method can improve the aerobic endurance of U-17 football players (Arianto & Setyawan, 2019). SSG can improve the aerobic and anaerobic capacity of football players and train football players more specifically (Evangelos et al., 2012). Small-side games allow the HR response to increase, similar to some short-duration intermittent runs that are effective in increasing player endurance (Dellal et al., 2011; Sannicandro et al., 2016; Sannicandro & Cofano, 2023). In addition, the results of research (Wahyudianto et al., 2020) explained that small sided games type Intermittent training has a significant effect on the aerobic capacity of Satria Muda football players.

Football is a sport that is carried out for a long duration, so good endurance is needed. Player movement is greatly helped if you have good endurance. Excellent endurance will support players to always be consistent and fight in matches, otherwise, without excellent endurance, it will be difficult for players to fight until the end of the match. This situation will be a must for players to improve endurance. One of the efforts that can be made to increase endurance is to carry out continuous and systematic training. The exercises performed must be by the principles of endurance training to build endurance.

The training process that is carried out structured, intensive, and systematic will be able to increase the endurance of football players. One way to see whether or not a person's endurance has improved is by measuring their VO_2max. VO_2max is a level of the body's ability expressed in liters per minute or milliliters/minute/kg body weight (Herlan & Komarudin, 2020). The body's capacity to consume oxygen optimally in activities or exercise is called VO_2max (Emral, 2017; FIFA, n.d.; Poon et al., 2021; Yanti et al., 2022; Candra, 2020). From several theories, it is explained that the VO_2max needs of football players are various. VO_2max of international football players is 55-68 ml/kg/minute (Slimani et al., 2019), and 48-62 ml/kg/min (Wells et al., 2011). Professional 56.5 ml/kg/min; Amateur 55.7 ml/kg/min (Helgerud et al., 2001). The high requirements for VO_2max in a football game mean that the coach must be able to provide the right training methods that can increase endurance.

In football, the exercises that are designed should be more specific to the actual game of football. In training to increase endurance ideally done with ball exercises (Scheunemann, 2012; Hoff et al., 2002). Training to improve the physical abilities of football players should use specific training such as SSG, technique drills, and playing position drills (Strudwick, 2016; Seeger, 2015). Training performed with high intensity in the form of special football games such as SSG can improve aerobic endurance (Ishee & Foster, 2013; Ingebrigtsen et al., 2012). The application of training methods to physical conditions must always be specific to football (Curry, 2019). Training using small side games from a weekly training load can improve physical condition and soccer technical skills (Radziminski et al., 2013).

A player's performance in a match improves whens his endurance increases (Russell et al., 2016; Mier & Alexander, 2011). Endurance training will increase VO_2max and positive enzymatic and metabolic adaptations, which increase resistance to fatigue (Costa et al., 2016). Therefore, the small-side game method can be used to improve the aerobic endurance of football players. This small-side games method sis representative of real football training, only the field is reduced. This means that this exercise can be a picture of a real football game, so this exercise has many advantages. The advantages of this small side games exercise are not only to increase the player's endurance but also to improve basic football technique skills. Then the small side games exercise can also improve the player's tactical understanding and also train the player's mentality.

Conclusions

The results of this study can improve the aerobic endurance of football players, this is evidenced by the value of t_{count} 10.15> t_{tabel} 1.729, thus H0 in this study is accepted. Based on the hypothesis proposed small side games method can increase the aerobic endurance of football players. From these results, it will add to the trainer's reference, especially physical trainers in increasing the aerobic endurance of soccer players

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Conflict of Interest

There is no conflict of interest in this research.

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ІГРИ НЕПОВНИМИ СКЛАДАМИ 5 НА 5: ПІДВИЩЕННЯ АЕРОБНОЇ ВИТРИВАЛОСТІ ЮНИХ ФУТБОЛІСТІВ

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Реферат. Стаття: 8 с., 4 табл., 1 рис., 67 джерел.

Метою цього дослідження було визначення впливу ігор неповними складами 5 на 5 на підвищення аеробної витривалості у футболістів.

Матеріали та методи. Цей тип дослідження є квазіекспериментом за схемою попереднього та підсумкового тестування на одній групі. Генеральною сукупністю в цьому дослідженні були гравці футбольної школи Ґама Муда в регентстві Пасаман (Індонезія), загальною численністю 60 осіб. Відбір вибірки проводили методом цільового відбору, тому розмір вибірки був заданий кількістю максимум 20 осіб. Показник витривалості гравців визначали шляхом вимірювання їхнього показника максимального споживання кисню (VO_2max). Як інструмент для отримання даних дослідження в дослідженні використовували тест Йо-йо з переміжним відпочинком (тест Йо-йо). Для аналізу даних у цьому дослідженні використовували статистичний метод критерію середньої різниці (t-критерій). Перш ніж перевірити нашу гіпотезу, ми спочатку провели тест на нормальність за допомогою критерію Ліллієфорса.

Результати. Після перевірки гіпотези одержані результати показують обчислене значення t-критерію (10,15) > табличне значення t-критерію (1,729), що вказує на те, що тренування з ігор неповними складами 5 на 5 ефективно підвищує аеробну витривалість юних футболістів.

Висновки. Результати цього дослідження демонструють, що тренування з ігор неповними складами 5 на 5 можуть покращувати аеробну витривалість юних футболістів.

Ключові слова: ігри неповним складом, аеробна витривалість, футбол.

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ORIGINAL SCIENTIFIC ARTICLE

BASIC VOLLEYBALL TECHNICAL SKILLS FOR STUDENTS: VALIDITY AND RELIABILITY

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Abstract

Study purpose. The goal of this project is to provide a basic volleyball skill exam for Universitas Muhammadiyah Surakarta students enrolled in the Sports Education study program.

Materials and methods. This work employed experimental techniques. They are testing the reliability and validity of fundamental volleyball skills for students between 18 and 24. For objectivity and validity, personal correlations are employed in data analysis, while reliability coefficients between classes are used in data analysis for reliability. The population and sample consisted of 114 students studying sports education in the first and third semesters, including 64 males and 50 females.

Results. The validity value, r = 0.653, was highly significant. Additionally, the researcher's score with tester 1's assistance is r = 0.759, with tester 2's assistance is r = 0.651, and the correlation coefficient between the results of assistant testers one and two is a high r = 0.686. The objectivity value of the result score for the volleyball skill instrument was r = 0.787 for the researcher and examiner one and r = 0.705 for examiner two. The correlation coefficient between assistant examiners one and two was high at r = 0.706. The motion reliability score for volleyball skills was high (r = 0.652). The volleyball skill reliability score had a very high result score of r = 0.872.

Conclusions. Based on the study findings, it is clear that the accuracy test of fundamental skills is highly effective and efficient and merits being used as a benchmark instrument to assess the skills of volleyball. To improve volleyball playing abilities, further research involving various factors, including social environment, psychosocial factors, and physical condition factors by student characteristics, is necessary. However, caution is required due to the small sample sizes used in this study and the need to consider other variables.

Keywords: the validity, reliability tests, volleyball batteries.

Introduction

The volleyball sport's regulations state that each team can play the ball one to two times before it crosses the net, but three times is the maximum. A one-handed serve that sends the ball over the net initiates plays (Oliinyk et al., 2021). Before the ball touches the ground, leaves the pitch, or is mishandled by a player, it can be played once more (Hu et al., 2022; Muharram et al., 2023; Soytürk, 2019; Yudasmara & Fadhli, 2018). According to the regulations, volleyball games start with a service technique. This method can be accepted by a forearm pass technique (forearm pass) or overhead passing technique (overhead pass), fed by forearm pass or overhead pass techniques, followed by a punch (technic spike), and finally a block (technic block) (Dewanti et al., 2023). According to Nasrulloh, players in this game must jump vertically while spiking and blocking to make contact with the ball from a height of their choosing (Nasrulloh et al., 2021).

Volleyball requires roughly 10-12 years of sportsman coaching to achieve maximum or perfect outcomes. Learning

volleyball critical motion abilities of primary school pupils through effective and efficient game-centered strategies is the conclusion of Samsudin's research (Samsudin et al., 2021). The principles of sports coaching, in Bompa's opinion, start at the multilateral level, the specialization stage, and the pinnacle stage of achievement (Bompa & Buzzichelli, 2019). The emphasis of the multilateral/novice stage, which starts with volleyball at the age of 11–12, is on preparation for introducing numerous sports. The specialization stage, which occurs between the ages of 14 and 15, emphasizes the choice of a specific subject that is actively pursued and has the potential for peak performance, such as volleyball. Athletes play volleyball at the peak of their abilities, typically between the ages of 20 and 25.

How to judge a player's talent during a game and selecting a good volleyball player are two challenges that coaches must overcome (Indrakasih et al., 2022). To plan training for athlete progress, coaches must have the proper guidance and resources (Budiarti et al., 2019). The measuring process is crucial because it enables the trainer to assess the training plan's effectiveness (Juditya et al., 2020). Based on the evaluation findings, numerous initiatives and improvements will be undertaken to enhance the training program's quality (Lima et al., 2021). Additionally, the coach can only analyze volleyball skills using the tools already used for student assessment, not the actual movements. Due to age and talent discrepancies, senior volleyball players cannot be evaluated using student skill assessments.

For coaches, professors, and physical education teachers to use volleyball skill instruments to evaluate and choose future volleyball players, it was essential to determine whether they accurately assessed the abilities and skills of volleyball players aged 18 to 24. The application also aims to assist volleyball coaches, lecturers, and physical education teachers in evaluating players' skills and appropriate moves. Volleyball skill instruments minimize the usage of tools and human resources, and their execution indications are more by the caliber of volleyball skills, such as serve, pass, block, and smash.

Materials and methods

Study participants

The research conducted experimental research to create a product of fundamental volleyball playing abilities for students between 18 and 24. According to Sugiyono's explanation, experimentation is a quantitative research approach used with experiments that meet the criteria of effectiveness, quality, or the same. This is done to ensure the influence of independent variables on dependent variables (results) under controlled circumstances (Sugiyono, 2017).

Study organization

This study used a pre-test and post-test to evaluate the validity and reliability of the fundamental volleyball skills of students between 18 and 23. The fundamental volleyball tactics of serving, forearm pass, overhand Pass, smashing, and blocking are used as test materials. Between January and March 2023, a purposeful sampling technique was used to gather samples with male and female gender characteristics criteria tailored to the requirements of the Universitas Muhammadiyah Surakarta Indonesia, students who were the focus of the current study. 64 males and 50 females were included in the 114 students chosen to participate in the current experiment. Students majoring in sports education at the Universitas Muhammadiyah Surakarta in the first and third semesters made up the population and sample for this study. The accuracy of volleyball sports techniques, including serve, underpass, overpass, smash, and block, is assessed based on the characteristics examined. The data was gathered using assessments that examined the precision of fundamental volleyball techniques: (1) Forearm pass: Students pass to the wall for one minute. The score is determined by the touch of the ball on the predetermined target with the position to make a bottom pass behind the line (a distance of 3 meters from the target wall) with a target height of 2.5 meters and the Scoring according to the touch of the ball in the target area of 1.2 and 3 with a target distance of 30 cm each; (2) Top Pass: For one minute, the students make top passes to the wall. (3) Top and bottom serve: Students perform ten upper serves, scoring based on the ball's fall on a predetermined target. The score is given according to the touch of the ball to the predetermined target with the position to perform a bottom pass behind the line (a distance of 3 meters from the target wall) with a target height of 3.5 meters and a Score according to the touch of the ball in the target area of 1.2 and 3 with a target distance of 30 cm each. The rating is based on the touch of the ball in the target area of 1, 2, 3, 4, and 5 with a size of 2.5 meters with a value of 2; the size of the line with a distance of 5 meters is given a value of 1, and 3 and line sizes with the princess 2.24 meters. The position to serve behind the line (9 meters from the target) has been used to determine the ball's fall in the target area. With an assessment based on the touch of the ball in the target area of 1, 2, 3, and 4 with a size of 3 meters can be a value of 2, the size of the line with a distance of 4.5 meters is given a value of 1, and 3. The size of 4.24 meters, the score is given according to the ball's fall in the target area that has been set with a position to smash behind the attack line (a distance of 3 meters from the target). The chance was presented ten times. The ball's descent to a predetermined target determines the score. The rating is given according to the touch of the ball in the target area of 1, 2, 3, and 4 with the provision that it can be scored four if the ball falls on the target line 2 0.75 meters, and can be three if the ball falls on the target size of 1 me. The position to block behind the attack line (3 meters from the target) has a net height of 2.43 meters, and the princess has a height of 2.24 meters. Each test's implementation and intended results can be summed up as follows;

Overhand Pass

Equipment: Ball, note, and target wall

Implementation steps: (1) Students may attempt two passes before taking the test; (2) Students complete the top pass for one minute; (3) Position for the top fitting is behind the line, three meters from the target wall.

Rating: (1) Assessment based on when the ball touches the target area; (2) if the ball is lost, the first throw to the target is not given a score; (3) Off-target ball touches are

given a value of 0; (4) If the ball touches precisely on the target line, the score obtained is the highest; and (5) The value obtained is the total score of 1 minute of overhand Pass executed.

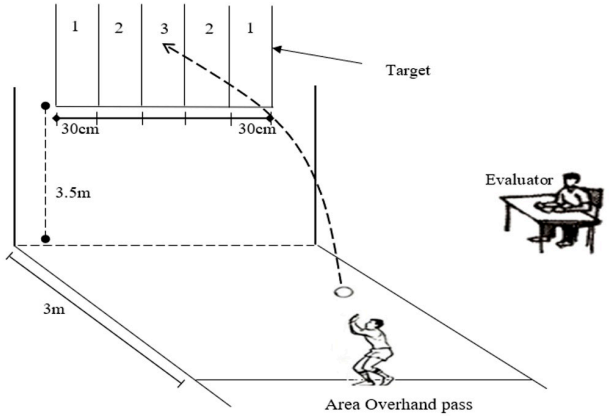

Fig. 1 Overhand Pass

Forearm pass

Equipment: Ball, note, and target wall

Implementation steps: (1) Students may attempt two passes before taking the test; (2) Students complete the top pass for one minute; (3) Position for the top fitting is behind the line, three meters from the target wall.

Rating: (1) Evaluation based on the ball's touch in the target area; (2) If the ball is lost, the first throw to the target is not given credit; (3) Off-target ball touches are given a value of 0; (4) If the ball touches precisely on the target line, the score obtained is the highest; and (5) The value obtained is the total score of one minute of forearm pass executed.

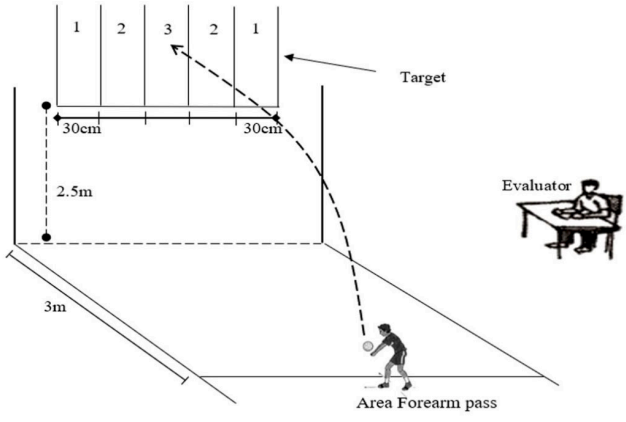

Fig. 2. Forearm pass

Service

Volleyball court, net, ball, and comments are provided

Procedure: (1) Students may perform the smash experiment twice before the test; (2) Students must smash ten times; and (3) Position for free service (as long as the service area is allowed).

Rating: (1) The ball's fall into the target area is taken into account; (2) The ball strikes the net and leaves the field (goes out); and (3) The value achieved is the sum of the scores for the ten serves made

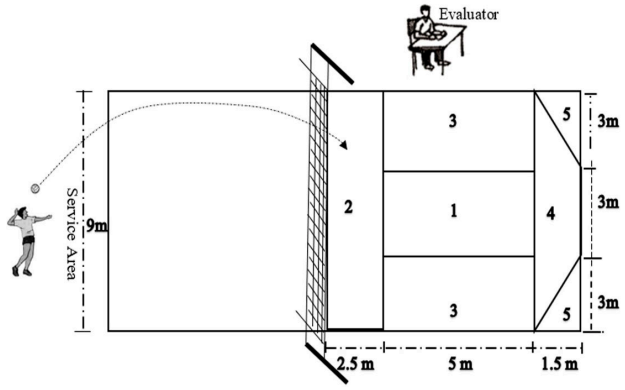

Fig. 3. Service

Block

Volleyball court, net, ball, and comments are provided

Procedure: (1) Students may do block experiments twice before the test; (2) Students block ten times; (3) Position for a free block (along the net).

The ball concerned at the net and out of court is given the number 0; the value gained is the total score of 10 blocks.

Rating: (1) Assessment based on the ball's fall in the target area.

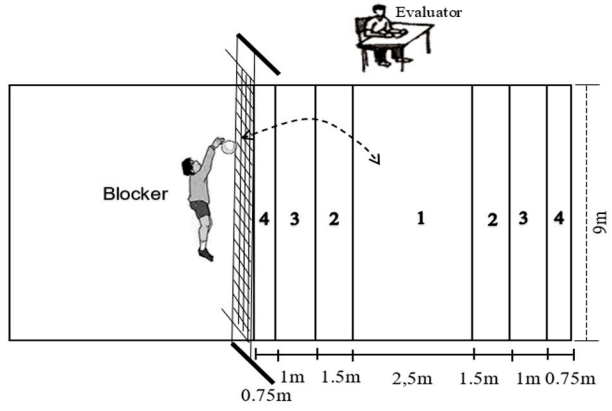

Fig. 4. Block

Smash

Volleyball court, net, ball, and comments are provided

Procedure: (1) Students may perform the smash experiment twice before the test; (2) Students may smash ten times; (3) Students may smash by throwing their balls; and (4) Students should crush in the middle (position 3).

When the ball strikes the net and leaves the field (goes out), it receives a score of 0; when it falls in the target area, it receives a score of 1; and when it lands in the target area, it receives a score of 10.

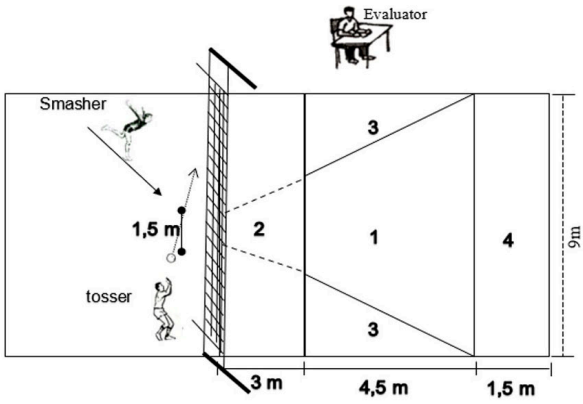

Fig. 5. Smash

Statistical analysis

Validity and reliability tests are used in data analysis methods. The correlation Product-Moment of Karl Pearson is the validity test that is employed. The Scale Reliability Analysis from Alpha Cronbach's Reliability Test (Sugiyono, 2017).

Table 1. Standards for interpreting a test instrument's correlation coefficient

Interval Coefficient	Category
0.80-1.000	Very high
0.60-0.799	High
0.40-0.599	Currently
0.20-0.399	Low
0.00-0.199	Very low

In addition, a paired test (t-test) was used to assess the accuracy of the fundamental volleyball skill exam. SPSS 25 overall data analysis.

Results

Figure 1 displays the outcomes of a descriptive analysis that considers mean scores, standard deviations, and other metrics to highlight the findings of this study on the validity and reliability of students' basic volleyball playing abilities in terms of gender characteristics.

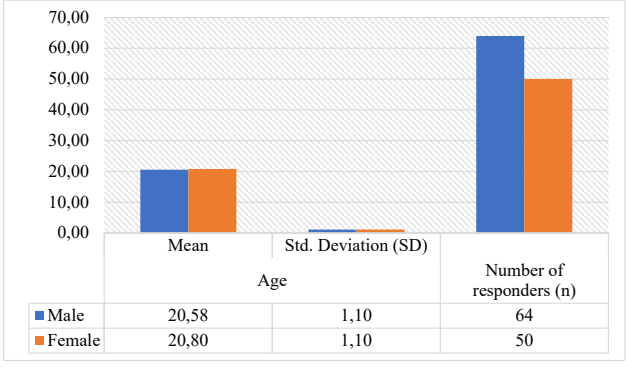

Fig. 6. Characteristics of sex and age

Figure 6 displays the sex characteristics of 64 males and 50 females, together with the mean ages of males and females (20.58 – 20.80 = 0.22). This indicates a 0.22-year difference in age features, while the sample's other characteristics studying in the first and third semesters of the Universitas Muhammadiyah Surakarta sports education study program are nearly the same. Furthermore, the results of the validity and reliability test of basic volleyball skills are in Table 2 while Table 3 interprets the results of the difference in mean and standard deviation (SD) of basic volleyball playing technique skills.

Table 2. Results of the Analysis of Volleyball Skill Instruments' Reliability and Validity

Variable	Male (N = 64)		Female (N = 50)	
	Validity	Reliability	Validity	Reliability
Overhand pass	0.639	0.744	0.638	0.852
Forearm pass	0.603	0.756	0.632	0.847
Service	0.673	0.758	0.686	0.801
Smash	0.666	0.752	0.656	0.832
Block	0.683	0.787	0.644	0.896

Table 3. Results of differences in the mean basic technical skills of playing volleyball

Variable	Gender M/F*	Mean ± SD
Overhand pass	M/F	1.96 ± 2.15
Forearm pass	M/F	1.42 ± 2.44
Service	M/F	1.48 ± 6.05
Smash	M/F	3.48 ± 5.23
Block	M/F	4.20 ± 2.17

*M = male; F = Female

The findings of the investigation of the validity and reliability of the fundamental volleyball skills of students in the high category are presented in Table 2. The acquisition of each test is proof of this: (1) Overhand pass with a validity of 0.639 and a reliability of 0.744 for males and a validity of 0.638 and a reliability of 0.852 for females; (2) Forearm pass with a validity of 0.603 and a reliability of 0.756 for males and a validity of 0.632 and a reliability of 0.847 for females; (3) Service with a validity of 0.673 and a reliability of 0.758 for males and a validity of Thus, it can be inferred that the tool can be used to assess students' proficiency in fundamental volleyball abilities. However, due to the population and sample size being so tiny for the Universitas Muhammadiyah Surakarta's sports education study program, care must be used when employing this instrument.

Additionally, based on variations in mean and standard deviation for the boys and females of each study variable, Table 3's descriptive analysis of research outcomes was performed. The acquisition of each test is proof of this: (1) Overhand pass, with a mean of 1.96 and a reliable standard deviation of 2.03; (2) Forearm pass, with a mean of 1.42 and a reliable standard deviation of 2.50; (3) Service, with a mean of 1.48 and a reliable standard deviation of 4.52; (4) Smash, with

a mean of 3.48 and a reliable standard deviation of 4.97; and (5) Block, with a mean of 4.20 and a reliable standard deviation of 1.80. It follows that there are disparities between the typical fundamental volleyball skills of male and female students. As a result, the fundamental volleyball skills of male and female students differ. This suggests that the coefficient, which was applied to a sample of 114 persons, can be generalized or applied to the population as a whole.

Discussion

When this research was conducted on sports education students at the Universitas Muhammadiyah Surakarta, the volleyball accuracy test instrument was modified from several valid research results and is suitable for testing and measuring basic volleyball skills of students aged 18-24 years. Test the instrument's validity and dependability and the accuracy of the fundamental volleyball methods, including serve, top pass, bottom pass, block, and smash in the high category. Each of the aforementioned basic volleyball skill tests utilizes a value for Cronbach's Alpha of 0.60. Therefore, it is possible to infer that the correlation coefficient with the range of 0.60 to 0.799 has good reliability. The test data results have a strong level of validity and reliability if the correlation coefficient is more significant with r-table N = 114, if the number of samples with a level of 5% = 0.05 is 114, or if the correlation coefficient is more significant than 0.5, or if the correlation coefficient is 0.176, or if primary volleyball skill data can be used to measure volleyball playing skills in students between the ages of 18 and 24. It may be anticipated that volleyball sporting accomplishments will be at their best in line with Furkan's advice that coaches, managers, and officials can exploit Battery Tests to pick players (Furkan, 2019).

According to Aulia's research, the invention of the study's instruments is a valuable tool for determining motion and the outcomes of volleyball abilities such as serve, dig, set, block, and spike (Aulia et al., 2022). Furthermore, according to Aulia's research, this volleyball skill instrument helps measure the skills of volleyball players between the ages of 18 and 25 (Aulia et al., 2022). According to Yudasmara's research findings, the test instrument has a high correlation coefficient value, enabling teachers to utilize it to gauge how well students learn volleyball. Tests are quick and straightforward to perform anywhere. It has also been demonstrated that the instrument can evaluate volleyball-related theoretical or practical concerns (Yudasmara & Fadhli, 2018). According to Komani's research (Komaini et al., 2022), volleyball smash test equipment is designed using sensor technology to quantify a player's capacity to smash the ball. According to Sujarwo's research findings, this instrument helps assess volleyball players' levels of self-assurance when serving and jumping (Arif & Sujarwo, 2021). Contrary to Soytürk's results, aspiring physical education teachers must learn to assess motion and apply alternative measurement techniques in volleyball matches (Soytürk, 2019).

The instrument's validity determines the veracity of any justifications or generalizations drawn from the data acquired (Palao et al., 2015). An instrument is considered valid for measurement (Conti et al., 2016). Analyzing measurements and checking for logical inconsistencies in data findings are requirements for validity studies (Garri et al., 2020). According to Xupeng Wan, a measuring device is considered accurate if it can determine the target's size (Wan & Niu, 2017). Objectivity is one of the elements that should be prioritized when it comes to testing, measurements, and evaluations (Destriana et al., 2021). If an instrument lacks objectivity, it is seen as unreliable. The concept of objectivity is crucial for all measurement tools and methodologies. The skill level of each volleyball player should be assessed equally (Wang et al., 2018).

As a result, instruments must adhere to particular standards, such as being highly valid or measuring what should be measured. Last but not least, the instrument must have high reliability, consistency in measurements, and high objectivity, or findings that are essentially the same regardless of how many people take measurements. The current study investigated the validity, objectivity, and reliability of volleyball skill instruments used to gauge players' skills and abilities between the ages of 18 and 24. The findings of this study show that an instrument developed to score volleyball players between the ages of 18 and 24 in terms of service, forearm pass, overhand Pass, block, and smash abilities, has excellent levels of validity, objectivity, and reliability. This shows that tools for measuring research skills can be used to gauge what needs to be gauged. When coaches, managers, and team officials employ the instrument test to choose players, it is reasonable to anticipate that volleyball sporting accomplishments will be at their peak.

Conclusions

Based on the study's findings, it is clear that the primary skill accuracy test is highly effective and efficient and merits being used as a normative instrument to assess the skills of volleyball players between the ages of 18 and 24. Further research involving various factors, including social environment, psychosocial factors, and physical condition factors under student characteristics, is necessary to improve volleyball playing abilities. However, caution is required due to the small sample sizes used in this study and the need to consider other variables.

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Conflict of interest

The researcher claims that there are no conflicts of interest in this study.

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БАЗОВІ ТЕХНІЧНІ НАВИЧКИ ГРИ У ВОЛЕЙБОЛ ДЛЯ СТУДЕНТІВ: ВАЛІДНІСТЬ І НАДІЙНІСТЬ

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Реферат. Стаття: 7 с., 3 табл., 6 рис., 25 джерел.

Мета дослідження. Метою цієї дослідницької роботи є забезпечення іспиту з базових навичок гри у волейбол для студентів Університету Мухаммадія Суракарта (Індонезія), які записалися на навчальну програму «Спортивне виховання».

Матеріали та методи. У цій роботі використовували експериментальні методи. За їх допомогою перевіряють надійність і валідність основних навичок гри у волейбол для студентів віком від 18 до 24 років. Для аналізу даних показників об'єктивності та валідності використовують індивідуальні кореляції, а для аналізу даних показників надійності використовують коефіцієнти надійності між класами. Генеральна сукупність і вибірка складалися зі 114 студентів, які вивчали спортивне виховання в першому та третьому семестрах, із яких 64 чоловіки та 50 жінок.

Результати. Значення валідності, r = 0,653, було високо значущим. Крім того, оцінка автора дослідження за участю дослідника-асистента 1 становить r = 0,759, за участю дослідника-асистента 2 ця оцінка становить r = 0,651, а коефіцієнт кореляції між результатами дослідників-асистентів один і два є високим на рівні r = 0,686. Значення показника об'єктивності підсумкової оцінки для інструменту оцінки навичок гри у волейбол становило r = 0,787 для автора дослідження та дослідника-асистента один та r = 0,705 для дослідника-асистента два. Коефіцієнт кореляції між дослідниками-асистентами один і два був високим на рівні r = 0,706. Оцінка надійності руху для навичок гри у волейбол була високою (r = 0,652). Оцінка надійності навичок гри у волейбол мала дуже високу підсумкову оцінку r = 0,872.

Висновки. Одержані результати дослідження дають підстави вважати очевидним, що тест на точність основних навичок є високоефективним і практичним і заслуговує на використання як еталонного інструменту оцінки навичок гри у волейбол. Для вдосконалення здібностей до гри у волейбол необхідні подальші дослідження з використанням різних факторів, зокрема факторів соціального середовища, психосоціальних факторів, факторів фізичного стану за характеристиками студентів. При цьому потрібно виявляти обачливість з огляду на малий розмір вибірки, що використовується в цьому дослідженні, і необхідність враховувати інші змінні.

Ключові слова: тести валідності, надійності, набори тестів навичок гри у волейбол.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECTS OF SCHOOL-BASED HANDBALL INTERVENTION ON 12–14-YEAR-OLD CHILDREN'S PHYSICAL FITNESS AND PERFORMANCE

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. School-based physical activity interventions contribute positively to children's general health, wellness, and quality of life. The present study aims to investigate the effect of a 12-week handball training intervention on the ingredients of physical fitness and physical performances of primary school children.

Materials and methods. In this quasi-experimental study, students participating in school-based handball training constitute the intervention group (IG) (n = 15, aged 12.3 ± 0.96) and those who do not participate (n = 17, aged 12.1 ± 0.83) constitute the control group (CG). The linear speed (T30m), change of direction speed (T-test time), lower extremity power (standing long jump (SLJ)), muscular strength and endurance (30-sec curl-ups and push-ups), and estimated maximum oxygen uptake (VO_2max) (YYIRTL-1) were measured at the beginning and end of the handball training session. Independent samples t-test was conducted to test the significant differences in pretests between groups. Paired samples t-test was carried out to analyze statistically significant differences within groups.

Results. The results revealed that, except for SLJ test scores, the pre-tests IG performed statistically significantly higher than the CG. In post-test scores, the IG performed statistically significantly higher than the CG in all test scores. In addition, physical fitness performance levels of the IG significantly changed between pre- and post-test ($p < 0.05$) but not in the control group ($p > 0.05$).

Conclusions. In conclusion, school-based handball intervention can positively affect students' physical fitness and performance characteristics.

Keywords: physical fitness, performance, school-based activity, health benefits, prepuberty.

Introduction

In a study published in The Lancet in July 2012, physical inactivity was announced as a pandemic (Kohl et al., 2012), and it has been known to spread without slowing down despite the global measures taken by governments and non-governmental organizations since then (Sallis, Bauman, & Pratt 1998). In WHO reports (2007), it is stated that there are diseases related to sedentary lifestyles, such as cardio-respiratory system disorders, cancer types and diabetes, and approximately 1.9 million deaths are related to physical inactivity (WHO, 2019). Obesity and lack of physical activity, which first emerged in a WHO report in 2000, draws attention to the fact that sedentary life in children and young people has reached alarming proportions (WHO, 2020).

It is also known that participating in regular physical activity contributes to the shaping of the individual's physical, cognitive, emotional, and social potential and benefits society (Longmuir & Tremblay, 2016). It has been observed that regular physical activity habits, which are known to have positive contributions to the general health, wellness, and quality of life of the individual (Edwards et al., 2017), have socio-economic benefits such as reducing obesity, heart diseases, cancer, and treatment (Edwards et al., 2017; Haskell et al., 2007; Warburton & Bredin, 2017) and reducing health expenditures (Gehris et al., 2018). Because of the previously mentioned benefits, WHO (2010) recommends children to have average of 60 minutes of moderate to vigorous physical activity daily at least three times a week, plus muscle-strengthening activities in addition to these studies.

Admittingly, those who participate in physical activity in their childhood and youth trigger positive psychosocial developments such as mastering fundamental movement skills, overcoming challenging physical activities, enjoying

participation, and increasing motivation to participate in sports. Therefore, the enhancement of participating in regular physical activity gives children the motivation and confidence to maintain regular participation in physical activity throughout their life (Cleland, Dwyer, & Venn, 2012; Rangel, Fellingham, Santana, & Lamas, 2022). In fact, a positive linear association between the duration of physical activity and positive health effects has been established, with longer duration associated with increased physical fitness (Pate 1995; Shephard, 1997).

In this context, school PE courses are a unique opportunity that provides direct access to the children and young population and have facilities, teachers, and curricula to achieve social and educational physical activity and healthy lifestyle objectives (Dobbins et al., 2013; Hills, Dengel, & Lubans, 2015). On the other hand, PE classes are unique places for many children to increase their physical fitness, play sports, and exercise (Sallis, Prochaska, & Taylor, 2000; Biddle & Mutrie, 2007). In addition to these, it is known that physical education lessons have psychosocial benefits such as body self-perception and general well-being (Bailey, 2006). Physical education courses are more likely to affect boys and young children better than girls and adolescents (Lemes et al., 2020). Because it is easier for these groups to reach higher physical activity levels, less sedentary behaviour and psychological satisfaction in the activities and sports events they participate in (Hilland et al., 2011).

Similarly, the positive effects of extracurricular sports activities on physical activity (Blair, Cheng, & Holder, 2001), motor competency (Cattuzzo et al., 2016), physical fitness (Cleland et al., 2005), psychological well-being (Bailey, 2005), and even academic achievement (Broh, 2002) of children and adolescents were investigated in many studies. Studies examining the benefits of children's participation in extracurricular activities were clustered, especially around football (Krustrup et al., 2010), basketball (DiFiori et al., 2018), and volleyball (Sozen, 2012). In the relevant literature, little information exists about the physical performance, physical fitness and motor characteristics of children and young handball players (Mohamed et al., 2009). On the other hand, handball, a competitive team sport, requires skills such as running, jumping, passing, throwing, catching, and dribbling together with the physical contact of the opponent in anaerobic and aerobic loads (Hermassi et al., 2017; Milanese et al., 2011). Stunning results have been found regarding the physical fitness and physical performance of children and young people participating in extra-curricular handball training. Fernandez-Fernandez et al. (2020) found a significant positive difference between the jump, sprint, and agility test scores and throwing velocity of the U-13 and U-15 age groups of handball players participating in extracurricular training all season and those not participating in a regular exercise program. Similarly, Vicente-Rodriguez et al. (2004) revealed that 14-year-old girls (n = 51) participating in handball training had better muscle mass, bone density, strength endurance running test and sprint time than their peers. In the study conducted with 14-year-old male (n = 88) and 13-year-old female (73) handball players, Zapartidis et al. (2009) found that there was a statistically significant difference in ball velocity, SLJ, 30 m sprint and VO_2max performances of males selected and not selected for the national team, and only ball velocity and SLJ performances of females. Training in team sports during puberty plays a significant role both in athletic performance (Garl, Ring, & Bomba, 1988). In this context, handball is attributed as a sport that improves and develops physical activity, physical fitness and performance in physical education classes and extracurricular sports activities for children and youth (Oxyzoglou et al., 2009).

Although studies show the benefits of physical education courses and extracurricular sports activities, studies still estimate the prevalence of inadequate physical activity in children and adolescents to be more than 80% worldwide (Foley et al., 2021; WHO, 2020). Research shows that children spend more time on non-energy sedentary behaviours such as sitting, lying down and watching screens and spend less time being physically active. This has been steadily increasing over the past decade (Guthold et al., 2018). Despite many comprehensive studies among elite young male and female players, little information is available concerning young handball players' physical fitness and performances characteristics in the current literature. However, to the best of our knowledge, studies evaluating the effect of handball training attended by pre-adolescent children are also scarce in the literature.

The purpose of the study was i) to determine the role and importance of participating in extracurricular sports in school-age children's physical fitness and performance development and ii) to examine the 12-week school-based handball intervention on the physical fitness performance in school children. It is hypothesized that handball training would develop all physical fitness and physical performance in young handball players. This study may be important for determining and comparing the physical fitness and performance characteristics of handball players of this age group and for creating the most appropriate training plans for these players. In addition, creating reference data on this age group of handball players is valuable for future comparisons and skill determination. As a result, this study can benefit long-term athletic development to improve juvenile handball players' health, fitness, and performance.

Materials and methods

Participants

A total of 32 schoolchildren, aged 12-14 years from the same school were included in the present study. The subjects were divided into two groups depending on their participation in any school sports. Fifteen were assigned to a handball group (age 12.3 ± 0.96 years) as they have been playing handball for at least 2 years and at least 2 times per week and have competition experience in school sports. The other subjects (n = 17, age 12.1 ± 0.83) who were not involved in extracurricular sports for at least 1 year in addition to their physical education class at school were defined as the control group. All participants and their parent(s) provided written informed consent and were informed about the procedures and potential threats and aids before being involved in the study. Subjects were free to quit the study anytime without providing a reason.

Study Protocol

The pre-and post-test measurements of the participants were evaluated one week before and after the 12-week intervention session. In general, handball training sessions

lasted for 90 minutes, including about 20 min of low intensity warmups including dynamic stretching exercises, 60 min of technical handball exercise drills and 10 minutes of cool-down. The handball training method is shown in Table 1. One familiarization session was held before the tests. The physical fitness performance levels (Running speed (T30m), Change of Direction (CoD speed (T-test time)), jumping ability (standing long jump (SLJ)), muscular strength and endurance (30-sec curl-up and push-up), and estimated maximum oxygen uptake (VO_2max) (Yo-Yo intermittent recovery test level-1 performance (YYIRT-1)) were tested. All physical fitness tests were conducted on an indoor handball court at the same time (16:00-18:00). A normalized warm-up (5-min of sub-maximal running, dynamic stretching activities, jump exercises, and sprints) procedure was followed prior to the testing session. 10-minute breaks were given between all tests (Fernández-Romero, Suárez, & Carral, 2017).

Statistical analysis

Descriptive statistics were calculated and presented as mean and SD for anthropometric and physical fitness variables for the gender and groups. The normality assumption of the data was met by the Skewness & kurtosis and Shapiro-Wilk tests; therefore, parametric tests were used. Independent samples t-test was conducted to test the significant differences in pretests between groups. Paired sample t-test was carried out to analyze statistically significant differences within groups. In Excel, the effect size was calculated by converting partial eta-squared scores to Cohen's d. The ES is classified as small ($0.00 \leq d \leq 0.49$), medium ($0.50 \leq d \leq 0.79$), and large ($d \geq 0.80$). The data were processed using SPSS Statistics 23.0 (IBM, 2015), and the significance level was set at $p < 0.05$.

Results

There were no statistically significant differences in any pretests between the IG and CG ($p > 0.05$). The height of the IG and the body mass and BMI of CG increased over time ($p < 0.05$) (Table 2).

Curl-up test results are given in Table 3. At baseline and post-training, the number maximum of curl-ups was significantly higher in IG than in CG ($p < 0.05$). After the 12-week handball intervention period, IG demonstrated a significant increase in the maximum number of curl-ups by 24% ($p = 0.00$, $d = -3.42$ [large effect]). In contrast, the number of curl-ups significantly decreased by -24% ($p = 0.001$, $d = 0.95$ [large effect]) in the CG.

Table 3 illustrates the changes in push-up test scores both in IG and in CG. The push-up test showed similar results, at baseline and post-training, the maximum number of push-ups was higher in IG than in CG ($p < 0.05$). IG increased the maximum number of push-ups from the pretest score of 18% ($p= 0.011$, $d = -0.76$ [medium effect]). No significant change was evident in CG push-up between a pretest score to a posttest score ($p = 0.641$).

Table 3 summarizes pre and post-test values for SLJ tests. At the baseline, no significant differences were observed between the two groups, whereas SLJ performance was found higher in TG than in CG after the intervention period

Table 1. The content of 12-week handball training intervention

	Warm-up (20 min)	Main Session (60 min)	Cool-down (10 min)
Week 1	Continuous running, lead ups	Ball handling drills, ball control static and dynamic, Basic athletic abilities with a technical component	Stretching
Week 2	Jumping jag series, lead ups	Movement in the field, Dribbling, Basic athletic abilities with a technical component	Stretching
Week 3	Continuous running, lead ups	Holding the ball, dribbling, moving in the court	Stretching
Week 4	Lead ups, calisthenics	Throwing the ball, holding the ball, Dribbling	Stretching
Week 5	Small-sided games, lead ups	Catching the ball, passing the ball dribbling the ball, and throwing the ball	Stretching
Week 6	Lead ups, calisthenics	Catching the ball, passing the ball dribbling the ball, and throwing the ball in different directions and against opponent	Stretching
Week 7	Jumping jag, small-sided games	Shot on goal, passing, catching, and throwing, Basic athletic abilities with a technical component	Stretching
Week 8	Lead ups, Continuous running	Shot on goal, passing, catching, and throwing, Basic athletic abilities with a technical component team offensive and defensive skill	Stretching
Week 9	Small-sided games, calisthenics	Attacking the opponent, shooting, Basic athletic abilities with a technical component, team offensive and defensive skills	Stretching
Week 10	Track running, calisthenics	Attacking the opponent, shooting, Basic athletic abilities with a technical component, team offensive and defensive skills	Stretching
Week 11	lead ups, jumping jag	Basic athletic abilities with a technical component, passing catching shooting and blocking, scrimmage game	Stretching
Week 12	Continuous running, Small sided games	Basic athletic abilities with a technical component, passing catching shooting and blocking, scrimmage game	Stretching

Table 2. Subjects' characteristics

	Intervention (n = 15)		Control (n = 17)	
	Pre	Post	Pre	Post
Height (m)	1.55 ± 0.09	1.55 ± 0.08*	1.54 ± 0.08	1.54 ± 0.08
Body mass (kg)	46.90 ± 7.38	46.50 ± 6.61	48.00 ± 10.6	50.10 ± 10*
BMI (kg/m^2)	19.30 ± 2.14	19.20 ± 2.33	20.10 ± 3.22	21.00 ± 2.99*

BMI: Body Mass Index; *p < 0.05; * Significant difference from pre-training

Table 3. Physical fitness performance before and after the 12-week intervention program

Group				Paired t test		
	Pre	Post	Δ%	p value	Cohens d	Magnitude
Measures	M±SD	M±SD				
IG (n = 15)						
Curl-up	17.90 ± 4.07*	23.50 ± 5.11*	24	0.00	-3.42	Large
Push-up	12.50 ± 3.16*	17.90 ± 6.67*	18	0.01	-0.76	Medium
SLJ	136.90 ± 4.99	147.30 ± 14.5*	6	0.01	-0.80	Large
T-test	12.60 ± 1.06*	10.30 ± 0.97*	-22	0.00	3.64	Large
T30m	6.15 ± 0.64*	5.59 ± 0.51*	-8	0.00	1.66	Large
VO_2max	28.30 ± 3.85*	34.80 ± 3.24*	19	0.00	-4.02	Large
CG (n = 17)						
Curl-up	10.10 ± 2.47	8.35 ± 2.12*	-24	0.00	0.95	Large
Push-up	6.47 ± 5.25	6.88 ± 4.82	6	0.64	-0.12	-
SLJ (cm)	127.60 ± 11.6	128.10 ± 10.5	0	0.66	-0.11	-
T-test (s)	14.90 ± 1.28	14.70 ± 1.33	-1	0.26	0.29	-
T30m (s)	7.10 ± 0.74	7.30 ± 0.87	-2	0.51	0.16	-
VO_2max	24.50 ± 3.2	22.50 ± 2.74*	-9	0.00	1.05	Large

(p < 0.05). The handball training followed by the IG had a beneficial impact on SLJ performance because jumping height after rebound increased by 6% (p = 0.008, d = -0.80 [large effect]). The CG exhibited no significant changes in SLJ performance (p > 0.05).

Pre and posttest for training and control groups were presented in Table 3. In both baseline and post-training, the IG had a higher agility test time than the CG (p < 0.05). A significant decrease of -22% (p= 0.00, d = 3.64 [large effect]) in the T-test score, which shows the enhancement in performance, was observed for the IG (12.6±1.06 to 10.3±0.97 seconds). However, there was no significant change observed in the control groups (p = 0.255).

At baseline and post-intervention, IG was significantly faster than the CG in the T30m test (p < 0.05) (Table 3). The analysis indicated that only the training group has a significant main effect over the 12-week intervention period (Δ% = -8%, p = 0.00, d = 1.66 [large effect], 6.15±0.64 to 5.59±0.51 seconds). In contrast, it was found that no significant difference between the pre-to post-test for the CG (p < 0.05).

Performance on the YYIRT-1 run significantly differed between the two groups (Table 3). The IG had a higher estimated VO_2max performance than CG at the baseline and post-intervention tests (p< 0.05). The estimated VO_2max performance showed the greatest improvement following the handball training group with an increase of 19% (p = 0.00, d = -4.02 [large effect]). On the other hand, a significant negative difference was observed in the estimated VO_2max values of the CG (Δ% = -9%, p < 0.001, d = 1.05 [large effect]) from pre to post-test.

Discussion

This study shows that 12-week school-based handball intervention is associated with higher physical fitness in prepubescent children. The findings of this present study are as follows: (i) Baseline data indicated that students who participated in school-based handball training, apart from their SLJ performance, achieved higher scores in maximum curl-ups, push-ups, and VO_2max, compared to their age-matched CG; (ii) as expected, IG improved running speed, agility, muscular strength and endurance, as well as the estimated VO_2max performance compared to CG; (iii) There was a decrease in the maximum number of curl-ups and VO_2max mean values in the CG. However, no significant changes were found in the maximum number of push-ups, SLJ, speed, and agility time.

Cardiovascular fitness level (Ruiz et al., 2016) and muscular strength (Castro-Piñero et al., 2010) are often

defined to as part of health-related fitness test batteries and usually have relationship with disease prevention and health (Howley, 2001). In the present study, the IG displayed a superior performance in terms of maximum curl-up and push-up numbers, as well as VO_2max scores, compared to the CG ($p < 0.05$). It has been previously observed that students enrolled in physical activity programmes exhibit improved cardiovascular fitness (Ahmed et al., 2017; Larsen et al., 2021; Madsen et al., 2022) in comparison to non-active individuals, as well as demonstrating a higher maximum capacity for completing curl-ups and push-ups (Ahmed et al., 2017). Moreover, previous studies have demonstrated that children who partake in physical activity interventions within the school environment exhibit greater jumping abilities compared to their non-active counterparts (Fernández-Romero et al., 2017; Marques & González-Badillo, 2006). The present baseline outcomes of the current study contradict prior research that implied greater achievement in SLJ among the active group. Gorostiaga et al., (2006), stated that handball trainings could enhance upper extremity strength compared to lower extremity. These low scores can be attributed to the programme's emphasis on technical and coordination training before the study, which may have resulted in insufficient training time for other areas. Ziv and Lidor (2009), suggested that explosive power training should be implemented in handball for athletic performance. The lower score in SLJ is correlated with poor muscular strength (Castro-Piñero et al., 2010) thus, coaches should give more attention to leg strength training in the training season program.

Both speed and agility were found higher for IG compared to the CG. Previous research suggests that engaging in sports during prepubescence can have a positive impact on the speed and agility performance of children (Gracia-Marco et al., 2021; Masanovic et al. 2020). In a study, boys who participated in soccer training in the prepubertal period exhibited better running speed (30-m sprint) and agility (T-test) performance than those who only participated in the physical education program (Ateş, 2018). Although speed and agility are considered performance-related physical fitness parameters (Howley, 2001), in particular, evaluating these abilities contributes to enhance health, especially bone health, (Ortega et al., 2008) and motor skill development in young individuals (Schmidt et al., 2018; Palou et al. 2019).

When analysing the effects of 12-week of handball intervention sessions, the students in the IG made greater gains in selected health-related fitness measures after 12-week of school-based handball intervention than the CG. The maximum number of curl-up and push-ups increased significantly after the intervention session in IG. These findings support previous studies' results, that school-based handball intervention enhances muscular strength and endurance in prepubertal children (Lemes et al., 2023). In this study Lemes et al. (2023) reported that girls, aged 10-16 years, who attended handball training programs at school (2 hours weekly for 38 weeks) were found to have greater the maximum number of sit-ups compared to children who attended only physical education classes. In addition, our results showed that the maximum number of curl-ups significantly decreased (-24%) in CG. It can be said, improvement in weight and BMI values in CG during the study could have affected the maximum number of curl-ups. Because both abdominal and upper body strength was inversely associated with overweight in cross-sectional analyses (Kim et al., 2005).

A significant increase in VO_2max mean values (19%) in IG and a significant decrease in VO_2max mean values (-9%) in CG demonstrated the benefits of a school-based handball training program to improve specific cardiovascular fitness level of prepubescent children. These findings agree with previous studies, which suggest that implementing handball activities in school settings can enhance prepubertal children's cardiovascular capacity (Ion, 2015; Lemes et al., 2023). Furthermore, the decrease in VO_2max mean values in CG can be explained by the increase in weight and BMI values during the study. These results were confirmed by previous studies (Kim et al., 2005).

The school-based handball intervention session was also successful in significantly increasing the jump distance measured in the SLJ test (6%). Previous studies (Ion, 2015) investigating handball training in children have reported the same tendency of greater improvement in jump tests involving SLJ. In this study, it is possible that the characteristics of the handball exercise, including throwing with long jumps, could be explained by the increased distance jumped after the handball intervention.

The current study, improvement in selected performance-related physical fitness parameters (agility (T-Test) and sprint (T30m) test time) was observed after 12-week of handball intervention sessions in IG. In parallel with our results, Oxyzoglou et al. (2009) reported that handball training programs (3 times/week for 60min (50 training sessions)) have been associated with increased 30-m sprint and agility time performance in preadolescent children. In addition, Ion (2015), reported a significant increase in 50 m running time after start practicing handball games in children. It can be said that the performance improvement in speed (-8%) and agility (-22%) time performance in the IG demonstrated the positive effects of handball training to improve the explosive skills of prepubescent children. This reflects the characteristics of the training programs of handball, which emphasize specific explosive actions such as fents and directional change, attacking/attacking the opponent, defending, and direct and lateral movement in the field (running, stops, turns). In addition, sprint and CoD exercises with and without a ball (Marques & González-Badillo, 2006), used throughout 12-week of school-based handball training may have also developed running speed performance. Thus, sport-specific speed and agility exercises are recommended for handball conditioning programs (Ziv & Lidor, 2009).

Conclusion

The results of this study corroborate previous findings which suggest that engagement in school-based physical activity programme is positively associated with enhanced levels of physical fitness, in comparison to students who do not partake in any physical activities. The marked improvement in the maximal number of curl-ups and push-ups, speed and agility time, VO_2max mean values, and SLJ distance indicates the effectiveness of a school-based handball intervention as a method for enhancing the both health related and performance-related physical fitness of

preadolescent children. The role of these improvements in supporting a healthy life in both the present and the future is crucial. In this end, it has been suggested that school-based handball activities are valuable tools for promoting the holistic development of children.

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ВПЛИВ УТРУЧАННЯ У ФОРМІ ШКІЛЬНИХ ТРЕНУВАНЬ ІЗ ГАНДБОЛУ НА ФІЗИЧНУ ПІДГОТОВЛЕНІСТЬ І РЕЗУЛЬТАТИВНІСТЬ ДІТЕЙ ВІКОМ 12–14 РОКІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 3 табл., 59 джерел.

Історія питання. Утручання у формі шкільних заходів із фізичної активності позитивно впливають на загальний стан здоров'я, гарне самопочуття та якість життя дітей. Метою цього дослідження є вивчення впливу 12-тижневого тренування з гандболу на компоненти фізичної підготовленості та фізичних показників дітей молодшого шкільного віку.

Матеріали та методи. У цьому квазіекспериментальному дослідженні учні, які беруть участь у шкільних тренуваннях із гандболу, складають групу втручання (ГВ) (n = 15, віком 12,3 ± 0,96 року), а ті, хто не бере участі (n = 17, віком 12,1 ± 0,83 року), складають групу порівняння. Лінійну швидкість (тест лінійної швидкості на дистанції 30 м – T30m), швидкість зміни напрямку (час виконання Т-тесту на спритність, який передбачає біг із маневруванням Т-подібною траєкторією), силу нижніх кінцівок (стрибки в довжину з місця (СДМ)), м'язову силу та витривалість (підйоми корпусу та віджимання протягом 30 секунд) та розрахунковий максимум споживання кисню (VO_2max) (тест Йо-йо з переміжним відпочинком (рівень 1) – YYIRTL-1) вимірювали на початку та в кінці тренування з гандболу. Для перевірки статистично значущих відмінностей у попередніх тестах між групами використовували t-критерій Стьюдента для незалежних вибірок. Для аналізу статистично значущих відмінностей у групах використовували t-критерій Стьюдента для парних вибірок.

Результати. Результати виявили, що, за винятком оцінок у тесті СДМ, показники попереднього тестування у ГВ були статистично значуще вищими, ніж у КГ. В оцінках підсумкового тестування показники у ГВ були статистично значуще вищими, ніж у КГ, в усіх тестових оцінках. Крім того, рівні показників фізичної підготовленості у ГВ статистично значуще змінилися за період між попереднім і підсумковим тестуванням ($p < 0,05$), а в контрольній групі – ні ($p > 0,05$).

Висновки. Підсумовуючи, утручання у формі шкільних занять із гандболу може позитивно впливати на характеристики фізичної підготовленості та результативності учнів.

Ключові слова: фізична підготовленість, результативність, шкільний захід, користь для здоров'я, період, що передує статевій зрілості.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTS OF FATIGUE INDUCED BY THE RUNNING-BASED ANAEROBIC SPRINT TEST ON THE PERFORMANCE IN EXECUTION TIME AND DECISION-MAKING IN TECHNICAL-TACTICAL ACTIONS IN SOCCER (PASSING AND DRIVING) IN A LABORATORY SITUATION

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Abstract

Study purpose. The running-based anaerobic sprint test (RAST) has been developed to assess anaerobic power and fatigue levels using a repeated sprint protocol. The aim of this research was to study the effect of fatigue induced by RAST on performance in execution time (ET) and decision-making (DMA) in technical-tactical actions in soccer in a laboratory situation.

Materials and methods. Quasi-experimental, longitudinal, pretest-posttest comparative study. Two groups of soccer players (n = 34) divided into a control group (n = 18) and an experimental group (n = 16) were evaluated twice at two different times.

Results. Taking into account the p-value, effect size and statistical power, there are differences before and after RAST in the variables Total Index (TI) and ET, and not in DMA. On the other hand, the control group remained stable at both times.

Conclusions. After the intervention, the experimental group showed a decrease in the figures of the ET and TI variables, but not in the DMA variable, in other words, the decisional time and motor time, components of the ET variable and essential at the time of rapid decision-making, increased in the posttest.

Keywords: fatigue, performance, cognition, Stroop task, soccer.

Introduction

Soccer is a team sport that involves physical (sprints, sprints, sprints, changes of direction, jumps) and technical demands (dribbling, passing, shooting) (Nédelec et al., 2012), in addition, it has a high cognitive demand, because cognitive flexibility is intertwined with decision making to change the direction of movement and the type of action required in each situation. Thus, technical skills depend on cognitive skills to obtain the results (Herman et al., 2015; Zentgraf et al., 2017).

Soccer players must quickly assess information about the ball with respect to their teammates, opponents, and location on the field before considering the appropriate action based on their skills, the coach's instructions, and the current match situation (Williams, 2000). When shooting, passing or dribbling, the player needs exceptional visual perception to register approaching opponents and teammates, as well as quick decision-making and inhibitory control to change the motor plan if a defender impedes the current execution (Wilke & Vogel, 2020).

Therefore, it is necessary to consider that the visual reaction time can be divided into two moments: the first is the period between the appearance of the stimulus and the onset of saccades, which has a duration between 180 and 300 ms. (Gila et al, 2009), and the second moment corresponds to the duration of the nerve impulse from the sensory organ to the motor plate, and ranges between 180 and 200 ms. (Bonnet, 1994). Likewise, the decisional time is another component of

the reaction time, and this refers to the time it takes to make decisions (DMA) due to the characteristics of the stimulus, i.e., the greater the complexity of the stimulus, the longer the duration of the decisional time and therefore of the ET (Calle-Jaramillo et al., 2023).

In this sense, fatigue is a multifactorial phenomenon that involves central structures (proximal to the neuromuscular junction) and peripheral structures (distal to the neuromuscular junction) (Aquino et al., 2022). Similarly, fatigue can be mental when there are sustained and prolonged periods of cognitive activity (Marcora et al., 2009) that compromises executive function (e.g., decision-making, cognitive flexibility, working memory) and the ability to maintain attention on a task (Lorist et al., 2005). Thus, both central and peripheral fatigue, and mental fatigue, are related to the neuromuscular and cognitive structures underlying the different moments that make up visual reaction time, thus affecting technical and tactical skills and consequently the performance of soccer players (Huijgen et al., 2015; Romeas et al., 2016).

Short high intensity efforts performed in sports such as soccer or basketball could fatigue the Central Nervous System (CNS) (Clemente Suárez et al., 2011). To demonstrate this, Flicker Fusion Thresholds (UFF) (method used to measure CNS fatigue and cognitive function) were used after a Running Repeat Ability (RSA) test (Ghozlan & Widlöcher, 1993), observing CNS fatigue due to decreased UFF (Simonson & Brozek, 1952). For this reason, fatigue is not only due to muscular factors but also to factors affecting the CNS (Clemente Suárez et al., 2011).

Several studies demonstrated the effects of fatigue induced by combined cognitive and motor tasks (Repeated Interval Loughborough Soccer Passing Test, 90-minute training matches) (Bian et al., 2022) and by isolated cognitive (color stroop task) (Gantois et al., 2020; Smith et al., 2016) or motor tasks (high-intensity physical loads) (Frýbort et al., 2016) on the technical-tactical performance of the soccer player.

Consequently, the aim of this research was to study the effect of RAST-induced fatigue on ET and DMA performance in technical-tactical actions in soccer in laboratory situation, using the Stroop Task Football Test (STFT) (Calle-Jaramillo et al., 2023) at two moments: without fatigue (pretest) and with RAST-induced fatigue (postest) (Nara et al., 2023). We hypothesize that there will be differences in TI between fatigued and non-fatigued soccer players.

Materials and methods

Participants

Thirty-four male soccer players of the U-20 category, belonging to the youth divisions of Envigado Fútbol Club, a professional soccer club, participated in the study. The characteristics of the sample (mean ± SD) were as follows: age (18.31 ± 1.07 years), height (178.56 ± 4.35 cm), weight (68.58 ± 4.47 kg) and time spent at the club (8.63 ± 0.98 years). To determine the sample size, the "A priori: computer requires sample size", t tests (difference between two independent means: two groups) function in G-power 3.1.9.7 program was used based on the following parameters: effect size 0.999; probability $\alpha<0.05$; statistical power ($1-\beta=0.80$) and two groups; the calculation established a minimum sample of 34 players.

Design

This was a quasi-experimental study with a pretest-postest non-equivalent and longitudinal comparative control group (Manterola & Otzen, 2015; Baños et al., 2019). A group of soccer players were assessed twice using the Stroop Task Football Test (STFT) (Calle-Jaramillo et al, 2023) in two different conditions. First, an assessment was performed without fatigue (pre-test) and subsequently with RAST-induced fatigue (post-test) (Nara et al., 2023).

Variables

Independent variables: RAST; dependent variables: TI, DMA, ET.

The variable ET is expressed in decimal minutes and is calculated by dividing the seconds the test lasts by 60 seconds. For example, 1 minute and 10 seconds equals 70 seconds, so 70 seconds equals 1.16 minutes. If the test lasted 50 seconds, then 50 seconds equals 0.83 minutes.

Procedure

The Stroop Task Football Test (STFT) evaluates decision-making (DMA) and execution time (ET) through technical-tactical actions (passing and driving) to study cognitive motor performance in soccer through the Total Index (TI) (Calle-Jaramillo et al., 2023).

In addition, the run-based anaerobic sprint test (RAST) has been developed to assess anaerobic power through a repeated sprint protocol with variables analogous to the Wingate Test (WAnT). The RAST consists of six 35-meter sprints separated by 10 seconds of recovery. The characteristic distances and recovery time of the RAST protocol suggest that it could be an ideal test for assessing RSA (ability to repeat sprints) in team sport players competing on the field (Nara et al., 2023).

Given that RSA has been hypothesized to be an indicator of physical performance in a soccer match (Rampinin et al., 2006) and a necessary component of physical fitness in team sports, standardized assessment is becoming increasingly important (Spencer et al., 2005). An effective RSA test must reflect sport-specific movement patterns observed during competition (Keir et al., 2013).

For this reason, the validity of recently developed RSA testing protocols has been assessed by comparisons with the popular Wingate test (WanT). The WAnT has previously been used as a test by which RSA protocols are validated (Zagatto et al., 2009).

There were seven days of difference between both tests: STFT without RAST (pretest) and STFT with RAST (postest). Both tests were performed in competition season at the same time of the day, 48 hours after training. Prior to the execution of the tests, participants performed a warm-up based on typical soccer actions and similar to the STFT to test their understanding of the STFT.

Environmental characteristics: The test was performed between 8:00 and 10:00 a.m. at a temperature between 18

and 25 degrees Celsius on soccer fields with synthetic turf. An official FIFA Golty® ball was used.

Inclusion criteria: Signed informed consent, completion of both tests (pretest and postest) and having attended all training sessions of the immediately preceding weekly cycle.

Exclusion criteria: Having consumed caffeine or any other stimulant substance on that day, diagnosis of any psychiatric or neurological problem, and physical injury or discomfort at the time of the test.

46 players participated in the study (see Figure 1), seven players did not meet the inclusion criteria, and 5 players were excluded for having presented injury or physical discomfort at the time of the test. Finally, in the analysis of the information, the records of 34 players were taken into account.

Ethical considerations: We refer to the ethical provisions of the Declaration of Helsinki.

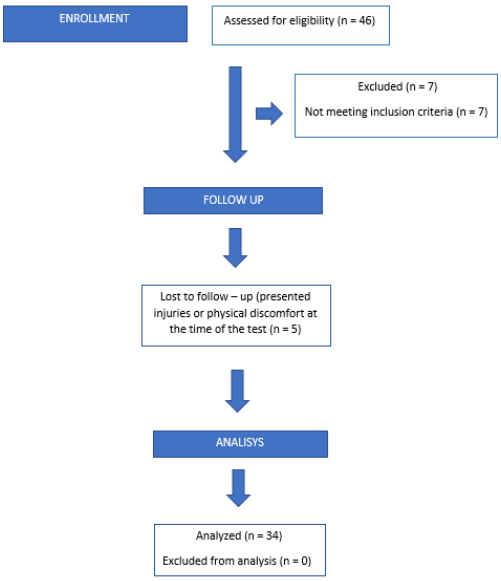
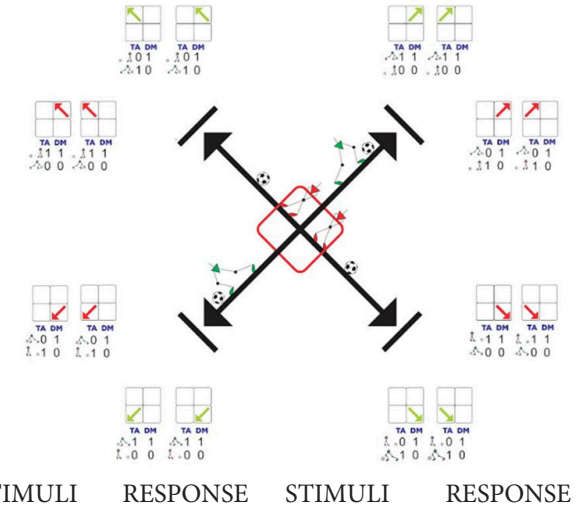


Fig. 1. Flowchart: inclusion/exclusion criteria to obtain the sample

Test design to assess the groups

The Stroop Task Football Test (STFT) was used to assess DMA, ET and TI with and without RAST-induced fatigue. The test consists of 32 stimuli delivered by a screen (16 stimuli with red arrows and 16 stimuli with green arrows), where red arrows correspond to passing and green arrows correspond to driving. The arrows may or may not match the quadrant (congruent trials vs. incongruent trials). The participant must respond to the direction of the arrow and not to the location, and must respond to the color of the arrow. This allows two responses (type of action and direction of movement) to be scored on each stimulus, for 64 possible hits. The number of correct answers is divided by the time the test lasts (ET), and the result is TI, a value that indicates the cognitive motor performance of the soccer player in the test (Calle-Jaramillo et al., 2023) (see Figure 2).

Performance of the STFT at the pretest and at the RAST-induced postest. After completion of the RAST, participants had a 15-second pause before starting the STFT (see Figure 3). The control group only performed the RAST at two different times.



Design to evaluate the group before RAST-induced fatigue (pretest) and after RAST-induced fatigue (postest)

Fig. 2. Scoring of the Stroop Task Soccer Test (STFT). Evaluation of trials with their respective stimuli and responses

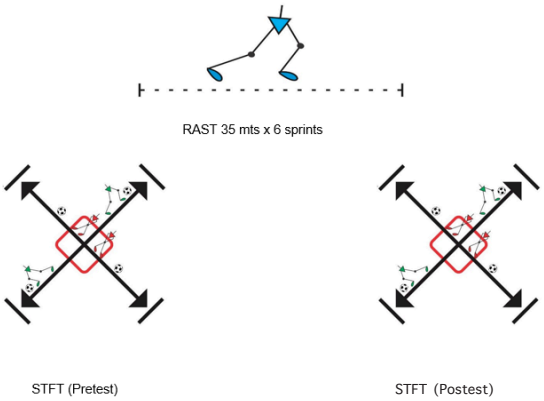


Fig. 3. Stroop Task Football Test (STFT) before (pretest) and after (postest) the Running Anaerobic Sprint Test (RAST)

Finally, the STFT data (Calle-Jaramillo et al., 2023) (see figure 3) were transcribed in IBM SPSS Statistical Software version 23®. Likewise, the duration of the sprints (RAST) was recorded using a manual stopwatch (CASIO - HS - 3V - 1RDT, Dimensions H x W x D: 62.00mm, 63.50mm, and 17.00mm, Weight: 40.30g).

Results

To begin the description of the results, we proceeded to evaluate the normality of the variables (DMA, ET and TI) by comparing the data of the subjects intergroup (control group

vs experimental group) and intragroup (pretest - postest) from the Shapiro - Wilk test (see table 1). The results indicated that in the pretest the DMA and ET variables of the control group and the experimental group presented non-normal distribution ($p<0.05$), but in the case of the TI variable, both groups presented normal distribution ($p>0.05$). On the other hand, in the post-test, the DMA variable in both the control and experimental groups and the ET variable in the control group presented non-normal distribution ($p<0.05$), however, the TE variables in the experimental group and the TI variable in the control and experimental groups presented normal distribution ($p>0.05$) (see Table 1).

Table 1. Normality of variables

Group		Shapiro-Wilk		
		Statistic	gl	p
Pretest DMA	Control	0.861	18	0.013
	Experimental	0.815	16	0.004
Pretest ET	Control	0.889	18	0.037
	Experimental	0.886	16	0.049
Pretest TI	Control	0.943	18	0.327
	Experimental	0.895	16	0.068
Postest DMA	Control	0.850	18	0.008
	Experimental	0.791	16	0.002
Postest ET	Control	0.894	18	0.046
	Experimental	0.973	16	0.882
Postest TI	Control	0.946	18	0.372
	Experimental	0.968	16	0.810

Comparing each of the groups before the intervention process, statistically significant differences were found between the experimental group and the control group in the DMA and ET variables; both in favor of the experimental group. In the case of the DMA variable, the difference had a significance lower than 0.05 and a large effect size (d=0.80), however, its statistical power (1-β=0.60) was below the reference value (0.80), i.e., there may be a type 2 error in 40% because there was a rejection of the null hypothesis in this contrast (see Table 2).

In the case of the ET variable, the experimental group had a median decimal time of 0.95 (RI=0.11) much lower with respect to the control group (Md=1.20; IR=0.16), a difference that was statistically significant with a very large effect size as was its statistical power ($p<0.01$; d=2.16; 1-β=0.99); which indicates that in the two variables described above it is not possible to assume the groups as homogeneous, especially with regard to the ET variable, in other words, the experimental group was superior to the control group (see Table 2).

In relation to the TI variable, the comparison between the two groups was made with the Student's t-test, where, in addition to normality, compliance with the homoscedasticity assumption was verified (f=0.001; p=0.981), assuming equality between variances. The comparison showed that the experimental group (M=63.80; SD=8.60) presented a higher rating than the control group (M=46.50; SD=8.14), a difference that was statistically significant, with a very large effect size and a probability of committing a type 2 error almost null ($p<0.01$; d=2.13; 1-β=0.99); therefore, in the TI variable, the groups were also non-equivalent before the intervention process (see Table 3).

Subsequently, the two groups were compared after the application of the independent variable (RAST-induced fatigue), where the behavior of the dependent variable DMA was similar and without statistically significant differences ($P>0.05$). In the case of the ET variable, the statistical difference between the experimental group (Md=1.10; IR=0.17) and the control (Md=1.28; IR=0.19) was significant, with large effect size as well as statistical power ($P<0.01$; d=1.27; 1-β=0.94); therefore, in the DMA variable, the experimental group in the postest ended up being equivalent to the control group. However, the ET variable evaluated after fatigue had a better performance in the experimental group, i.e., it was still better than the control group (see Table 4).

Regarding the TI variable, the experimental group presented a decrease in its score (M=54.37; SD=8.96), however, this value was higher than that of the control group (M=46.63; SD=6.09), a difference that was statistically significant ($p<0.01$); d=1.07; 1-β=0.85); therefore, the experimental group, as before the intervention, was better than the control group (see Table 5).

In the comparison between pretest and postest of the three dependent variables, there were no statistically significant differences (see Table 6 and 7).

Comparing the results between the pretest and postest of the experimental group, that is, after the fatigue induced by the RAST, in the case of the DMA variable, no statistically

Table 2. Comparison between the experimental and control groups in the pretest of the DMA and ET variables

Variable	Group	Md	IR	UMW	p	d	1-β
DMA	Experimental (n=16)	62.00	5.00	74.00	0.015	0.80	0.60
	Control (n=18)	58.00	8.00				
ET	Experimental (n=16)	0.95	0.11	22.00	0.001	2.14	0.99
	Control (n=18)	1.20	0.16				

Table 3. Comparison between the experimental and control groups in the pretest of the TI variable

Variable	Group	M	SD	t	p	Mean differences	IC_{95}		d	1-β
TI	Experimental (n=16)	63.80	8.60	-6.023	0.001	-17.305	-23.157	-11.453	2.13	0.99
	Control (n=18)	46.50	8.14							

gl=32

Table 4. Comparison between the experimental and control groups in the post-test of the DMA and ET variables

Variable	Group	Md	IR	UMW	p	d	1-β
DMA	Experimental (n=16)	61.50	6	120.00	0.403		
	Control (n=18)	61.00	10				
ET	Experimental (n=16)	1.10	0.17	51.50	0.001	1.27	0.94
	Control (n=18)	1.28	0.19				

Table 5. Comparison between the experimental and control groups in the post-test of the TI variable

Variable	Group	M	SD	t	p	Mean differences	IC_{95}		d	1-β
TI	Experimental (n=16)	54.37	8.96	-2.973	0.006	-7.737	-13.036	-2.436	1.07	0.85
	Control (n=18)	46.63	6.09							

gl=32

Table 6. Comparison between pretest and postest of the DMA and ET variables of the control group

Variable	Valuation	Md	IR	Z (Wilcoxon)	p	d	1-β
DMA	Pretest	58.00	8.00	-1.72	0.086		
	Postest	61.00	10.00				
ET	Pretest	1.20	0.16	-0.87	0.384		
	Postest	1.28	0.19				

Table 7. Comparison between pretest and postest of the TI variable of the control group.

Variable	Valuation	M	SD	t	p	Mean differences	IC_{95}		d	1-β
TI	Pretest	46.50	8.14	-0.091	0.93	-0.1338	-3.2486	2.9808		
	Postest	46.63	6.09							

gl=17

Table 8. Comparison between pretest and postest of DMA and ET variables of the experimental group

Variable	Valuation	Md	IR	Z (Wilcoxon)	p	d	1-β
DMA	Pretest	62.00	5.00	-1.230	0.219		
	Postest	61.50	6.00				
ET	Pretest	0.95	0.11	-3.182	0.001	1.38	1.00
	Postest	1.1000	0.17				

Table 9. Comparison between pretest and postest of the TI variable of the experimental group

Variable	Valuation	M	SD	t	p	Mean differences	IC95		d	1-β
IT	Pretest	63.80	8.60	6.949	0.001	9.43467	6.5409	12.3283	1.16	0.99
	Postest	54.37	8.96							

gl=15

significant differences were found; while for the ET variable there were statistically significant differences, with a large effect size and a possibility of committing a type 2 error of 0%. ($p<0.01$; d =1.38; 1-β=1.00) (see Table 8).

In the TI variable, there was a statistically significant difference, with large effect size and statistically high power ($p<0.01$; d =1.16; 1-β=0.99) between the pretest (M=63.80; SD=8.60) and postest (M=54.37; SD=8.96) (see Table 9).

Discussion

The aim of this research was to study the effect of RAST-induced fatigue on performance in execution time (ET) and decision making (DMA) in technical-tactical actions in soccer in a laboratory situation, using the Stroop Task Football Test (STFT) (Calle-Jaramillo et al., 2023) in young soccer players at two different times: without fatigue (pretest) and with RAST-induced fatigue (postest).

Previous studies such as the "Repeated Interval Loughborough Soccer Passing Tests: An Ecologically Valid Motor Task to Induce Mental Fatigue in Soccer" (Bian et al., 2022), evaluated cognitive behavior in 15 young soccer players (mean age 22.0, SD: 2.5 years) following mental fatigue, showing negative effects on penalty time (+5.9 ±4.9 vs. +5.4 ±4.2 s, p = 0.748) and passing accuracy (-1.4 ±1.5 vs.-1.0 ±1.3, p= 0.465) in the Loughborough Soccer Passing Tests (LSPT). Comparing the results of the previous research with those found in this study, similarities are found in terms

of time, since ET tends to increase in fatigue condition; however, at the same time it differs, since the DMA in the technical action of passing and driving was not affected by the presence of fatigue.

Another study analyzed the effect of mental fatigue on decision-making in 20 male professional soccer players (mean age 22.6 years, SD: 3.3), using the Stroop task (accuracy and response time) to assess inhibitory control before and after mental fatigue induced by the 15-minute Stroop task and the 30-minute Stroop task, finding an increase in response time during the Stroop task after the 30-minute Stroop task condition ($F(2,17) = 6.57$, $p = 0.03$) compared to the 15-min Stroop task and control conditions (Effects of mental fatigue on passing decision-making performance in professional soccer athletes) (Gantois et al., 2020). Thus, reaction time was also affected by mental fatigue; results similar to those reported in this study.

In addition, other research showed the impact of mental fatigue on decision-making in soccer. Twelve male soccer players (mean age 19.3 years, SD: 1.5) performed a decision-making test preceded in a randomized order by 30 min of Stroop task (mental fatigue) or 30 min of magazine reading (control). Soccer-specific decision-making performance was assessed through accuracy and pass response time using edited video clips of professional soccer matches. Decision-making accuracy was lower and response time was longer after the Stroop task that generated mental fatigue. Response accuracy was likely lower in the mental fatigue condition (80.9 ± 6.4%) compared to the control condition (85.7 ± 4.9%; SD = -0.89 ± 0.73). Similarly, response time was probably slower in the mental fatigue condition (768 ± 134 ms) compared with the control condition (685 ± 156 ms; SD = 0.49 ± 0.47). Comparing the results of the previous research with those found in our study, similarities are found regarding ET, since it tends to increase TI in fatigue condition; however, at the same time it differs, since decision making in the technical action of passing and driving was not affected by the presence of fatigue (Smith et al., 2016).

Similarly, a study by Frýbort et al. (2016), showed that physical load affected speed, but not decision-making accuracy in 42 semi-professional male elite soccer players (mean age 18.0 ± SD: 0.9), evidencing that high-intensity exercise negatively affected visuomotor response time compared to moderate-intensity exercise due to physiological fatigue. The results showed a mean effect (Z-test = 0.34) and ANOVA (897.02 ± 57.46 vs. 940.95 ± 71.14; $p = 0.002$), which are similar to those reported in this study, where TE and not DMA changed due to the presence of fatigue, which in this case was also physically induced.

Understanding that elite soccer has a multifactorial load (psychological, physical, cognitive) that induces mental, central and/or peripheral fatigue, it is necessary to evaluate the technical tactical performance of the player when he has all types of fatigue combined or when he has the types of fatigue separately, so it is suggested for future research to analyze the cognitive motor behavior according to the type(s) of induced and non-induced fatigue at different times of the season. Not isolating and not combining the types of fatigue to evaluate the player's performance is an aspect to be taken into account for future research.

Conclusions

After the intervention (RAST-induced fatigue), the experimental group showed a decrease in the figures of the ET and TI variables, but not in the DMA variable, while the control group remained stable in all variables. In other words, decisional time and motor time, components of the ET variable and essential for rapid decision-making, increased in the postest.

Although the intervention in the experimental group decreased performance in two of the three variables (ET and TI), this was not lower than the figures of the control group, however, the intervention shows that the soccer players are susceptible to RAST-induced fatigue in the experimental group.

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ВПЛИВ УТОМИ, СПРИЧИНЕНОЇ АНАЕРОБНИМ СПРИНТ-ТЕСТОМ НА ОСНОВІ БІГУ, НА РЕЗУЛЬТАТИВНІСТЬ ЗА ПОКАЗНИКАМИ ЧАСУ ВИКОНАННЯ ТА ПРИЙНЯТТЯ РІШЕНЬ ПІД ЧАС ТЕХНІКО-ТАКТИЧНИХ ДІЙ У ФУТБОЛІ (ПЕРЕДАЧА ТА ВЕДЕННЯ М'ЯЧА) У ЛАБОРАТОРНІЙ СИТУАЦІЇ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 9 табл., 3 рис., 27 джерел.

Мета дослідження. Анаеробний спринт-тест на основі бігу (RAST) був розроблений для оцінки анаеробної потужності та рівнів утоми за допомогою протоколу повторного спринту. Метою цього дослідження було вивчення впливу втоми, спричиненої тестом RAST, на результативність за показниками часу виконання (ET) і прийняття рішень (DMA) під час техніко-тактичних дій у футболі в лабораторній ситуації.

Матеріали та методи. Квазіекспериментальне, лонгітюдне порівняльне дослідження з попереднім і підсумковим тестуванням. Дві групи футболістів (n = 34), поділені на контрольну (n = 18) та експериментальну (n = 16), оцінювали двічі в два різні моменти часу.

Результати. Беручи до уваги p-значення, розмір ефекту та статистичну потужність, спостерігаються відмінності до та після тесту RAST у змінних «загальний індекс» (TI) та «час виконання» (ET), а у змінній «прийняття рішень» (DMA) – ні. З другого боку, контрольна група залишалася стабільною обидва рази.

Висновки. Після втручання в експериментальній групі спостерігалося зниження значень змінних ET та TI, але не змінної DMA, іншими словами, показники часу прийняття рішення та моторного часу, які є компонентами змінної ET та є істотно важливими в момент швидкого прийняття рішень, зросли за результатами підсумкового тестування.

Ключові слова: втома, результативність, пізнання, тест Струпа на виключення нерелевантної інформації, футбол.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFICIENCY OF THE APPLICATION OF ELECTRONIC TECHNIQUES IN THE CONTROL OF DYNAMIC BALANCE IN THE PROCESS OF INCLUSIVE PHYSICAL EDUCATION

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Abstract

The purpose of the study was to determine the authenticity of the dynamic balance control device developed on the basis of modern trends in the field of electronic equipment for students with disabilities.

Materials and methods. 32 students with disabilities, aged 18–24 years, I–III years of study, who received a doctor's permission to participate in testing and had vestibular disorders, were selected for the studied sample, in accordance with the provisions of voluntariness and anonymity. General scientific methods of gathering theoretical information, the method of technical modeling, pedagogical testing and methods of mathematical statistics were used.

Results. A dynamic balance control device was developed on the basis of the most up-to-date electronic equipment and programming. The device consists of an integrated electronic unit, a programmable microcontroller system unit, and a PC. The information received by the capacitive sensors placed in the unit of the integrated electronic unit during the student's performance of the test task is processed in the unit of the programmable microcontroller system and transmitted via non-contact infrared communication lines to the PC where it is graphically presented. To establish the authenticity of testing using the developed device, reliability and validity coefficients were determined, which in numerical values reached a "high" level, in contrast to the test the results of which were recorded directly by the teacher and numerically corresponded to the limits of "low" and "medium".

Conclusions. The dynamic balance control device presented in the work is designed using the most up-to-date electronic equipment and programming. Considering the importance of eliminating vestibular disorders and related dynamic balance disorders in students with disabilities, the use of the presented development of the control device in the practice of inclusive PE is aimed at ensuring the effectiveness of this process. The integration of a control device developed based on current trends in the field of electronic equipment into the inclusive physical education of students with disabilities is the basis for the development of new approaches in the process of dynamic balance testing based on objective assessment.

Keywords: students with disabilities, physical education, testing, inclusion, control, electronic equipment, dynamic balance.

Introduction

Problem statement. The invasion of the Russian Federation into Ukraine increased attention to a number of important issues in the field of higher education at the global level. In particular, ensuring the quality of the educational process for students with disabilities is associated with several problems that have worsened under martial law. Given the development of events regarding the duration of the military aggression of the Russian Federation, the number of such persons will increase. Therefore, the problem of physical and psychological rehabilitation of students with disabilities dur-

ing their studies in higher education institutions is gaining considerable relevance.

In ensuring the full-fledged life activities of students with disabilities in higher education, a significant place is given to the potential of inclusive physical education (PE) (Haegele & Sutherland, 2015). Adaptation of this process to today's requirements, and its modernization, which ensures the process of correction of health disorders of students with disabilities, is of particular importance.

Since the experience of inclusive PE in higher education institutions is practically absent in Ukraine, the development of this direction as a factor in health preservation and rehabilitation of persons with disabilities is currently one of the priority tasks of the educational policy of higher education.

Analysis of recent research and publications. First of all, we should note that the national doctrine of education development in Ukraine in the 21st century defines that the main factor in the development of education should be innovative activity (Mykytyuk et al., 2022). The issue of the necessity and significance of innovative processes in inclusive education is reflected a number of scientific works (Goodwin & Watkinson, 2000; Lidor & Hutzler, 2019; Page, Anderson, & Charteris, 2021; Grenier, Patey, & Grenier-Burtis, 2022).

It is believed (Haegele & Sutherland, 2015), that solving the problem has a multidisciplinary basis. According to specialists (Pocock & Miyahara, 2018), the effective here is the inclusive PE of students with disabilities using forms, means, and methods of PE (Ivashchenko, 2020) in a complex with the latest advances in electronic techniques (Gogoi, 2019; Gupta, 2021).

There is no doubt that the goals of modern inclusive PE require the latest technologies (Kuntjoro et al., 2022). Currently, considerable experience has been accumulated in this field of knowledge, which proves the role of unified electronic techniques, which are constantly developing almost every day (Blavt et al., 2022). Researched, that a wide range of electronic techniques, covering any procedures, providing storage, receiving, manipulation, and transmission of information in electronic form in digital form (Klavina, 2011; Koryahin et al., 2022), open significant new opportunities for evaluating the effectiveness of the PE process.

A significant percentage of students with disabilities now have vestibular disorders, which can be the result of numerous diseases or craniocerebral injuries. If disease or injury damages the vestibular system, balance and postural control disorders, problems with stability and coordination of movements, dizziness, etc. can occur (Voronova et al., 2021). A consequence of vestibular dysfunction can be cognitive and communicative disorders, concentration difficulties, etc., which, accordingly, creates difficulties in the learning process (VeDA). Such disorders are characterized as brain "fatigue" syndrome, which is accompanied by various cognitive disorders (Hall et al., 2016). In addition, emotional disorders, which are very relevant in the conditions of prolonged stress of war, indirectly affect gait and balance (Da Cruz et al., 2010; Gurgel et al., 2012).

Correction and elimination of vestibular disorders, as a science-based area of PE practice, is aimed at the effective management of vestibular symptoms (Herdman, 2013; Fitzgerald, 2006). Assessment of the process of correction of vestibular disorders should include assessment of balance and dynamic coordination (Dunne et al., 2023). From the standpoint of pedagogical science regarding the organization of the educational environment in higher education, but with an emphasis on taking into account the determinants and model of inclusive education in a complex with modern advances in electronic techniques and software in the process of correction and elimination of vestibular disorders are very timely.

The purpose of the research was to determine the authenticity of the dynamic balance control device developed based on modern trends in the field of electronic techniques for students with disabilities.

Materials and methods

Research methods

The conducted research involved implementation in three stages: development of the device, collection of empirical data, and mathematical processing. To formulate reliable, relevant research answers, methods based on interdisciplinary strategies were chosen in the implementation of the research. Along with general scientific methods, methods evolved from other disciplines were used to obtain theoretical and empirical material (analysis, synthesis, and generalization). The method of technical modeling was used to create a test control device that was subject to study. In addition, the method of pedagogical experiment and mathematical methods of descriptive statistics were applied, which were used to formulate conclusions based on an accurate description of the data obtained.

For individuals with vestibular problems and dynamic balance assessment, the Four Square Step Test (Four_Square_Step_Test) was used. The testing procedure involves stepping through the membranes forward, sideways and backwards (Fig. 1). Description of the test: the student must successively step over four membranes set with a cross on the ground. At the beginning of the test, the student stands in square 1 facing square 2. The goal is to enter each square as quickly as possible with both feet in the following sequence: square 2, 3, 4, 1, 4, 3, 2, 1 (clockwise counterclockwise arrow). During the test, the student must be in a standing position on two legs in each square. Two attempts are made and the best time (in seconds) is taken as the score. Both feet should touch the floor in each square. The attempt is considered unsuccessful if the student fails to complete the sequence, loses balance, contacts the membrane.

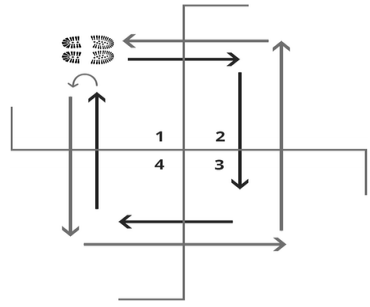

Fig. 1. Scheme of the test

Study participants

The research sample consisted of 32 students with disabilities who met the inclusion criteria (had vestibular disorders) for the study. Written consent to participate in testing was obtained from each of the research participants.

The condition for participation in the experiment was the stability of the condition, the absence of pronounced symptoms of exacerbation of vestibular disorders, or the main disease at the time of screening and data collection. The research sample was formed from equal numbers of men and women aged 18 to 24 years, I-III courses of study Lviv Polytechnic National University, Kamianets-Podilskyi Ivan Ohienko National University and Lutsk National Technical University, who received a doctor's permission to participate in testing. During the process of obtaining informed consent, students were informed that in the event of inappropriate reactions (dizziness, rapid heart rate, etc.), the test procedure was terminated.

The study was carried out in accordance with the provisions of voluntariness and anonymity. All test participants gave written consent to participate in the experiment.The study was planned and carried out following the principles of bioethics set forth by the World Medical Association (WMA-2013) in the Helsinki Declaration "Ethical Principles of Medical Research Involving Humans" and UNESCO in the "General Declaration on Bioethics and Human Rights".

The provisions of voluntariness and anonymity carried out the study. All test participants gave written consent to participate in the experiment.

Research organization

The collection of empirical data on students' performance of the test task was implemented in two ways of recording the result. One was carried out with the participation of a specialist who used a stopwatch and visual control, the other – with the help of a developed control device. To ensure the reliability of the experiment, testing was carried out during three months of the academic semester, trying to ensure the same conditions. The test participants were given precise instructions and formulated tasks.

Statistical analysis

All statistical analyses were performed using SPSS Version 22.0 (IBM Corporation).

To determine the quality and applicability of the developed control device in the practice of inclusive PE, the characteristics of the study's compliance with the formal criteria of authenticity - reliability and validity of the test were calculated. As complementary indicators, they are used as an assessment of the reliability and significance of research results.

The test is considered reliable only if it provides high measurement accuracy (Magill, & Anderson, 2017). Reliability as validity was measured by retesting the same test subjects no later than two weeks after the first test.

Given that the test results are presented quantitatively, a correlational study was used to determine the specified test characteristics of authenticity (reliability and validity) and to investigate the relationship between the variables without control or manipulation by the researcher (Bhandari, 2023).

To determine the degree of correlation between different measurements for testing new means of measuring variables, it is recommended to use correlation analysis, at the same time, such analysis is considered ideal for rapid data collection in natural conditions (Turney, 2022).

Results

First of all, we note that vestibular disorders cause a lot of discomfort to students with disabilities. Constant dizziness and migraines, difficulty maintaining balance while walking and other functional movements, such as getting up from a chair, reduced work capacity, and even the fact that they can cause accidents. Balance is most directly affected by postural disturbances when the center of gravity shifts (Voronova, Lazareva, Kovelska, & Kobinskyi, 2021).

The main problem of test control of dynamic balance using the test is to ensure standardization of the testing procedure and fixation of results. Our research was aimed at eliminating subjectivity in these operations to ensure the objectivity of the control and the reliability of the obtained results. This is important because they are the basis for the correction of individual programs of inclusive PE (Blavt, 2022).

Therefore, we have developed a dynamic balance control device for students with disabilities. The device consists of an integrated electronic unit, a programmable microcontroller system unit, and personal computer (PC). Signals in the device are transmitted by infrared communication lines (Fig. 2).

The basis of the device is an integrated electronic unit, which is built based on the use of sensor electronics, which is now widely used in modern smart systems. The function of the integrated electronic unit consists of non-contact measurement of the position of the legs during the test, movement dynamics, turning angles during walking, as well as the accuracy of the test task.

Capacitive sensors form the basis of the integrated electronic assembly. Capacitive sensors, which function according to the principle of non-contact capacitive tomography (Wojcik, Vistak, Mykytyuk, Politanskyi,

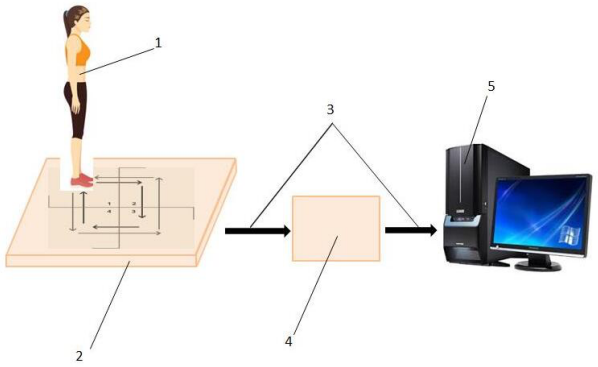

Fig. 2. Scheme of the developed dynamic balance control device: 1 – student, 2 – integrated electronic unit, 3 – infrared communication lines, 4 – programmable microcontroller system unit, 5 – PC

Diskovskyi, Sushynskyi, Kremer, Prystay, Jaxylykova, & Shedreyeva, 2020), are placed in a block of integrated electronic assembly, made in the form of a square. Along the perimeter of the square, there are electrodes of spatial scanning capacitive sensors, and inside the square – a two-coordinate sensor matrix for detecting surface pressure. The two-coordinate matrix records the position of the student's legs when performing the test exercise, as the main parameter of dynamic balance. Such a sensor matrix, ensuring the fixation of footprints on its surface, allows to determine their position on the measuring plane during the performance of the test task.

An important parameter of the capacitive sensor electrodes used in the developed device is the measurement speed. In the integrated electronic combination, the speed of operation is 100.000 measurements per second. In terms of image acquisition time, this provision has a throughput of several hundred frames per second and a data processing time of only a few milliseconds per frame. The range of pressure measurement on the surface allows you to identify the position of the feet of student of all weight categories. The measurement is made at a speed of 6 frames per second.

Further, informative signals measurement are transmitted to the block of the programmable microcontroller system, and then to the PC. The signals received in the PC are processed by the software developed for the implementation of the device.

The next stage of the experimental research involved testing and determining the authenticity of the test using various means of recording the result (Tab. 1, 2). To ensure the reliability of the experiment, testing was carried out three times.

Establishing the authenticity of the test, using the fixation of the results with a stopwatch, proved that the reliability according to numerical indicators corresponds to the limits of low and medium. The validity of these tests is within the same limits. The presence of a fairly high coefficient of variation, which characterizes the range of differences, draws attention. Indicators of the coefficient of variation within the limits of significant variation for all the studied parameters indicate that the stability of the results in the studied sample is lower than the metrological norms of reliability.

According to the results of the statistical processing of the results, the use of the developed device provides a high level of authenticity, which is reflected in the reliability and validity indicators. Such results, in comparison with the fixation of results in the traditional way using a stopwatch, when the quantitative values of authenticity, are significantly inferior to those obtained from the use of the developed device. The obtained numerical indicators of authenticity reached the level and "high level", and even "very high".

Table 1. Results of dynamic balance testing with stopwatch fixation (n = 32)

Statistical parameters	Test tasks and measurement results (s)					
	1st attempt		2st attempt		3st attempt	
	male	female	male	female	male	female
M	4.2	5.1	4.3	4.9	4.7	5.5
S	0.85	1.1	1.2	1.3	0.87	1.7
V (%)	31.5	34.5	30.5	35.8	32.1	36.1
rtt						
reliability	0.702	0.612	0.712	0.641	0.718	0.691
validity	0.295	0.281	0.305	0.290	0.317	0.233

Table 2. Results of dynamic balance testing with fixation by an electronic control device (n = 32)

Statistical parameters	Test tasks and measurement results (s)					
	1st attempt		2st attempt		3st attempt	
	male	female	male	female	male	female
M	4.11	4.89	4.17	4.51	4.05	4.33
S	0.71	0.91	1.01	0.83	0.79	1.12
V (%)	23.4	25.1	23.9	26.1	22.5	26.3
rtt						
reliability	0.818	0.812	0.842	0.817	0.911	0.893
validity	0.388	0.401	0.390	0.395	0.417	0.393

In addition, the use of the developed device allows you to record test results with an accuracy of seconds, which is a powerful factor in ensuring the reliability of the assessment. Thus, the digitization of testing, providing direct feedback with assessment.

The software has been developed to digitize test results. Using programming, they ensured the formation of a test control database. Accumulation, updating and graphic presentation of test control information made possible the efficiency of analysis with the results of test control. In the database, archiving of test counter data in the infrastructure of data storage and processing centers was provided in a personal text format for each student and is available to them.

Discussion

It is the need of the hour to organize the educational and educational process of PE in higher education, which would meet the educational needs of all students with disabilities without exception (Grenier, Patey, & Grenier-Burtis, 2022; Pocock & Miyahara, 2018; Blavt et al., 2023). This issue requires an effective and quick solution, taking into account the rapid increase in the number of students with disabilities since the full-scale invasion of russia on the territory of Ukraine, and the duration of hostilities, to eliminate the limitations of their educational opportunities and health care (Blavt, Bodnar, Mykhalskyi, Gurtova, & Tsovkh, 2023).

Scientific developments related to the modernization of inclusive PE are aimed at combining classes in useful proportions and methods of monitoring their effectiveness (Baglieri & Bacon, 2020; Sawade, 2023; Qi & Ha, 2012). We support scientific approaches (Gogoi, 2019; Koryahin et al., 2020; Varga & Révész, 2023), regarding the need to raise the level of scientific research in physical education, integrating them into the global practice of informatization. As mentioned (Mykytyuk et al., 2022; Gupta, 2021), the use of modern electronic resources on the basis of permanent informatization of PE is recognized as a key factor in ensuring the quality and efficiency of PE.

Focusing on changes in the current understanding and practices of inclusive PE to correct health disorders of students with disabilities, vestibular disorders are widely understood

as those that determine the quality of daily life (Gurgel et al., 2012). A special place in this process is occupied by the functions of walking and maintaining balance (Voronova et al., 2021) and body stability, for example, while standing and sitting. Given the relevance of the topic, we draw attention to the proven significant connection between the presence of emotional disorders and the way of life and work of the vestibular apparatus (Da Cruz et al., 2010). The obtained empirical results (Hall et al., 2016; Herdman 2013), of the experiment confirm the dependence of dynamic balance on the functional state of the vestibular apparatus and the presence of functional disorders, which is obviously a factor in the variation of results in retests.

The practical value of the control device presented for the first time in the work lies in the possibility of its application to persons with amputated limbs. We agree that in this case (Koryahin et al., 2020; Rum et al., 2021), electronic techniques of control are not only a technological method of scientific research, a source of supplying new information, knowledge and ensuring interdisciplinary interactions, but also a method of forecasting and prediction.

Conclusions

In the process of ensuring quality education for students with disabilities, a special place is given to effective inclusive physical education in institutions of higher education, whose number is permanently increasing. In the national-state dimension, the actualization of the content of inclusive PE is determined by the challenges caused by the growth of requirements to ensure the effectiveness of the educational field of knowledge in the aspect of national health preservation.

The use of innovative technologies in inclusive physical education is positioned in the interdisciplinary plane. The dynamic balance control device presented in the work is designed using the most modern electronic techniques and programming. Considering the importance of eliminating vestibular disorders and associated disorders of balance and coordination of movements, the use of the presented development in the practice of inclusive PE of students with disabilities is aimed at ensuring the effectiveness of this process.

The degree of authenticity of the developed dynamic balance control device for students with disabilities was experimentally investigated. According to the statistical analysis, in the digital values, the indicators of reliability and validity reached the "high" level, in contrast to the studied indicators obtained by the traditional method, which were recorded at the "acceptable" and "average" levels.

Among the advantages of the developed control device, we single out: simplicity and ease of use, achieving objectivity of control, devoid of subjectivity in recording results, promptness of the obtained results and their evaluation, suitability of test control results for automated processing and use of statistical methods, archiving and saving in the database. The efficiency of the test process and obtaining information in digital form are valuable aspects of the implementation of the development in the practice of inclusive PE for students with disabilities.

Conflicts of interest

No conflicts of interest exist.

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ЕФЕКТИВНІСТЬ ЗАСТОСУВАННЯ ЕЛЕКТРОННОЇ ТЕХНІКИ У КОНТРОЛІ ДИНАМІЧНОЇ РІВНОВАГИ В ПРОЦЕСІ ІНКЛЮЗИВНОГО ФІЗИЧНОГО ВИХОВАННЯ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 2 рис., 37 джерел.

Мета дослідження полягала у визначенні автентичності розробленого на основі сучасних трендів в галузі електронної техніки пристрою контролю динамічної рівноваги студентів з інвалідністю.

Матеріал та методи. До досліджуваної вибірки, відповідно до положень добровільності та анонімності, були добрані студенти з інвалідністю віком 18-24 роки I-III курсів навчання, які отримали дозвіл лікаря на участь у тестуванні та мали вестибулярні порушення. Використано загальнонаукові методи збору теоретичної інформації, метод технічного моделювання, педагогічне тестування й методи математичної статистики.

Результати. Розроблено пристрій контролю динамічної рівноваги на основі найсучаснішої електронної техніки та програмування. Пристрій складається з блоку програмованої вбудованої мікроконтролерної системи. джерела живлення, ПК, блоку інтегрованого електронного об'єднання. Інформація, отримана сенсорами, розміщеними у блоці інтегрованого електронного об'єднання при виконанні студентом тестового завдання, обробляється мікроконтролером та передається безконтактними лінями інфрачервоного зв'язку на ПК, де графічно представляється. Для установлення автентичності тестування з використанням розробленого приладу, було визначено коефіцієнти надійності та валідності, які у числових значеннях досягли «високого» рівня, на противагу тесту, результати якого фіксувались безпосередньо викладачем з використанням секундоміра й за числовими показниками відповідні межам «низької» та «середньої».

Висновки. Представлений у роботі пристрій контролю динамічної рівноваги сконструйовано з використанням найсучаснішої електронної техніки та програмування. Зважаючи на важливість усунення вестибулярних розладів та пов'язаних із ними порушень динамічної рівноваги у студентів з інвалідністю, використання презентованої розробки пристрою контролю у практиці інклюзивного ФВ скеровано на забезпечення ефективності цього процесу. Інтеграція у інклюзивне фізичне виховання студентів з інвалідністю пристрою контролю, розробленого на основі сучасних трендів в галузі електронної техніки, є основою розроблення нових підходів у процесі тестування динамічної рівноваги на основі об'єктивного оцінювання.

Ключові слова: здобувачі вищої освіти з інвалідністю, фізичне виховання, тестування, інклюзія, контроль, електронна техніка, динамічна рівновага.

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ORIGINAL SCIENTIFIC ARTICLE

MUSCLE MASS AND MUSCLE STRENGTH FOLLOWING 6 WEEKS OF BLOOD FLOW RESTRICTION COMBINE WITH LOW-INTENSITY STRENGTH TRAINING IN OVERWEIGHT ADOLESCENTS

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Abstract

Background and Study purpose. Blood flow restriction training is a new training technique that involves low-intensity exercise and can generate physiological changes equivalent to high-intensity exercise. The aim of this study is to assess the impact of blood flow restriction in conjunction with low-intensity resistance exercise on muscle mass and muscle strength among overweight adolescents, in comparison to conventional resistance exercise.

Materials and methods. The study involved two randomized groups: an experimental group, which performed 40% of one repetition maximum (1RM) resistance exercise combined with 60% of arterial occlusion pressure (AOP), and a traditional resistance exercise group, which performed 70% of 1RM resistance exercise. All participants underwent pre-test and post-test evaluations for body composition, 1RM, and muscle circumference. The training program lasted for six weeks and consisted of upper and lower body training, including exercises such as leg press, leg curl, arm curl, and arm extension.

Results. The group that underwent low-load blood flow restriction (LLBFR) training showed a notable increase in muscle mass ($p<0.049$) as well as arm and leg circumference ($p<0.047$ and $p<0.046$, respectively) compared to before the training program, similar to the results of high-intensity resistance exercise.

Conclusions. Combining blood flow restriction with low-intensity resistance training is a potentially effective approach to increase muscle size and strength, especially in overweight adolescents. Moreover, this type of training can decrease the amount of exercise load, making it a feasible option for individuals who may not tolerate high loads due to certain medical conditions or other limitations.

Keywords: resistance exercise, overweight, vascular occlusion, blood flow restriction, local hypoxia, low-intensity.

Introduction

For almost two decades, overweight and obesity have been recognized as significant health concerns globally (WHO., 2000). Both developed and developing countries are experiencing a rise in these conditions Lang & Froelicher. (2006). According to the World Health Organization (WHO), there were 1.6 billion overweight adults, over 400 million obese adults, and at least 20 million overweight children under five years old. If current trends persist, these numbers are expected to increase to 2.3 billion overweight and 700 million obese individuals. Overweight and obesity are major public health concerns worldwide and are associated with various chronic diseases, such as hyperlipidemia, type 2 diabetes, atherosclerosis, liver disease, cancer, and neurodegenerative diseases that can lead to reduced quality of life and increased mortality rates. It is crucial to address this issue through lifestyle modifications, such as increased physical activity and a healthy diet, to prevent and manage obesity-related health problems (Teufel et al., 2021).

As it lowers body weight, total fat, visceral fat, intrahepatic fat, and blood pressure, moderate-intensity aerobic exercise is an effective treatment for adult overweight/obesity, whereas moderate-intensity resistance exercise can help maintain lean body mass during weight loss (Oppert et al., 2021). However, those with excessive body weight/obesity, the elderly, recuperating athletes, or those with no prior training experience who cannot endure significant mechanical pressure on the joints during high-resistance

training may sustain sports injuries from high-intensity strength or aerobic training. These risks have been discussed in numerous studies. For example, a high body mass index and percent body fat are associated with significant increases in muscle injury markers following high-intensity exercise (Kim & Yoon., 2021), and high-intensity running, cycling, and swimming can harm muscles in athletes (Huang et al., 2019). However, Blood flow restriction training has been shown to aid in the rehabilitation of knee injuries and improve musculoskeletal system recovery. By applying external pressure to the limb using devices such as inflatable cuffs or elastic bandages, blood flow restriction can partially block arterial blood flow and occlude venous blood flow in the pressured limbs, which can reduce muscle damage and promote muscle recovery. Some studies have also suggested that blood flow restriction training can improve muscle strength and hypertrophy in athletes recovering from injury or surgery (Castilla et al., 2021; Wortman et al., 2021).

Blood flow restriction training has been developed as an alternative to high-intensity training for individuals who cannot tolerate high mechanical pressure. This technique involves applying external pressure to the limb during exercise, partially blocking arterial blood flow and occluding venous blood flow in the pressured limbs (Perera et al., 2022). This produces the effect of intensive training while using lower resistance or endurance exercises. Previous studies have demonstrated that blood flow restriction training can increase muscle mass and strength, improve muscle fitness, aerobic capacity, knee rehabilitation, acute bone formation markers and hormonal responses, and athletic performance in various populations (Korkmaz et al., 2022; Sun., 2022; Bemben et al., 2022). However, there is limited research on the effects of low-intensity resistance training combined with blood flow restriction on muscle mass and strength in overweight adolescents. Therefore, our study aims to investigate the effects of this type of training on body composition parameters, muscle mass, and strength, and compare them to a high-intensity resistance training group.

Material and methods

Participants

The study recruited 30 participants who were considered overweight based on a BMI between 25 and 29.9 and engaged in recreational exercise. The participants were considered recreational, meaning they engaged in exercise for leisure and not as part of a structured training program. The sample size was determined based on an estimated effect size of 0.25, with a significance level of $p \leq 0.05$ and a statistical power greater than 0.80, resulting in a required sample size of $n = 30$ (Curty et al., 2018). Individuals with vascular health issues such as hypertension, deep vein thrombosis, or distended varicose veins, as well as those with a history of medical treatment or drug use, were excluded from the study. All participants were given detailed explanations of the experiment's purpose, procedures, and methods and voluntarily provided informed consent before participating. The thirty participants were randomly assigned to either the group that received 40% of one-rep max (1RM) resistance exercise with 60% of arterial occlusion pressure (AOP) for blood flow restriction (n=15) or the group that underwent traditional resistance exercise group, which performed 70% of 1RM resistance exercise high-intensity resistance training (n=15). An independent t-test was conducted to compare the age, height, weight, and body mass index (BMI) between the two groups, revealing no statistically significant differences ($p > 0.05$). The study's procedures, methods, and consent form were approved by the Human Research Ethics Committee of Walailak University (approval number: WUEC-23-084-01), and the study was conducted from March to June 2023.

Study design

In this study, a randomized trial design was used, and the participants were divided into two groups using the randomized block approach. The two groups were the blood flow restriction combine with low-intensity resistance training (LTBFR) group and the high-intensity resistance training (HT) group, as shown in Figure 1.

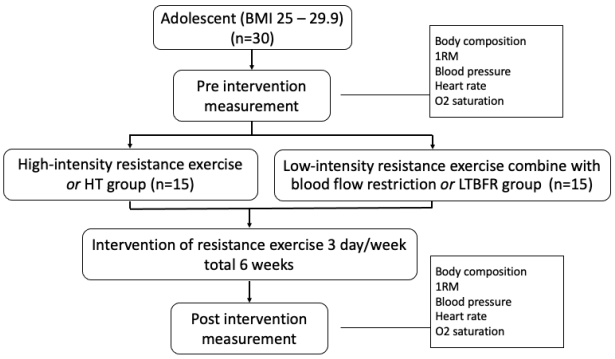

Fig. 1. The outline of the groups of the study

To be eligible for participation in this study, individuals had to be capable of performing their daily activities without experiencing persistent depression and should have adequate social support. Those who could not exercise safely, had a generalized anxiety disorder, changed their medication or therapy within the past three months, experienced an acute injury or illness while exercising, or engaged in alcohol/substance misuse or smoking were excluded from the study. Participants were instructed to refrain from self-medication, notify the study's medical director if they developed a fever or acute infection or started using new medication, and avoid making any changes to their diet during the study period.

Experimental procedures

Body composition

Prior to the exercise session, body composition was assessed by measuring height, body weight (BW), and body mass index (BMI) using a body composition monitor (Tanita model UM-076) in accordance with the manufacturer's guidelines.

Determination of arterial occlusion pressure

Leg and Arm Circumference

Before determining the arterial occlusion pressure, measurements were taken for the circumference of both the legs and arms. A tape measure was used to measure the distance from the acromion process to the olecranon process on the arm, and a mark was made at a point located 50% distal to the acromion process. Similarly, the circumference of the right thigh was measured at a point corresponding to 33% of the distance from the inguinal crease to the top of the patella. These measurements were obtained at designated marks to ensure precise and accurate application sites for the cuffs.

Brachial systolic and brachial diastolic blood pressure

Brachial systolic and diastolic blood pressure were assessed using an appropriately sized automatic blood pressure cuff (Allwell, Model BSX593). Measurements for systolic brachial blood pressure (SBP) and diastolic brachial blood pressure (DBP) were taken in duplicate, and the average of these values was used for analysis.

Training protocol

The study's procedure commenced by measuring baseline factors, including body composition, muscle mass, and muscle strength. Two groups were then evaluated:

1. The first group performed resistance exercise using 40% of their one-repetition maximum (1RM) in combination with 60% of the arterial occlusion pressure (AOP) for blood flow restriction.

2. The second group engaged in traditional resistance exercise using 70% of their 1RM.

Both groups participated in 60-minute sessions, conducted three times per week, for a duration of six weeks. Throughout the study, all measurements and training sessions were conducted in a controlled environment, maintaining a constant temperature and humidity level. Figure 2 provides a visual representation of the experimental setup.

Blood flow restriction determining – Cuff Pressure

The level of pressure needed to block blood flow in a limb, known as arterial occlusion pressure (AOP), varies depending on factors such as the shape, width, and length of the tourniquet, limb size, and individual blood pressure. In this study, the pressure used to limit blood flow during resistance exercise was set at 60% of the AOP, which can be achieved by inflating the exercise cuff until blood flow stops completely (100% of AOP).

The Arterial Occlusion Pressure (mmHg) for 100% of AOP (Loenneke et al., 2015) was calculated as follows:

Lower Body = 0.912 (SBP) + 0.734 (DBP) + 5.893 (Thigh circumference (cm)) – 220.046

Upper Body = 0.667 (SBP) + 0.399 (DBP) + 1.461 (Arm circumference (cm)) – 17.236

Then, for blood flow restriction combined with 40% of 1RM of low-intensity exercise, use a percentage of that pressure as 60% of AOP during exercise.

After a 10-minute rest period, specialized blood pressure cuffs made of nylon (5 cm wide) were applied to the proximal portions of each arm. These cuffs were connected to a cuff inflator system to regulate pressure. A pressure equivalent to 60% of the AOP was targeted for each arm. To determine the appropriate pressure, the arterial occlusion pressure (AOP) was estimated using specific formulas for both upper body parts, which amounted to around 80 - 110 mmHg for the upper body (calculation for individual participant). Throughout the training period, the O2 saturation was continuously measured to monitor oxygen levels. Upon completion of this session, the cuffs were removed from the arms, and participants were instructed to rest quietly in the relax position with normal blood flow for an additional 5 minutes.

Following the 5 minute rest period with normal blood flow, the cuffs for leg (10 cm wide) were applied to the proximal portions of each leg. Similarly, a pressure equivalent to 60% of the AOP was targeted for each leg. To determine the appropriate pressure, the arterial occlusion pressure (AOP) was estimated using specific formulas for lower body parts, which amounted to around 130-250 mmHg for the lower body (calculation for individual participant). Throughout the training period, the O_2 saturation was continuously measured to monitor oxygen levels. Upon completion of this session, the cuffs were removed from the arms, and participants were instructed to rest quietly in the supine position with normal blood flow for an additional 5 minutes (Loenneke et al., 2015).

Resistance training intervention

The participants in the study performed resistance training three times a week for six weeks, on Mondays, Wednes-

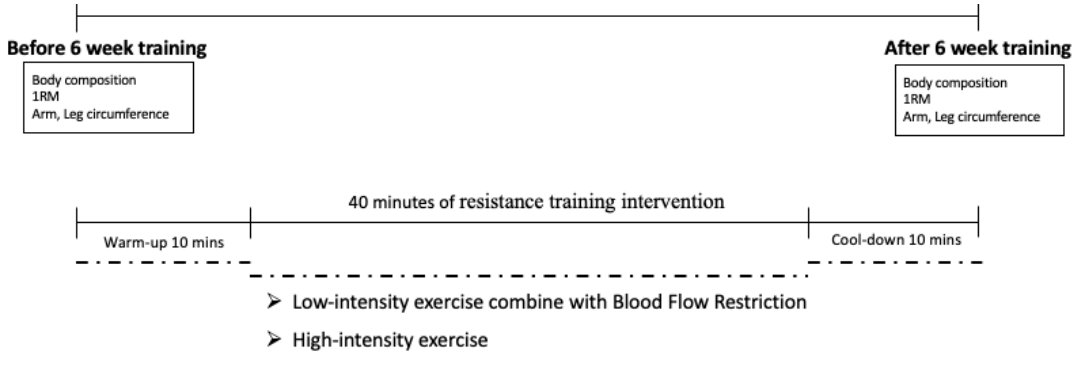

Fig. 2. The outline of the time schedule of the study

days, and Fridays from 4:00-7:00 PM. Each session lasted 60 minutes and focused on upper and lower body physicality. The participants determined their one-repetition maximum (1RM) for the biceps curl, triceps extension, leg extension, and leg press. The resistance training program consisted of four stations, with each station performing three sets of three reps. The low-intensity resistance training group with 60% arterial occlusion pressure (AOP) of blood flow restriction used 40% of their 1RM, while the high-intensity resistance training group used 70% of 1RM and was evaluated before and after week six. The training sessions included 10 minutes of warming up and stretching in standing and sitting poses, followed by 40 minutes of resistance training at the four stations, and a 10-minute cool-down period (Table 1 shows the details of the training program).

Table 1. Components of the resistance training intervention (three times/week for six weeks)

Components	Set	Repetitions
Upper body		
Biceps curl	3-5	12-15
Triceps extension	3-5	12-15
Lower body		
Leg extension	3-5	12-15
Leg press	3-5	12-15

One repetition maximum (1-RM)

To assess changes in muscle strength, the researchers measured the one-repetition maximum (1-RM) for the participants. The 1-RM leg press and 1-RM leg extension were evaluated using a bilateral leg press machine and a bilateral leg extension machine (Spirit, UK) respectively. For the 1-RM biceps curl test, the bilateral machine triceps extension with the dominant arm was used. Additionally, the 1-RM triceps extension was measured using the triceps extension machine (Spirit, UK). These specific tests were chosen to determine an individual's maximum strength in the targeted muscle groups. The data obtained from these tests provided valuable insights into changes in muscle strength over time and were essential in designing appropriate exercise programs tailored to each participant's needs.

Statistical analysis

Data values are presented as the mean ± standard error of the mean (SEM). IBM SPSS Statistics 26 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Paired sample t-tests were used for comparisons between groups. One-way analysis of variance (ANOVA) with Tukey's post-hoc test was performed to evaluate significant differences between the groups. Statistical significance was set at $P < 0.05$.

Results

Demographic characteristic of the participants

Thirty participants were screened between March and June 2023 and were randomly assigned to one of two groups (n = 15 each). The first group underwent a low-intensity resistance training program with 40% of 1RM combined with blood flow restriction training at 60% of AOP, while the second group received high-intensity resistance training at 70% of 1RM. The baseline characteristics, including mean age (year), height (cm), body weight (kg), and body mass index (kg/m^2), were measured and found to have no statistically significant differences between the two groups, as shown in Table 2.

Comparison of participant muscle mass before and after the test

Table 3 and Figure 3 display the mean values of pre- and post-test for the two groups. In the LTBFR group, the mean muscle mass after the LTBFR training was significantly

Table 2. Demographic characteristics of the participants at baseline

Characteristics	LTBFR (n=15)	HT (n=15)	95% CI	p-value
Age (year)	20.15 ± 0.19	20.00 ± 0.28	-0.85 to 0.54	0.652
Height (cm)	170.62 ± 1.36	168.62 ± 2.88	-8.56 to 4.56	0.535
Weight (kg)	76.94 ± 3.24	77.81 ± 5.56	-12.41 to 14.15	0.894
BMI (kg/m2)	27.61 ± 0.95	27.17 ± 1.38	-3.89 to 3.01	0.796

Data are presented as mean ± standard error of the mean (SEM), with unpaired t-test. BMI, body mass index

Table 3. Comparison of pre- and post-test muscle mass for the 40% of 1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR)

Characteristics	n	Muscle Mass (kg)		Difference between means	% Change	p-value
		Pre-test	Post-test			
LTBFR	15	50.55 ± 2.97	58.21 ± 2.23*	7.66 ± 3.71	15.15	0.049
HT	15	54.77 ± 3.81	65.32 ± 3.40*	10.55 ± 5.11	19.24	0.049

Data are represented as the mean ± standard error of the mean (SEM). *P < 0.05 indicates significant difference when compared with pre- and post-test demographics for the 40%1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR) participants group. Data were compared between pre- and post- group using an unpaired t-test

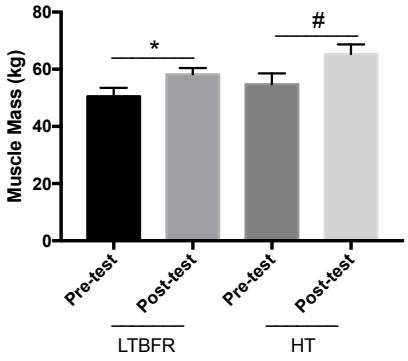

Fig. 3. Comparison of pre- and post-test muscle mass both the 40% of 1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR) and high intensity resistance training (HT)

higher than the mean muscle mass before LTBFR training ($p < 0.049$). Similarly, in the HT group, the mean muscle mass after the HT training was significantly higher than the mean muscle mass before HT training ($p < 0.049$), as shown in Figure 3.

Increasing of arm circumference and leg circumference following the intervention

Based on Table 4 and Figure 3, it appears that both LTBFR and HT training resulted in significant increases in arm and leg circumference. Specifically, LTBFR training resulted in a significant increase in arm circumference ($p<0.036$) while HT training resulted in a significant increase in both arm ($p<0.047$) and leg ($p<0.046$) circumference. The percent change in circumference was higher for HT training in the arm (10.15%) compared to LTBFR training (8.87%), while the percent change in leg circumference was higher for LTBFR training (8.65%) compared to HT training (9.97%). Overall, it seems that both LTBFR and HT training were effective in increasing arm and leg circumference.

Increasing of One- repetition maximum (1RM) following the intervention

Table 5 and Figure 5 display the results of the pre- and post-tests for one-repetition maximum (1RM). The data shows that both LTBFR and HT interventions resulted in a significant increase in 1RM compared to before training. The percent increase in leg extension and leg press for LTBFR

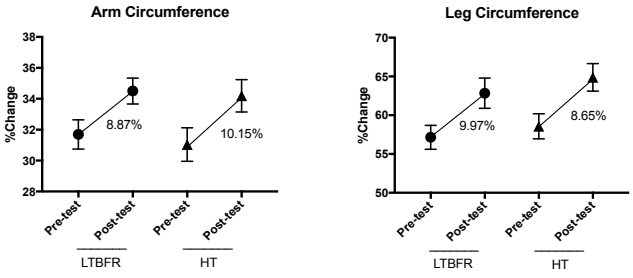

Fig. 4. Percent change of arm and leg circumference of pre- and post-test for LTBFR and HT group

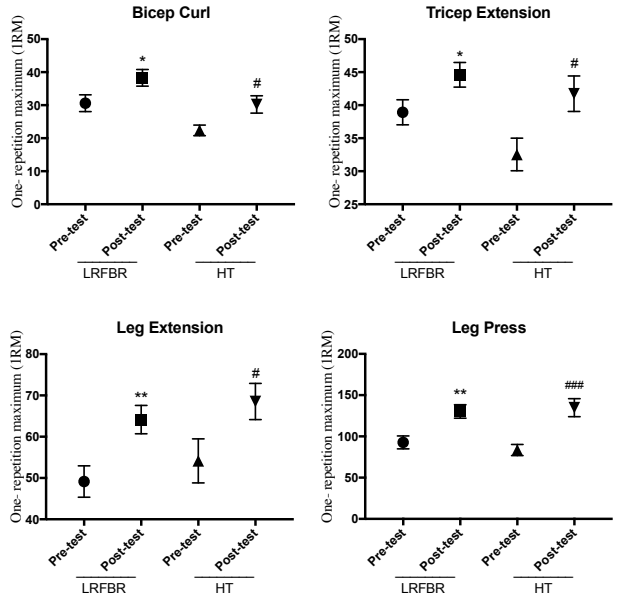

Fig. 5. One-repetition maximum (1RM) of pre- and post-test for the 40% of 1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR) and high intensity resistance training (HT)

training was higher than for HT training, with increases of 30.52% and 40.38%, respectively, for LTBFR and 26.56% and 61.36%, respectively, for HT.

Discussion

The objective of our study was to assess the impact of combining low-intensity resistance training with blood flow restriction on muscle mass and strength in overweight adolescent. Our main discovery was that after six weeks

Table 4. Arm and leg circumference of pre- and post-test for the 40% of 1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR) and high intensity resistance training (HT)

Resistance training station	LTBFR (n=15)		% Change	p-value	HT (n=15)		% Change	p-value
	Pre-test	Post-test			Pre-test	Post-test		
Arm circumference (cm)	31.69 ± 0.94	34.50 ± 0.84*	8.87	0.036	31.04 ± 1.08	34.19 ± 1.05#	10.15	0.047
Leg circumference (cm)	57.15 ± 1.55	62.85 ± 1.95*	9.97	0.031	58.58 ± 1.61	63.65 ± 1.79#	8.65	0.046

Data are represented as the mean ± SEM. *P < 0.05 indicates significant difference when compared with pre- and post-test demographics for the 40% of 1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR) participants group, #P < 0.05 indicates significant difference when compared with pre- and post-test demographics for the 70% of 1RM of high-intensity participants group. Data were compared between pre- and post- group using an unpaired t-test

Table 5. One-repetition maximum (1RM) of pre- and post-test for the 40% of 1RM of low-intensity combined with 60% of AOP of blood flow restriction (LTBFR) and high intensity resistance training (HT)

Resistance training station	LTBFR (n=15)		% Change	p-value	HT (n=15)		% Change	p-value
	Pre-test	Post-test			Pre-test	Post-test		
Biceps curl (kg)	30.66 ± 2.55	38.31 ± 2.53*	25.11	0.042	22.38 ± 1.59	30.23 ± 2.62#	35.08	0.017
Triceps extension (kg)	38.92 ± 1.89	44.61 ± 1.86*	14.62	0.043	32.54 ± 2.47	41.73 ± 2.69#	28.24	0.019
Leg extension (kg)	49.15 ± 3.79	64.15 ± 3.43**	30.52	0.007	54.15 ± 5.32	68.54 ± 4.38#	26.56	0.048
Leg press (kg)	92.77 ± 7.86	130.23 ± 8.13**	40.38	0.003	83.54 ± 6.71	134.80 ± 10.88###	61.36	0.0005

Data are represented as the mean ± SEM. Data were compared between pre- and post- group using an unpaired t-test.

of this training, there was a significant increase in muscle mass (15.15%) compared to the baseline measurement. Both LTBFR and HT interventions resulted in significant increases in muscle mass after 6 weeks of training. The muscle hypertrophy potential was determined by calculating the percentage increase in muscle mass, and the results showed that LTBFR had a 15.15% increase in muscle mass and HT had a 19.24% increase, indicating that both interventions had similar levels of muscle growth. The effect sizes observed suggest that the results are reliable and consistent with previous studies on various populations (Centner et al., 2019; Zhang et al., 2022; Lixandrão et al., 2018) including individuals with musculoskeletal injuries (Hughes et al., 2017). The values obtained in the current study are similar to the findings of a previous study that showed that two weeks of twice-daily squat and leg curl training with BFR produced thigh muscle hypertrophy of 0.32% per session (Abe et al., 2005) and increases thigh muscle cross-sectional area as well as maximal muscle strength (Yasuda et al., 2016). However, the cellular and molecular mechanisms underlying the hypertrophic response to LTBFR training are not fully understood. Skeletal muscle hypertrophy is generally attributed to an increase in protein accretion, or the accumulation of contractile protein (Schiaffino et al., 2021). This happens when the balance between protein synthesis and degradation shifts toward synthesis. Skeletal muscle is a flexible tissue that can adapt to even minor changes in nutrition and physical activity. Resistance exercise, in particular, causes a slight increase in muscle protein breakdown (Schiaffino et al., 2021; Atherton et al., 2010; Morton et al., 2015), but it also stimulates muscle protein synthesis to a greater extent. When resistance exercise is done before consuming protein, the two stimuli complement each other, resulting in even greater muscle protein synthesis than muscle protein breakdown (Glynn et al., 2010). Repeated sessions of resistance exercise and protein intake lead to an increase in skeletal muscle protein accumulation, also known as hypertrophy (Cermak et al., 2012). Typically, the load required to stimulate this level of protein synthesis is believed to by in excess 8-10 sets of resistance exercise at a 70-80% of 1RM of resistance training (Dreyer et al., 2006). Interestingly, a single bout of knee extension exercise combine with blood flow restriction elicits the same level of protein synthesis with a lower repetition count and 20% of 1RM of resistance training. Recent research has shown that a single bout of low-intensity knee extension exercise with blood flow restriction at 20% of 1RM intensity can increase thigh muscle protein synthesis (Fujita et al., 2007). The combination of low intensity resistance exercise and blood flow restriction has been shown to increase protein synthesis and result in muscle hypertrophy. This effect is believed to be due to the unique physiological response of blood flow restriction, which limits blood flow to the working muscle, creating a hypoxic environment that stimulates the release of growth factors and enhances muscle protein synthesis (Lim & Goh., 2022). The lower intensity and repetition count required to achieve this effect with blood flow restriction compared to traditional high-intensity resistance exercise makes it a promising tool for individuals who may not be able to tolerate high-intensity exercise or who are looking for a more time-efficient approach to building muscle mass.

The physical effects of LTBFR resistance training may be influenced by metabolic stress, as the mechanical strain induced by LTBFR resistance training is thought to be similar to that of traditional high-intensity resistance training (Pearson & Hussain., 2015). It has been suggested that, compared to lower-intensity resistance training, blood flow restriction training results in lower oxygen bioavailability, which leads to the onset of anaerobic glycolysis in muscles and the accumulation of fatigue metabolites such as lactate product (Fry et al., 2010; Shimizu et al., 2016; Takarada et al., 2000). Recently, Fujita and Yasuda observed an increase in muscle protein synthesis and ribosomal S6 kinase 1 (S6K1) phosphorylation following a single session of blood flow restriction combined with low-intensity resistance exercise. These changes in transcriptional factors associated with muscle hypertrophy after LTBFR may be attributed to the up-regulation of genes related to hypertrophy, such as phosphoinositide 3- kinase (PI3K), protein kinase B (AKT), and mTOR (Yasuda et al., 2009). Drummond et al. also found that the brief periods of hypoxia and reperfusion induced by BFR activate the mTOR pathway, promoting cell survival and growth adaptations in skeletal muscle. Furthermore, the up-regulation of vascular endothelial growth factor (VEGF), a crucial modulator in vasculogenesis and angiogenesis, is necessary for hypertrophy and can be stimulated by hypoxia and lactate accumulation (Drummond et al., 2008; Simons et al., 2016). These mechanisms are associated with local hormone secretion, cell swelling, muscle damage, and increased production of reactive oxygen species, all of which contribute to anabolic muscle phenomena (Loenneke et al., 2012).

With regard to muscle strength the present study showed that estimated 1RM in biceps curl, triceps extension, leg extension and leg press increased significantly after 6-week resistance training in the blood flow restriction group.

To summarize, the study found that both LTBFR and HT interventions resulted in significant increases in overall strength and power, as measured by 1RM, after 6 weeks of training. The HT group had a greater increase in 1RM compared to the LTBFR group, suggesting that high-intensity resistance training may be more effective for increasing muscle strength. However, LTBFR resistance training still offered superior increases in muscle strength compared to the baseline measurement. Additionally, when comparing specific exercises, percent change in muscle strength was higher for the LTBFR group for biceps curl, triceps extension, leg curl, and leg press. The results of the study showed that LTBFR training led to greater strength gains in the leg extension compared to HT training. Specifically, there was an average percent change of 30.52% in the LTBFR group and 14.91% in the HT group. These findings are consistent with previous research, such as a study by Fujita et al. (2008) which found significant increases in maximal leg extension strength after a two-week training program that included lactic acid accumulation (Fujita et al., 2008). Indeed, the increase in fast-twitch muscle fiber activation and the accumulation of lactic acid in muscle fibers are potential mechanisms that may explain the strength gains observed in the LTBFR group (Takarada et al., 2000; Loenneke et al., 2012). Additionally, the increase in serum growth hormone concentrations in the blood flow restriction group may have contributed to the observed muscle hypertrophy and neuromuscular adaptation (Miller et al., 2021; Yinghao et al., 2021; Fekri-Kourabbaslou et al., 2022). These metabolic and neurohormonal changes induced by blood flow restriction may have stimulated anabolic pathways and protein synthesis in the muscle, leading to hypertrophy and strength gains.

While the present study demonstrated promising results, there are some limitations to be acknowledged. Firstly, the study only included overweight adolescents, so it is unclear whether similar results would be observed in other populations, such as athletes or elderly individuals. Secondly, the study did not investigate potential sex differences in the response to blood flow restriction combine with resistance training, which should be explored in future research. Additionally, while the study suggested that blood flow restriction with resistance training may improve vascular endothelial function and peripheral blood circulation (Green et al., 2004; Miyauchi et al., 2003), further investigation is necessary to confirm these mechanisms. For example, measuring vascular endothelial growth factor and mammalian target of rapamycin, its regulates cell proliferation, would help clarify these mechanisms (Shimizu et al., 2016). Overall, despite these limitations, the combination of low-intensity resistance training with blood flow restriction appears to be a promising strategy for promoting muscle hypertrophy and strength, particularly in overweight adolescents. Further research is needed to fully understand the underlying mechanisms and to determine the effectiveness of this training in other populations.

Conclusions

That is a significant finding, low-intensity resistance training combined with blood flow restriction can be a feasible substitute for high-intensity resistance training in promoting muscle strength and hypertrophy in overweight adolescents, which may benefit those who cannot or choose not to perform high-intensity resistance training. However, these findings should be confirmed by additional research, which should also examine the potential long-term impacts of LTBFR on muscle mass and strength. Moreover, further research is needed to investigate the effects of LTBFR on other populations.

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Conflict of interest

The authors declare that there is no conflict of interest.

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М'ЯЗОВА МАСА ТА М'ЯЗОВА СИЛА ПІСЛЯ 6 ТИЖНІВ ТРЕНУВАНЬ З ОБМЕЖЕННЯМ КРОВОТОКУ В ПОЄДНАННІ З НИЗЬКОІНТЕНСИВНИМИ СИЛОВИМИ ТРЕНУВАННЯМИ У ПІДЛІТКІВ ІЗ НАДМІРНОЮ ВАГОЮ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 5 табл., 5 рис., 43 джерела.

Історія питання та мета дослідження. Тренування з обмеженням кровотоку – це нова техніка тренувань, яка включає вправи низької інтенсивності та може викликати фізіологічні зміни, еквівалентні вправам високої інтенсивності. Метою цього дослідження є оцінка впливу обмеження кровотоку в поєднанні з низькоінтенсивними вправами з опором на м'язову масу та м'язову силу в підлітків із надмірною вагою порівняно зі звичайними вправами з опором.

Матеріали та методи. У дослідженні взяли участь дві рандомізовані групи: експериментальна група, яка виконувала вправи з опором на рівні 40% одноповторного максимуму (1ПМ) у поєднанні з рівнем 60% тиску артеріальної оклюзії (ТАО), і група звичайних вправ з опором, яка виконувала вправи з опором на рівні 70% 1ПМ. Усі учасники пройшли оцінювання складу тіла, 1ПМ та окружності м'язів до та після тестування. Програма тренувань тривала шість тижнів і складалася з тренувань м'язів верхньої та нижньої частини тіла, включаючи такі вправи, як жим ногами, згинання ніг, згинання рук і розгинання рук.

Результати. Група, яка проходила тренування з обмеженням кровотоку з низьким навантаженням (LLBFR), продемонструвала помітне збільшення м'язової маси ($p<0,049$), а також окружності рук і ніг ($p<0,047$ та $p<0,046$ відповідно) порівняно з відповідними показниками до початку програми тренувань, подібне до результатів високоінтенсивних вправ з опором.

Висновки. Поєднання тренувань з обмеженням кровотоку з низькоінтенсивними тренуваннями з опором є потенційно ефективним підходом до збільшення розміру та сили м'язів, особливо у підлітків із надмірною вагою. Більше того, цей тип тренувань може зменшити обсяг фізичного навантаження, що робить його можливим варіантом для осіб, які можуть не переносити високі навантаження через певні медичні стани чи інші обмеження.

Ключові слова: вправи з опором, з надлишковою вагою, оклюзія судин, обмеження кровотоку, локальна гіпоксія, низькоінтенсивний.

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ORIGINAL SCIENTIFIC ARTICLE

CONTROL AND EVALUATION OF THE STRENGTH ABILITIES OF PRIMARY SCHOOL AGE KARATE BOYS

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Abstract

The purpose of this research is to provide a qualitative assessment of the development of strength abilities in 7 year old boys using the results of complex control.

Materials and methods. 32 boys of 7 years old took part in the research. The children and their parents were informed about all peculiarities of the research and gave consent to participate in the experiment. The following research methods were applied to solve the tasks: analysis of scientific and methodical literature, pedagogical testing, and mathematical statistics of research results processing.

Results. Pearson's correlation coefficient was calculated to estimate the closeness of interaction between parameters. The Spearman-Brown formula was used to determine the overall reliability (homogeneity) of the test. The test "Sit-ups in 30 s from the supine position" and the test "Throwing of a stuffed ball from a shoulder with a right hand" have the greatest number of numerous statistical interconnections (r_{xy} = 0.701-0.851) of high degree of significance ($p<0,001$) with other tests characterizing the structure of power fitness of the studied children. It is noteworthy that the test "Throwing a stuffed ball from a shoulder" is an exercise that involves different muscle groups of the trunk and upper and lower limbs. In its structure, it is similar to the technique of punching, so it is advisable to include it in the battery of tests to measure explosive power in martial arts. The 9-point scales of test evaluations were developed.

Conclusions. The tests we tested considering the specific qualities necessary for karate are logically and empirically informative and reliable. They can be recommended for the control of different relatively independent types of power abilities of 7 year old karate boys.

Keywords: strength training, reliability of tests, informativeness of tests, Kyokushinkai karate, boys.

Introduction

In recent decades, scientists have observed dynamic changes in the physical fitness of children and adults toward deterioration (Granacher, Lesinski, Büsch et al., 2016; Bull, Al-Ansari, Biddle et al., 2020; Driukov & Marchenko, 2021). The results of fitness tests indicate a tendency to decrease strength and physical performance in early childhood (Iermakov et al., 2020; Liqin Yin, Changfa Tang & Xia Tao, 2018; Khudolii, Ivashchenko, Iermakov et al., 2019).

Masanovic, Gardasevic, Marques et al. (2020) analyzed research studies that covered 1,746,023 children and adolescents from 14 countries (China, Finland, Sweden, Belgium, New Zealand, Denmark, Spain, Norway, Mozambique, Poland, the United States, Lithuania, Portugal, Canada) from 1969 to 2010. Most studies show a steady decline in strength and endurance, which is not surprising given the constant changes in the lifestyles of children and adolescents.

The tests used to determine static and dynamic muscle strength in the study by Rutkowski, Sobiech and Chwałczyńska (2019) showed significantly lower results compared with reference values from 16 years ago. Long-term changes in muscle fitness over 10 years have been reported in handgrip strength (-6%), squats (-27%), and bent arm hangs (-26%) in English children aged 10-11 years (Smith, Eather, Morgan et al., 2014).

From a health perspective, this decline is a cause for concern, as many studies have shown an inverse correlation between muscle fitness and obesity, cardiovascular disease, and metabolic risk factors in youth (Piek, Bayman & Barnett, 2016; Biernat, Krzepota & Sadowska, 2018; Gjonbalaj et al., 2022). The authors' opinions coincide with the need to develop a comprehensive series of tests that are easy to use to assess motor skills (Masanovic, Gardasevic, Marques et al., 2020; Marchenko & Verdysh, 2021; Kruglov & Khudolii, 2022). This will definitely strengthen the data on longitudinal trends in the physical fitness of children and adolescents around the world.

Karate trainings can be a positive alternative to a sedentary lifestyle for children in terms of their leisure time. It is an active and comprehensive form of involving the body in movement (Marchenko, Ivashchenko, Jagiello et al., 2022). They do not require special equipment and can be widely implemented as part of physical education classes in schools and contribute to the development of motor skills and physical abilities (Rutkowski, Sobiech & Chwałczyńska, 2019; Marchenko, Khudolii, Ivashchenko et al., 2023; Marchenko, Ivashchenko, Jagiełło et al., 2023).

The issues related to testing the strength abilities of 7 year old boys at the stage of initial training in Kyokushinkai karate need to be studied. Studying the qualitative assessment of the level of strength development, checking the tests for reliability and informativeness, and developing normative tables will make it possible to improve control over the effectiveness of the training process and competitive activity of young athletes.

The purpose of this research was to provide a qualitative assessment of the development of strength abilities in 7 year old boys according to the results of complex control.

Materials and methods

Participants

32 boys of 7 years old took part in the research. The children and their parents were informed about all peculiarities of the research and agreed to participate in the experiment.

Design of the study

The following research methods were used to solve the tasks: analysis of scientific and methodological literature, pedagogical testing, and methods of mathematical statistics for processing research results.

The testing program included well-known tests (Eurofit, 1993; Serhienko, 2015; Goncharenko, 2021). Tests were selected in such a way as to comprehensively characterize the structure of children's strength training.

Dynamic strength:
Test 1 – push-ups;
Test 2 – mixed hanging push-ups;
Test 3 – sit-ups in 30s from the supine position
Power endurance:
Test 4 – bent arm hang.
Static strength:
Test 5 – handgrips of a right hand;
Test 6 – handgrips of a left hand.
Explosive muscle strength:
Test – standing long jump;
Test 8 – Vertical jump;
Test 9 – throwing a stuffed ball (1kg) from a shoulder with a right hand
Test 10 – throwing a stuffed ball (1kg) from a shoulder with a left hand

Statistical analysis

Data were collected and systematized using EXCEL (Microsoft Excel 2016, Microsoft Corp., Redmond, WA, USA). Statistical analysis was performed using the statistical software package IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp. USA. The following parameters were calculated: the arithmetic mean of the value (X), the standard square deviation, which characterizes the variability of the trait (S). The hypothesis of normality of the data distribution was determined using the Kolmogorov-Smirnov test (Dn). To assess the closeness of the interaction between the parameters, Pearson's correlation coefficient (rxy) was calculated. The obtained values of the correlation coefficients were considered according to Hopkins (2002) as trivial ($r < 0.1$), small ($0.1 \le r < 0.3$), moderate ($0.3 \le r < 0.5$), large ($0,5) \le r < 0,7$), numerous ($0.7 \le r < 0.9$), almost perfect ($r \ge 0.9$), and perfect ($r = 1$). The significance level was set at $p < 0.05$. The Spearman-Brown formula (r_{tt}) was used to determine the overall reliability (homogeneity) of the test. We used a sigmoidal rating scale to obtain the evaluation standards.

Results

The results of the research are presented in Tables 1-4. The indicators of the studied children presented in table 1 characterize the level of their power abilities. The analysis of average statistical indicators of testing shows that, in general, all indicators of tests correspond to the law of normal distribution by the Kolmogorov-Smirnov criterion. Comparison of the obtained results with the tables "Normative

Table 1. Average statistical indicators of the test results

No	Tests	X	S
1	Push-ups, times	13.53	5.891
2	Mixed hanging push-ups on a rope, times	9.03	3.277
3	Bent arm hang, s	9.50	3.877
4	Standing long jump, cm	125.81	11.363
5	Sit-ups in 30s from the supine position, times	13.72	3.285
6	Handgrips of a right hand, kg	11.59	2.650
7	Handgrips of a left hand, kg	9.88	2.091
8	Vertical jump, cm	17.47	2.770
9	Throwing a stuffed ball from a shoulder with a right hand, cm	292.22	67.048
10	Throwing a stuffed ball from a shoulder with a left hand, cm	228.38	65.927

estimations of physical fitness in primary school age pupils in Ukraine" (Serhiyenko, 2010) and normative tables presented in the curriculum "Kyokushinkai karate" for CYSS (Goncharenko, 2021) indicate that the power fitness of most studied children is at high, above average, and average levels. Many children could not perform the exercise "Hanging push-ups", so it was decided to use a modified test "Mixed hanging push-ups on a rope".

For an objective estimation of boys' power fitness, an analysis of the informativeness of tests was conducted. Table 2 presents characteristics of the interrelation of variables of general power fitness of boys aged 7 years in the form of results of Pearson correlation coefficients. The test "Sit-ups in 30s from the supine position" and the test "Throwing of a stuffed ball from a shoulder with a right hand" have the greatest number of numerous statistical interconnections (r_{xy} = 0.701-0.851) of a high degree of significance (p<0.001) with other tests characterizing the structure of power fitness of the studied children. It is noteworthy that the test "Throwing a stuffed ball from a shoulder" is an exercise that involves different muscle groups of the trunk and upper and lower limbs. A statistically significant correlation (p<0.001) was found with very high correlation coefficients between the results of the test "Throwing a stuffed ball from the shoulder with a right hand" and the results obtained in the following exercises: "Mixed hanging push-ups on a rope", r_{xy} = 0.701, "Bent arm hang", r_{xy} = 0.707, "Sit-ups in 30 s from the supine position", r_{xy} = 0.851, "Handgrips of a right hand", r_{xy} = 0.763, "Throwing a stuffed ball from the shoulder with a left hand", r_{xy} = 0.840. Also "Throwing a stuffed ball from the shoulder with a left hand" with the results in the tests "Sit-ups in 30 s from the supine position", r_{xy} = 0.740.

At a high degree of significance (p<0.001) the results in the exercise "Sit-ups in 30s from the supine position" are very closely interconnected with a large galaxy of tests: "Push-ups", r_{xy} = 0.753, "Bent arm hang", r_{xy} = 0.792, "Standing long jump", r_{xy} = 0.725. The highest correlation coefficient obtained between "Sit-ups in 30s from the supine position" and "Throwing a stuffed ball from a shoulder with a right hand" emphasizes active participation of muscles of an abdominal press during the performance of a push and consequently during the performance of strikes by hands. Strong abdominal muscles are able to transmit a greater force impulse from the leg push from the support to the arms and allow for greater rotational force during the execution of arm striking techniques.

If you perform this test without technical skills and rely only on the strength of your arm muscles, the result is not always desirable. Therefore, it should be borne in mind that throwing heavy objects from the shoulder is best performed with the simultaneous use of the legs (performed from the "kumite dachi" fighting stance with the legs semi-bent), torso muscles (helping to push the ball during its start), and arms (they do the lion's share of the work), but without considering the previous two positions, the test's effectiveness is reduced by 20-30%). It should be noted that the test "Throwing a stuffed ball from a shoulder" is similar in structure to the striking technique, so it is advisable to include it in the battery of tests when measuring high-speed power in martial arts.

Table 2. Correlation dependence between the test tasks

No	Indicators		1	2	3	4	5	6	7	8	9	10	r_{tt}
1	Push-ups, times	r_{xy}	1										0.973
		p											
2	Mixed hanging push-ups on a rope, times	r_{xy}	.388*	1									0.959
		p	.028										
3	Bent arm hang, s	r_{xy}	.849**	.517**	1								0.952
		p	.000	.002									
4	Standing long jump, cm	r_{xy}	.461**	.671**	.517**	1							0.978
		p	.008	.000	.002								
5	Sit-ups in 30s from the supine position, times	r_{xy}	.753**	.618**	.792**	.725**	1						0.959
		p	.000	.000	.000	.000							
6	Handgrips of a right hand, kg	r_{xy}	.518**	.588**	.617**	.448*	.687**	1					0.970
		p	.002	.000	.000	.010	.000						
7	Handgrips of a left hand, kg	r_{xy}	.448*	.547**	.529**	.484**	.657**	.794**	1				0.786
		p	.010	.001	.002	.005	.000	.000					
8	Vertical jump, cm	r_{xy}	.394*	.506**	.489**	.592**	.637**	.499**	.442*	1			0.897
		p	.026	.003	.004	.000	.000	.004	.011				
9	Throwing a stuffed ball from a shoulder with a right hand, cm	r_{xy}	.676**	.701**	.707**	.627**	.851**	.763**	.663**	.635**	1		0.996
		p	.000	.000	.000	.000	.000	.000	.000	.000			
10	Throwing a stuffed ball from a shoulder with a right hand, cm	r_{xy}	.553**	.568**	.523**	.526**	.740**	.579**	.642**	.446*	.840**	1	0.995
		p	.001	.001	.002	.002	.000	.001	.000	.011	.000		

*correlation is significant at the level of 0.05 (two-sided); **correlation is significant at the level of 0.01 (two-sided)

Table 3. Sigma limits deviations of a 9-point scale for evaluating test scores

Qualitative assessment of motor abilities	Points	Sigma limits
Lack of abilities	1	less X – 1.76 S
Very poor abilities	2	from X – 1.26 S to X – 1.75 S
Low abilities	3	from X – 0.76 S to X – 1.25 S
Minor abilities	4	from X – 0.26 S to X – 0.75 S
Average abilities	5	from X + 0.25 S to X – 0.25 S
Capable	6	from X + 0.26 S to X + 0.75 S
Very capable	7	from X + 0.76 S to X + 1.25 S
Super capable	8	from X + 1.26 S to X + 1.75 S
Gifted	9	from X + 1.76 S and more

In the process of correlation analysis, a numerous statistical correlation of high significance was found between the tests "Bent arm hang" and "Push-ups", r_{xy} = 0.849 at p<0.001 and in "Handgrips of a left and a right hand", r_{xy} = 0.794, p<0.001.

The strong interaction of correlation coefficients calculated between the test results with a high degree of significance (p<0.001) made it possible to conclude that the tests are equivalent. Their joint use increases the reliability of assessments of the respective strength abilities. In practice, it may be useful to use only one equivalent test, which simplifies testing and only slightly reduces the informational content of the test battery.

The results of the test "Vertical jump" show an order of magnitude lower correlation with the whole range of other tests (r_{xy} = 0.506-0.637), characterizing different levels of the system of boys' power fitness at the degree of significance (0.01<p<0.001).

After retesting, the reliability coefficient (r_{tt}) was calculated using the intraclass correlation coefficient between the two sets of results. This showed that the tests we selected have unequal but sufficient retest reliability (r_{tt} = 0.786-0.996). Excellent reliability was found in all tests except for "Vertical jump" (r_{tt} = 0.897) and "Handgrips of a left hand" (r_{tt} = 0.786). This may indicate that such element of power fitness as "speed and power" is probably not fully formed and not sufficiently stable in 7-year-old pupils. "Vertical jump" turned out to be technically difficult for children; its performance requires a sufficiently developed ability to coordinate movements. Handgrip reflects the functional state of the child's muscular and nervous systems and is an integral indicator of training and endurance. However, at the beginning of school, children use the leading hand more actively in their learning activities. Therefore, the results of the test "Handgrips of a left hand" showed lower retest reliability.

The mean square deviation served as the basis for determining confidence intervals according to the rule of three sigmas in the development of evaluation scales and indicative indicators for 9 levels (Table 3). According to Serhienko & Sharyi (2010), a 9-point scale for evaluating test scores is the most informative and differentiates the average results more than a 5-point scale.

Discussion

The study assumed that the effectiveness of the training process of 7 year old karate boys within the framework of physical education classes at school depends on the qualitative assessment of the level of development of strength abilities.

The selection of scientifically based tests, checking their informativeness and reliability can solve the problem of decreasing strength and physical performance in children by obtaining accurate data on the state of their strength training. This will allow optimal planning and organization of the process of strength training.

Knowledge about the necessity of such important characteristics as informativeness and reliability for the

Table 4. Evaluation scale for control of coordination abilities of karate boys aged 7 years old

Tests	Points								
	1	2	3	4	5	6	7	8	9
Push-ups, times	< 4	4-6	7-9	10-12	13-15	16-18	19-21	22-24	> 24
Mixed hanging push-ups on a rope, times	< 2	2-3	4-5	6-7	8-9	10-11	12-13	14-15	> 15
Bent arm hang, s	< 2 .6	2.6-4.5	4.6-6.5	6.6-8.4	8.5-10.5	10.6-12.5	12.6-14.5	14.6-16.5	> 16.5
Standing long jump, cm	< 105	105-110	111-116	117-122	123-128	129-134	135-140	141-146	> 146
Sit-ups in 30s from the supine position, times	< 7.0	7-8	9-10	11-12	13-14	15-16	17-18	19-20	> 20
Handgrips of a right hand, kg	< 6.8	6.8-8.1	8.2-9.5	9.6-10.9	11-12.3	12.4-13.7	13.8-15.1	15.2-16.4	> 16.4
Handgrips of a left hand, kg	< 6.1	6.1-7.1	7.2-8.2	8.3-9.3	9.4-10.4	10.5-11.5	11.6-12.6	12.7-13.7	> 13.7
Vertical jump, cm	< 12.6	12.6-13.9	14.0-15.3	15.4-16.7	16.8-18.1	18.2-19.5	19.6-20.9	21.0-22.3	> 22.3
Throwing a stuffed ball from a shoulder with a right hand, cm	< 173	173-206	207-240	241-274	275-308	309-342	343-376	377-410	> 410
Throwing a stuffed ball from a shoulder with a left hand, cm	< 113	113-145	146-178	179-211	212-244	245-277	278-310	311-343	> 343

correct use of any tests has been confirmed (Anastasi & Urbina, 2007; Serhienko, 2010; Chaabène, Hachana, Franchini et al., 2012). These aspects were considered in the battery of tests. This improves the process of teaching physical exercise techniques, makes it possible to achieve the goal in the shortest possible time, significantly reduces injuries, and increases interest in training in sports (Marchenko & Kovalenko, 2020; Marchenko & Bezpalko, 2020; Marchenko & Satdyiev, 2021).

The results obtained complement the information of Marchenko & Ishchenko (2016), Rutkowski, Sobiech & Chwałczyńska (2019), and Hontarenko, Marchenko & Korol, 2022 about the very low level of results in the "Hanging push-ups" test. Our study identified children who could not perform the exercise; therefore, a modified test "Mixed hanging push-ups on a rope" was used. Knowledge about the importance of strength development and its different types in martial arts, means and methods of its determination, and special and effective development has been studied and supplemented (Chaabene, Tabben, Mkaouer et al., 2015; Liqin Yin, Changfa Tang & Xia Tao, 2018; Marchenko & Satdyiev, 2021).

The results of the study by Gąsior, Pawłowski, Jeleń (2020) demonstrate that in childhood, the handgrips test-retest has acceptable reliability. In this study, we found excellent reliability of the handgrips of a right hand and poor reliability of the handgrips of a left hand, which contradicts the data of the authors. This may be due to the more active use of the leading hand during training. According to Driukov & Marchenko (2021) and Mukhina & Marchenko (2021), this test is sufficiently informative for a comprehensive assessment of children's prospects during the selection process for training in a karate sports section.

Kyokushinkai karate is a striking martial art that requires highly developed explosive power and speed. We agree with the opinion of Stamenković, Manić, Roklicer et al. (2022) that the use of the "Standing long jump" and "Medicine ball throw" tests are absolutely justified and logical to include in the battery of tests when measuring high-speed power in karate boys.

Conclusions

Based on the analysis of literary sources and experience of our own research, we can state that the choice of control exercises (tests) determines the depth of the studied material and, therefore, its evidence base. Checking and assessing the level of formation of important motor abilities in primary school students is quite complex, but one of the most important areas of activity for scientists and sports teachers. The choice of indicators of complex control depends on the purpose of testing, which determines the criteria for evaluating the relevant test indicators (informativeness, reliability, etc.).

The authors argue that regular strength training can increase physical activity and improve the physical fitness and individual health of schoolchildren. A high level of strength training is the basis for the effective implementation of high physical, technical, and tactical requirements in Kyokushinkai karate.

The tests we have tested, which considering the specific qualities required for karate, are logically and empirically informative and reliable. They can be recommended for controlling the different relatively independent types of strength abilities of 7-year-old karate boys.

Conflict of interest

The authors declare no conflict of interest.

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КОНТРОЛЬ І ОЦІНКА СИЛОВИХ ЗДІБНОСТЕЙ ХЛОПЦІВ КАРАТИСТІВ МОЛОДШОГО ШКІЛЬНОГО ВІКУ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 35 джерел.

Мета дослідження – надати якісну оцінку розвитку силових здібностей хлопців 7 років за результатами комплексного контролю.

Матеріали і методи. У дослідженні взяли участь 32 хлопця 7 років. Діти та їхні батьки були інформовані про всі особливості дослідження і дали згоду на участь в експерименті. Для вирішення поставлених завдань були застосовані такі методи дослідження: аналіз науково-методичної літератури, педагогічне тестування та методи математичної статистики обробки результатів дослідження.

Результати. Для оцінки тісноти взаємозв'язку між параметрами розраховувався коефіцієнт кореляції Пірсона. Для визначення загальної надійності (гомогенності) тесту використовувалась формула Спірмена-Брауна. Тест «Піднімання в сід за 30 с» і тест «Кидок набивного м'яча від плеча правою рукою» мають найбільшу кількість дуже великих статистичних взаємозв'язків (r_{xy} = 0,701-0,851) високого ступеня значимості (p<0,001) з іншими тестами, які характеризують структуру силової підготовленості досліджуваних дітей. Звертає на себе увагу те, що тест «Кидок набивного м'яча від плеча» являє собою вправу, в якій задіяні різні м'язові групи тулуба, верхніх та нижніх кінцівок. За своєю структурою він подібний техніці ударів руками, тому його доцільно включати в батарею тестів під час вимірювання вибухової сили в єдиноборствах. Розроблено 9-ти бальні шкали оцінок тестових випробувань.

Висновки. Апробовані нами тести враховують специфічні якості необхідні для карате, є логічно та емпірично інформативними та надійними. Вони можуть бути рекомендованими для контролю різних відносно самостійних видів силових здібностей хлопців каратистів 7 років.

Ключові слова: силова підготовленість, надійність тестів, інформативність тестів, кіокушинкай карате, хлопці.

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REVIEW ARTICLE

CONCEPTUAL FRAMEWORK OF APPLIED HOLISTIC EDUCATION IN PHYSICAL EDUCATION AND SPORTS: A SYSTEMATIC REVIEW OF EMPIRICAL EVIDENCE

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Abstract

Background and Study purpose. Holistic education becomes an important aspect to achieve target on education as proposed by sustainable development goals (SDGs). Many believe that education of the future should be comprehensive, aspirational and inclusive, that is holistic education. Physical education is part of school subjects that can be used to realized the educational goal of holistic learning. Through mindful planning and understanding of conceptual framework, physical activity and sports in physical education can be a powerful tool to improve the development of the whole child that includes cognitive, socio-emotional, and physical aspect. To date, there are few systematic reviews that discuss holism in the context of education, and almost none of them specifically discuss holistic education in the physical education setting.

Materials and methods. This paper systematically reports previous empirical studies about the strategies used to implement holistic education in physical education class. There are 15 papers selected in this study following the Preffered Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results. As the result, this study proposes a conceptual framework for designing a teaching strategy in PE to promote whole child development. The framework encompasses the learning dimension of body, mind and spirit. All the aspects are discussed below.

Conclusions. Based on the results and discussion obtained from the 15 reviewed papers, we proposed a conceptual framework to design an approach to implement holistic education in physical education.

Keywords: systematic review, holistic education, physical education, PRISMA.

Introduction

Improving the quality of education is a concern for global leaders. There is special attention given by world leaders on education improvement by inserted education vision in The Sustainable Development Goals (SDGs)(United Nations, 2015). The education which proposed in the SDGs highlight the transformation of education toward comprehensive, holistic, aspirational, and inclusive. According to Mahmoudi et al. (2012), holistic education means to repair future citizen that could transform themselves into individual that concern and mindful about others, for the communities ,and for the planet. This is certainly very relevant to the 21st century demands to balance global economic growth with human development.

Many countries have initiated the use of holistic education in the national education curricula, for example, USA, Canada, Finland, Singapore (Miseliunaite et al., 2022). Those are countries that basically renowned by its high quality of education. They realize that holistic education is necessary to ensure sustainable development, especially regarding human resources. However, judged by SDGs reports, many countries still struggling to achieve significant goals on education. In Indonesia, holistic education has been used as a policy basis in assessing student's learning outcomes that include affective, cognitive, and psychomotor. However, in practice, there are often misconceptions about

the application of holistic education in school settings. For example, it can be observed from study by Hamami & Nuryana (2022) which interpret holistic learning on the balance between religious and science education. This is certainly contrary to the holistic concept which emphasizes balance in student's outcome that incorporating domain of heart, body, and mind.

Physical education (PE), as part of compulsory subject in most school in every level of primary and secondary education, recently has become more important. This is because the value of physical activity and sports in PE is being highlighted to prevent social and psychological problem such as school violence and suicide (Jeon et al., 2021). Unlike any other subject, PE contain physical and sports lesson that can be used to transfer holistic ability to students. Sports hold a significant place in lives and culture. It is not just an activity for improving health and fitness, but it also has a deeper meaning and value. Sports provide many benefits, both physical and mental, that contribute to overall well-being. Sports could provide students with opportunities to learn how to manage their time, set goals, and handle pressure. It also could teach them how to handle success and failure, which are essential skills for success in life. Therefore, Goudas et al. (2006) proposed a call for "education through physical" as opposed to "education of the physical".

Although the attention of holistic education is increasing, there were few literatures study of well-rounded competency within holistic education concept. The study is limited to the following: the contribution of holistic education to world's problem (Miseliunaite et al., 2022), holistic education as an approach for 21st century (Mahmoudi et al., 2012). To the best of our knowledge, literature study focusing on implementation of holistic education within physical education context is scarce or even has not been conducted. Therefore, this paper aim to run investigation from previous study about the strategy that can be used to implementing holistic education into physical education. The main research question of this study is "What are the critical factor that should be considered in designing holistic-based physical education?". Based on the literature review, we propose a conceptual framework that might benefit teacher to guide an instructional model that could facilitate holistic learning in physical education lesson.

Materials and methods

This study uses a preferred reporting items for the systemic review and meta-analysis (PRISMA) approach in collecting, selecting and analyzing papers related to the implementation of holistic education in physical education classes. The PRISMA method has been widely used in the study of literature on health and technology, as for social science, it has also been found in several important studies in education (Sukirman et al., 2021). PRISMA was chosen as the methodological foundation in this study because it was considered the most suitable method to reduce potential bias.

Search procedures and data sources

Databases used in this study include Scopus, Web of Science (WoS), ProQuest, and Springer Link. The above databases are determined based on their good reputation in the academic world, also the availability for access to our condition. After establishing the databases, researchers then set searching keywords, namely "holistic education", "whole child education", "physical education", "sports", "school", "outdoor activity". This study uses the Boolean operators "AND" and "OR" to string keywords into search strings used in bibliographic search. The search string created is applied to searches that include the entire article (title, abstract, keywords). There is no publication time limit from the article search carried out, meaning that each article can be accepted if it is relevant to a predetermined research topic. The final search was carried out in the end of December 2022 resulted in 233 documents. In databases that provide "search within results" features such as Scopus and Web of Science, the search string created is followed up by entering keywords separately and sequentially into the "search within result" line. To produce articles that relevant with the topics of this study, restrictions are used only on education and social studies by utilizing the "filtered by subjects" feature to limit searches only to social studies. The subjects specified in "filtered by subjects" are social sciences. From the advanced search results using the automated search tool, 91 documents were obtained which will be further processed to the screening stage. The detailed result yielded by searching protocol in this study is provided in Table 1.

Table 1. Detail results obtained by the search protocol

Database sources	Documents yielded
Scopus	81
WoS	53
ProQuest	26
Springer Link	73
Total	233

Eligibility criteria

Before entering the screening process, the collected documents are checked for the possible duplication in more than one database. After eliminating duplicates and refine search using automated search tool, the initial investigation was reduced to 91 documents. There are exclusion and inclusion criteria in this study. Documents which met the exclusion criteria will be eliminated, meanwhile documents which met the inclusion criteria will be included. The detailed exclusion and inclusion criteria is presented in Table 2. All documents other than empirical studies is excluded because it does not contain original research to answer research question. Irrelevant documents refer to any study on holistic education which has no relation to physical education is also rejected. Documents which conducted research in other than school-setting is also excluded. Documents included in this review should use student as a study sample, including high school students, but not limited to junior high school and elementary school student. The selection criteria was also based on following criteria: (1) written in English, (2) peer-reviewed journal, (3) open access.

A total of 91 documents were screened. All documents were entered into Excel and given a sequential number from 1 to 91 based on alphabetical order of the title. This was

Table 2. Exclusion and inclusion criteria

Exclusion criteria	Inclusion criteria
Systematic review	Empirical study
Irrelevant documents	Relevant studies
Non curricular activities	Curicullar and co-curricular PE and sports activities
Ongoing research publication	Completed research
Non English publication article	Written in English

followed by a three-stage screening process. In the first stage of the screening process, the title of the documents were reviewed. The purpose of this stage is to exclude documents that seem not relevant to the topic of holistic physical education in schools. If found documents that unclearly met the exclusion criteria, the documents is retained for the next step. If a document was excluded, the exclusion reason was assigned next to document title in the Excel. A total of 55 documents is verified for further screening process. Detailed report on the number of documents being excluded is presented in Figure 1.

Conducted the second round of screening process, the researchers screened the abstract of all remaining documents to determine whether these works employ an experimental study approach on holistic physical education at school. A document was only excluded if it was obvious that it was not fit with the investigation topic of the current study. Figure 1 showed that after the second stage of screening, a total of 25 documents is left for the last stage.

Finally, researchers reviewed all remaining documents during third stage of screening process by read all content of the documents to determine which documents provided

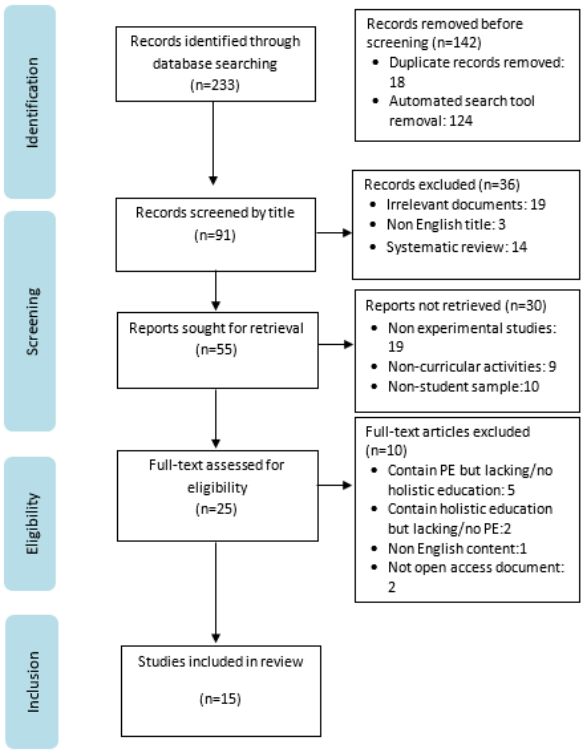

Fig. 1. PRISMA search protocol on this study

sufficient empirical information to be included in the study. Based on the selection criteria presented in Table 2, we selected 15 records as eligible criteria. These were included in the study for further in-depth analysis (see Table 3).

Data extraction and analysis

Information on the included articles were extracted by reading the full text of the manuscript. Then, NVivo software for qualitative methods analysis was used in the present study to code important information into selected theme. This software was selected due to the following advantages: (1) managed data effortlessly; (2) able to find themes easily; (3) save time and energy for data classification. The coding framework was executed based on research question using open coding strategy until data richness was achieved. Coding is administered in paragraphs that are done repeatedly to ensure we do not missed important data. All documents were evaluated and coded based on the following arrangement: bibliography of the article, objective of the study, research design, research settings, study participants, intervention, research instruments, data collection procedure, findings, study limitations, future works, and recommendation.

Results

There were 15 articles included in this study. Most of the articles analyzed in this study represent Western education, and come from the European continent (Poland, Netherlands, Greece, Spain), the Americas (Canada). Meanwhile, the representation of the eastern education system is represented by articles from several countries on the Asian continent such as South Korea, and Japan. This supports the findings of Lee at al. (2014) which states that holistic education is mostly applied in the Euro-American education system, but still relevant to be applied in eastern education systems. Findings from studies categorized into several theme which contain information to answer the research question to summarize answer on the current practice of achieving student's holistic competency using physical education and sports.

Table 4 describes the classification of variables that are contain in the research of 15 selected papers. We categorized them into three types including cognitive skill, socio-emotional skill, and psychomotor skill. Research summarized in this study analyzed the impact that can be caused by physical activity and sports through PE setting in school.

All papers included in this study is limited to empirical study within the scope of physical education or physical activity at school. From the 15 selected papers, mostly were experimental research as illustrated in Fig. 2, namely 73% or 11 articles (Cañabate et al., 2020; Kolovelonis et al., 2023; Koszałka-Silska et al., 2021; Luna et al., 2021; Meijer et al., 2022; Melero-Cañas et al., 2021; Mullender-Wijnsma et al., 2019; Pirrie & Lodewyk, 2012; Wawrzyniak et al., 2022), followed by correlational 13% or 2 articles (Gwon & Shin, 2023; Morita et al., 2016), explanatory 7% or 2 articles (Jeon et al., 2021; Rillo-Albert et al., 2021).

PE on improving psychomotor ability

It is well known that PE is closely related to the empowerment of psychomotor ability. However, not all

Table 3. Selected documents included in the study

No	Authors & Year	Country	Publisher	Database
1	(Rillo-Albert et al., 2021)	Spain	MDPI	ProQuest
2	(Cañabate et al., 2020)	Spain	MDPI	ProQuest
3	(Koszałka-Silska et al., 2021) with a comparison group. ANOVA (2 × 2	Poland	MDPI	ProQuest
4	(Condello et al., 2021)	Italy	MDPI	Scopus
5	(Goudas et al., 2006)	Greece	Springer	SpringerLink
6	(Luna et al., 2021)	Spain	MDPI	ProQuest
7	(Jeon et al., 2021)	South Korea	MDPI	WOS
8	(Meijer et al., 2022)	Netherlands	Wiley	Scopus
9	(Mullender-Wijnsma et al., 2019)	Netherlands	Springer	WOS
10	(Morita et al., 2016)	Japan	Elsevier	WOS
11	(Gwon & Shin, 2023)	South Korea	MDPI	ProQuest
12	(Kolovelonis et al., 2023)	Greece	MDPI	ProQuest
13	(Melero-Cañas et al., 2021)	Spain	MDPI	Scopus
14	(Pirrie & Lodewyk, 2012)	Canada	Elsevier	Scopus
15	(Wawrzyniak et al., 2022)	Poland	MDPI	Scopus

Table 4. Classification of the research variables

Cognitive skill	Socio-emotional skill	Psychomotor skill
Executive function	Emotional intelligence	Physical fitness
Academic achievement	Social competence	Gross motoric skill
Cognitive performance	Emotional regulation	Sports-specific skill
Neurocognitive functioning	Self-esteem	BMI
Cognitive skill	Prosocial behavior	
Brain morphology	Self-belief	
Academic grit	Socio-emotional competencies	
	Motor conflict	

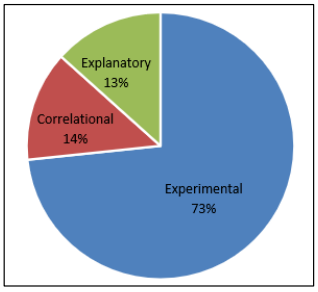

Fig. 2. Study design on selected documents

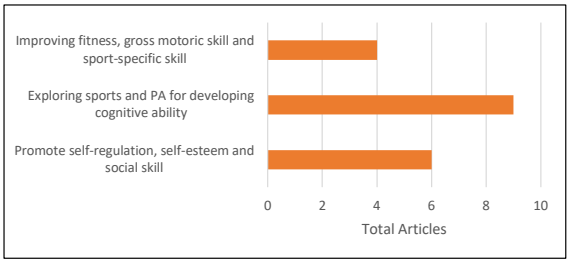

Fig. 3. Main objective of the studies

research available in the research database is included in holistic education studies. Based on 15 papers included in this study, four papers were attributed physical ability to be one of the research variables along with variables from other competency domain (i.e cognitive and socio-emotional).

Based on the reviewed paper, researchers found that their design of study has several impacts on psychomotor ability. As the research conducted by Morita et al. (2016) said that fitness level and obesity level to be one of important factors for student's academic achievement. Additionally, based on the experiment conducted by Wawrzyniak et al. (2022) pointed that delivering PE with cognitive task can stimulate development of both psychomotor and cognitive skill. In addition to achieving benefits in improving fitness level and gross motor skills, PE in holistic learning design can also be used as a means to improve sports-specific skills while still achieving goals in other learning domains. Condello et al., (2021) claimed that PE with integrative theory base can help student to achieve motor and non-motor abilities.

In order to achieve benefit in fitness and psychomotor while still able to secure the advantage on other learning domain in the framework of holistic education, some

researchers suggest that PE lesson should meet the minimum requirement of 20 minutes of moderate-to-vigorous physical activity (MVPA) on each session (Morita et al., 2016; Pirrie & Lodewyk, 2012). In addition, ideally it should also be ensured that students feel joy when participating in PE lessons, so that even though the intensity is moderate-to-vigorous, students can still show a good learning attitude during learning (Gwon & Shin, 2023; Jeon et al., 2021; Kolovelonis et al., 2023; Melero-Cañas et al., 2021).

PE on improving cognitive ability

Cognitive skills are the skills that are used to think, learn, and reason. Some factors that can affect a student's cognitive skill include genetics, environment, and education. PE has been found to have a positive impact on cognitive skills (Gwon & Shin, 2023; Kolovelonis et al., 2023; Meijer et al., 2022; Melero-Cañas et al., 2021). PE can improve cognitive skills in several ways. First, it can increase blood flow to the brain. When the body doing exercise, the heart pumps more blood to the brain, which helps to improve brain function. Second, PE can improve memory and learning.

Exercise has been found to increase the production of a protein called BDNF, which is essential for the growth and survival of brain cells. Third, PE can improve attention and focus. Exercise has been found to increase the production of dopamine, a neurotransmitter that is essential for attention and focus (Chaddock-Heyman et al., 2016; Meijer et al., 2022). It is also supported by Jeon et al. (2021) which states that physical activity in the morning can increase students' intelligence potential through improving brain functions such as concentration, memory, and attitude in the classroom. However, what needs to be considered is that the type and intensity of physical activity that were reported can affect the final result. Experts believe that aerobic activity is superior to other types of physical activity in terms of improving brain function (Chaddock-Heyman et al., 2016; Morita et al., 2016). In order to get optimal results, the duration of physical activity should also be taken into account. Researchers suggested that moderate to vigorous physical activities (MVPA) and longer exposure of MVPA might be required to produce effect on brain structure and function (Meijer et al., 2022; Pirrie & Lodewyk, 2012). Another indirect effect of PE on academic ability is presented by Mullender-Wijnsma et al. (2019). They believe that physically active academic lesson can contribute to student's on-task behavior and academic motivation.

Teaching strategy to support the learning outcomes of cognitive ability is varied among researchers. Jeon et al. (2021) established 0th period of PE class to foster health and academic performance among Korean students. The 0th period of PE was implemented based on the fact that morning exercise is good for brain. The activity was held before the beginning of regular class hour. They claimed through this activity, students are having better learning attitudes, that contribute to their academic performance in class. Kolovelonis et al. (2023) used combination of popular game and physical activity to create "exergames" to be implemented in physical education class. They claimed that in order to conduct a successful PE program, teacher need to arrange activities that attract student's interest to maintain student's motivation to participate in the lesson. This is similar with another research findings that playfulness is important in PE. Through a physical lesson that perceived to be fun, students can develop academic grit that will not only benefit them in PE, but other academic areas to engage in positive school lives (Gwon & Shin, 2023). Different tactical approach used to combine mathematical concept with physical education to create positive impact on cognitive aspect (Wawrzyniak et al., 2022). In this way, classroom teachers (CTs) and physical education teachers (PETs) can collaboratively create meaningful PE by integrating physical exercise with cognitive tasks.

PE on improving socio-emotional skill

The relationship between physical and psychological aspects in sports has been widely recognized in the concept of sound-body sound-mind where indicators of successful coaching should include the development of both (Goudas et al., 2006). PE can have a significant impact on a student's socio-emotional intelligence by fostering skills such as teamwork, communication, emotional regulation, self-awareness, and empathy. By fostering a sense of teamwork and collaboration, PE classes can also help students build positive relationships with their peers and address issues such as bullying and social isolation. Luna et al. (2021) and Goudas et al. (2006) point out that physical activity and sports can promote, both directly and indirectly, student's social and emotional well-being. School physical education is suitable context for student to learn physical and socio-emotional skill simultaneously. This due to several reasons: First, physical and socio-emotional skill can be taught together through demonstration and practice. Second, various skills learned in sports can be applied to social context. The skills including: the abilities to perform under pressure, problem solving, teamwork, communication and to deal with success and failure. Third, sports and physical activity is part of the school curriculum that applies from elementary to secondary education. Therefore, students are likely to be familiar with PE learning environment.

PE teacher should understand that there is intrapersonal dan interpersonal aspect of socio-emotional skill. Not only physically healthy and skilled, through PE, students are educated to be able to manage emotions (intrapersonal) and build good social relationships (interpersonal) with those around them (Jiménez-Parra et al., 2022; Rillo-Albert et al., 2021). Cañabate et al. (2020) conducted research to improve emotional awareness on student's practicing Yoga and Taichi. They investigate whether Yoga, Taichi, and other introjective practices give an impact to student's emotional intelligence. The result stated that there is a significant effect of those practices toward the improvement of student's intrapersonal skill including emotional attention, clarity of feeling and emotional repair. Incorporated SE education to PE lesson is recommended to be done since primary education. This is because in the preadolescent period it is important to form a strong personality through the development of SE intelligence which includes social competences and self-esteem. Jiménez-Parra et al. (2022) added that SE intelligence benefit children and later in their life as an adult to avoid risk of having social and mental disorders. Researchers experimented with educational programs designed to optimize students' SE skills in PE classes. For example,

Goudas et al. (2006) with programs termed as GOAL (Going for Goal) and SUPER (Sports United to Promote Education and Recreation), are programs run to combine physical skills and life skills in PE classes. As a result, in addition to being able to improve or retain physical fitness, students are also able to increase their lifeskill capacity through goal setting orientation. Meanwhile, Luna et al., (2021) initiated an educational intervention based on The Sports Education Model (SEM) to study the effect on social and emotional wellbeing. SEM is a teaching and learning approach that aims to provide students with a more holistic and comprehensive sports experience.

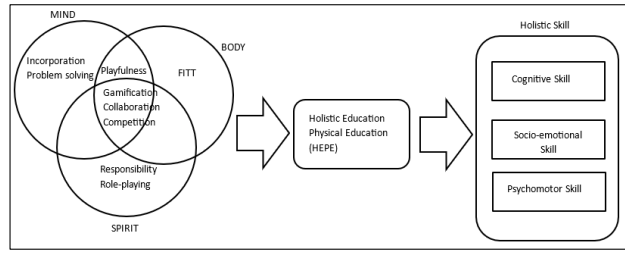

Fig. 4. Conceptual framework to implement holistic education through physical education

Discussion

Based on the above-mentioned articles, we summarized several factors that can be considered to develop and implement PE educational program to achieve holistic development of students. We proposed a conceptual framework to implement a strategy of holistic education physical education (HEPE) as presented in Fig. 4. Based on the concept of holism (Miller, 2019), generally it can be grouped into 3 parts, they are mind, body, and spirit. Mind refers to cognitive aspect, spirit refers to emotional and social capacities, while body means fitness and motor ability. Based on studies included in this systematic literature review, each has attributes that cannot be neglected if the goal is achieve objectives in every learning domain. For example, in the cognitive domain, it is necessary to ensure that learning activities must contain elements of problem solving and combine physical activity and sports with lessons from other subjects such as math and language (Setyaningsih et al., 2019; Sutama et al., 2022; Wawrzyniak et al., 2022). Through such cognitive-enriched, Physical education can not only benefit health and physical fitness but also for other curricular subject such as math, language, and writing. This is because in its implementation, students not only do physical activity but also indirectly learn to count, read, and write. Although the context of Wawrzyniak et al.'s research, (2022) is for elementary school students, this idea can be applied at higher education levels by incorporating other subjects into PE lessons.

Spirit education is part of holistic education because it involves every part of one's being including their emotion, their senses, and their relationship with other (Best, 2011; Thambu et al., 2021). In other words, it comprises intrapersonal and interpersonal skills, both of which are important in efforts to interpret oneself and the social environment. Element of spirit education that we propose in the conceptual framework is responsibility dan role-playing. Responsibility is a concept where students must have responsibility for themselves in terms of emotional control and have roles and responsibilities in their social environment. It involves teaching them to be aware of their social and environmental impact, to understand the consequences of their actions, and to be proactive in making positive contributions to their communities. By emphasizing social responsibility in education, students not only become better citizens, but they also develop a sense of empathy, compassion, and respect for others. Role-playing can be a valuable tool in physical education as well. By assuming different roles and scenarios, students can explore topics such as sportsmanship, teamwork, and leadership, especially through involvement in team sports activity. This can help them develop skills such as communication, problem-solving, and decision-making, as well as a better understanding of different perspectives.

Another dimension of holistic education is education of the body, meaning that being committed in regular exercise and physical activity to improve health and fitness. By emphasizing the importance of physical health, students can develop lifelong habits that promote overall wellness. Physical education classes can also help students develop skills such as coordination, balance, and flexibility, as well as promote teamwork and sportsmanship. Element attributed to body or physical education is exercise principle which consist of frequency, intensity, time, and type (FITT). These principles are used to design effective exercise programs. Frequency refers to how often a person exercises, intensity refers to how hard they exercise, time refers to how long they exercise, and type refers to the type of exercise they do. By carefully considering these factors, teachers can design a PE lesson that is safe, effective, and able to improve student health and fitness. Most of the articles in this study following the schedule of PE as in school curriculum. They vary between once a week to three times per week with each duration could last for 90 minutes. The activity thought in the PE class was mostly sports, and aerobic physical exercise with intensity of medium-to-vigorous. Interventional program is also varied between studies. However, Melero-Cañas et al. (2021) and Wawrzyniak et al., (2022) argue that in order to yield significant effect especially on cognitive and psychomotor domain, intervention should be done through whole academic year.

We propose important elements related to the application of HEPE. These elements are based on the holism concept that each learning domain is related to each other (Shroff, 2011). There are the following: gamification, collaboration, competition, and playfulness. Gamification is described as implementing game element into non-game context (Zainuddin et al., 2020). Gamification added joy,create engagement, learning motivation and social influence while making student immerse in experiential learning. Therefore, gamification is suitable to be implemented of this context so that student will perceive the designed activity fun and attractive. Another shared element is collaboration. Given that HEPE is designed toward problem-based learning, student are encourage to work in group. When student work together to learn, their knowledge and classroom involvement improved. In addition to that, by having a collaboration, student can enrich their social interaction to promote development of socio-emotional competence (Koszałka-Silska et al., 2021) with a comparison group. ANOVA (2 × 2. Competition is also important element to be considered in HEPE. According

to sports education model (SEM), meaningful competition is necessary to provide stimulation and positive motivation (Luna et al., 2021). The last shared element is playfulness, meaning that learning should be fun and engaging. Gwon & Shin (2023) noted that with playability increase, there will be academic grit that also increase. Academic grit is mediating factor for PE-related attitude. Therefore, we can expect a better learning attitude if students possessing academic grit as a result of lesson playability.

We presented holistic skill as the dependent variable in the conceptual framework, which consist of three components, they are cognitive skill, socio-emotional skill, and psychomotor skill. In holistic education concept, all various learning domain is related. There is relationship between body and mind, as well as relationship between the individual and social environment (Miller, 2019). Without having to put aside one aspect from another, learning design must be able to develop individual potential as a whole. Therefore, it is important for an educator to be able to plan, implement, and evaluate learning activities based on learning outcomes in the cognitive, socio-emotional, and psychomotor domains.

Conclusions

Based on the results and discussion obtained from the 15 reviewed papers, we proposed a conceptual framework to design an approach to implement holistic education on physical education. According to holism principle, we make a proposition of connection between body, mind, and spirit. The body encompasses physical health and fitness, mind is about academic achievement or cognitive performance, and spirit is including intrapersonal skill in form of emotional intelligence, and interpersonal skill in form of social competence. The study can be designed in experimental research with two-group pre-posttest design to investigate the differences. Both sports and physical exercise can be used as a lesson to improve students' holistic development. However, many studies noted that sports can be more useful to explore student's prosocial behavior while cognitive enriched activity can improve student's cognitive ability. All in all, to create engagement during intervention, gamification of learning is needed.

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Conflict of interest

The authors declare no conflict of interest in this study.

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КОНЦЕПТУАЛЬНА СТРУКТУРА ПРИКЛАДНОЇ ЦІЛІСНОЇ ОСВІТИ У ФІЗИЧНОМУ ВИХОВАННІ ТА СПОРТІ: СИСТЕМАТИЧНИЙ ОГЛЯД ЕМПІРИЧНИХ ДАНИХ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 4 табл., 4 рис., 30 джерел.

Історія питання та мета дослідження. Цілісна освіта стає важливим аспектом для досягнення освітніх цілей, які узгоджуються із цілями сталого розвитку (ЦСР). Багато хто вважає, що освіта майбутнього має бути комплексною, престижною та інклюзивною, тобто цілісною освітою. Фізичне виховання є тією частиною шкільних предметів, яка може бути використана для реалізації освітньої мети цілісного навчання. Завдяки ретельному плануванню та розумінню концептуальної структури фізична активність і спорт у фізичному вихованні можуть бути потужним інструментом для покращення розвитку дитини в цілому, що включає когнітивний, соціально-емоційний і фізичний аспекти. На сьогоднішній день існує небагато систематичних оглядів, у яких обговорюється цілісність у контексті освіти, і майже в жодному з них конкретно не обговорюється цілісна освіта в умовах фізичного виховання.

Матеріали та методи. У цій статті систематично викладений звіт про попередні емпіричні дослідження стратегій, які використовують для реалізації цілісної освіти на уроках фізичного виховання. У цьому дослідженні було відібрано 15 статей відповідно до рекомендацій «Переважні елементи звітування для систематичних оглядів і метааналізів» (PRISMA).

Результати. Як результат у цьому дослідженні пропонується концептуальна структура для розробки стратегії викладання фізичного виховання для сприяння всебічному розвитку дитини. Ця структура охоплює навчальний вимір тіла, розуму та духу. Усі ці аспекти обговорюються нижче.

Висновки. На підставі результатів та обговорення 15 розглянутих документів ми запропонували концептуальну структуру для розробки підходу до реалізації цілісної освіти у фізичному вихованні.

Ключові слова: систематичний огляд, цілісна освіта, фізичне виховання, рекомендації PRISMA.

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ЕТАПИ РЕДАКЦІЙНОГО ПРОЦЕСУ

Попередній розгляд подання (до 2 тижнів)

- призначення редактора;
- перевірка рукопису щодо відповідності тематики журналу;
- технічна перевірка (обсяг рукопису, обсяг анотації, оцінка подання щодо стилістичних та бібліографічних вимог, викладених у Керівництві для авторів);
- визначення актуальності, новизни та оригінальності роботи;
- наявність педагогічного експерименту, його відповідність методології дослідження, яку можна повторити (репрезентативність вибірки, однорідність вибірки за віком, руховою підготовленістю, рівнем спортивної підготовленості, стажем занять, тощо);
- якщо рукопис є оглядовим, то перевіряється використання протоколу PRISMA, який охоплює систематичні огляди та мета-аналізи. Авторам рекомендовано заповнити контрольний список і блок-схему та включити їх до подання;
- перевірка на плагіат.

Якщо рукопис отримав позитивну оцінку, то він спрямовується на рецензування, інакше – відхиляється.

Рецензування

Підбір та запрошення рецензентів, очікування відповіді на запит (до 2 тижнів). Типовий період, необхідний для проведення рецензування складає чотири тижні.

Всі статті, що оприлюднюються в журналі, проходять рецензування.

Головний редактор журналу направляє статтю на рецензування фахівцям, що мають найбільш близьку до теми статті наукову спеціалізацію. Рецензування проходить за подвійною сліпою схемою.

У процесі рецензування завжди розглядаються:

- етичні аспекти;
- оригінальність твору;
- важливість інформації;
- чіткість та зрозумілість тексту;
- доцільність використання методів дослідження;
- інтерпретація результатів;
- обґрунтованість висновків.

Прийняти рішення щодо публікації (до 2 тижнів)

- обговорення рецензій: запит нової версії, прийняття або відхилення подання;
- якщо приймається рішення про запит виправленої версії рукопису, то автору надається 2 тижні на підготовку рукопису;
- якщо приймається рішення про прийняття рукопису, то він спрямовується на етап підготовки до публікації.
- якщо приймається рішення про прийняття рукопису, то авторам буде необхідно перерахувати журналу Плату за публікацію статті для компенсування витрат на видання.

Підготовка до публікації (4 тижні)

- літературне редагування;
- комп'ютерна верстка;
- ознайомлення авторів з макетом;
- виправлення помилок друку та форматування;
- підготовка і завантаження електронної версії журналу.

Публікація (за графіком)

EDITORIAL PROCESS

Preliminary consideration of the submission (up to 2 weeks)

- appointment of an editor;
- checking the manuscript for consistency with the thematic scope of the journal;
- technical check (volume of the manuscript, volume of the abstract, assessment of the submission in terms of the stylistic and bibliographic requirements set forth in the Guidelines for authors);
- determining the relevance, novelty and originality of the paper;
- verifying the presence of a pedagogical experiment, its compliance with the research methods which can be repeated (representativeness of the sample, homogeneity of the sample in terms of age, motor fitness, level of sports fitness, training experience, etc.);
- if the manuscript is a review paper, the use of the PRISMA protocol, which covers systematic reviews and meta-analyses, is checked. Authors are recommended to complete the checklist and the flow diagram and include them in the submission.
- plagiarism check;

If the manuscript received a favorable assessment, it is sent for review, otherwise it is rejected.

Peer Review

Selection and invitation of reviewers, waiting for a response to the request (up to 2 weeks). The typical period of time allowed for reviews is four weeks.

All articles in this journal undergo peer review. The editor-in-chief of the journal sends the paper for peer review to experts whose scientific speciality is the closest to the topic of the paper. Peer reviewing takes place under a double-blind scheme.

In each paper, the peer review process always considers:

- ethical aspects;
- originality of the paper;
- the importance of information;
- clarity and comprehensibility of the text;
- expediency of using the research methods;interpretation of results;
- validity of conclusions.

Making a decision on publication (up to 2 weeks)

- discussion of reviews: request for a new version, acceptance or rejection of the submission;
- if a decision is made to request a corrected version of the manuscript, the author is given 2 weeks to prepare the manuscript;
- if a decision is made to accept the manuscript, it is sent to the step of preparation for publication;
- if a decision is made to accept the manuscript, the author will need to pay the journal the Fee for publication of the paper to compensate for the publication costs.

Preparation for publication (4 weeks)

- literary editing;
- desktop publishing;
- familiarization of the authors with the layout;
- correction of printing and formatting errors;
- preparation and upload of the electronic version of the journal.

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