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ORIGINAL SCIENTIFIC ARTICLE

INCREASING PHYSICAL ACTIVITY AND FUNDAMENTAL MOVEMENT SKILLS OF PRIMARY SCHOOL STUDENTS DURING THE COVID-19 THROUGH EXERGAME

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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

Study purpose. The low physical activity and fundamental movement skills of students in the COVID-19 era are gaps in this study. This study aims to exam the effects of exergame on the physical activity and fundamental movement skills of students during the COVID-19 era.

Materials and methods. Quantitative research with experimental methods was used in this study. The subjects of this study came from students at primary schools 1 and 2 in Karawang (n = 120). Subjects from primary school 1 Karawang entered the experimental group (n = 60), namely getting treatment in the form of exergame, and subjects from primary school 2 Karawang were included in the control group (n = 60) who did not receive any treatment and only carried out physical education learning activities. The intervention program was carried out for seven weeks. To measure the physical activity of the students, the ActiGraph GT9X Link accelerometer was used, and the fundamental movement skills of the children were assessed using the TGMD-3.

Results. The results showed that the implementation of exergame was proven to significantly improve physical activity ($p < 0.05$) and the same results show that exergame has a significant effect on fundamental movement skills ($p < 0.05$). However, there was no increase in physical activity and fundamental movement skills in the control group ($p > 0.05$).

Conclusions. This research is evidence that exergame is an effective tool to improve physical activity and fundamental movement skills students during the COVID-19 era.

Keywords: exergame, fundamental movement skills, physical activity, experimental.

Introduction

COVID-19 still has a negative impact on all people in the world including the field of physical education in elementary schools, for example the experience of student movement is hampered and the student's physical activity (PA) are low (Xin et al., 2020). Survey data shows that the level of PA carried out by students by 60.0% has decreased to 17.7% due to fear of contracting COVID-19 (Xiang, Zhang & Kuwahara, 2020). Other data reports that the inactivity of community CL in the world globally during the COVID-19 pandemic is estimated at 28% (1.4 billion people) (Puccinelli et al., 2021). Previous studies reported that the decline in the level of PA was due to several factors, such as the policy of staying at home orders, closures of parks, gymnasiums, fitness centers and prohibitions from doing sports or mass PA in public places (Woods et al., 2020). In addition, according

to Violant-Holz et al., (2020) that the decline in PA was due to the effect of lock down (Violant-Holz et al., 2020) and social distancing during a pandemic.

Another factor affected by the COVID-19 pandemic is the fundamental movemen skills (FMS) of students. FMS is the ability to perform three basic movement skills such as locomotor skills, stability skills (Dobell, Pringle, Faghy, & Roscoe, 2020) while aiming to perform sufficient physical activity (PA and manipulative or object control skills (Foulkes et al., 2020; Jones, Innerd, Giles & Azevedo, 2020). Previous studies have found that the development of well-established FMS has the potential to create a healthy lifestyle in the future (Bai et al., 2020). Another benefit of FMS is that it can reduce overweight or obesity in students (O'Brien, Belton, & Issartel, 2016) skip and kick. Previous studies in the UK and internationally reported that the rates of FMS among primary school students has decreased over time (Grainger, Innerd, Graham, & Wright, 2020). Similar to data found in Indonesia, the FMS of primary school students is still low and continues to decline due to an unhealthy lifestyle and rarely doing sports (Burhaein, 2017). Therefore, developing FMS in elementary school children is a very important goal and a priority, because FMS is very useful for them to participate in sports and even non-sports activities.

A potential new training strategy to improve PA and FMS is through exergames (i.e., Xbox 36). Exergame is an innovative and interactive video game that combines training and video (Kappen, Mirza-Babaei, & Nacke, 2019). It requires full body movement from the player. Activities in exergame include cycling (Moholdt et al., 2017a), fitness games, tennis, baseball, dancing, soccer, basketball, boxing, dance, snowboarding. The advantages of exergame are being able to conduct training at home safely (Adcock et al., 2020) and comfortably without being disturbed by bad weather (Yu et al., 2020) especially avoiding the transmission of COVID-19. Exergame has been shown to be a fun activity for children, adolescents, young adults and older adults (Monedero, Murphy, & O'Gorman, 2017)(ii. Research by Andrade et al., (2020) reports that exergame causes boys and girls to have positive improvements in psychological aspects, namely mood and self-esteem. Some researchers claim that exergame is attractive to children and effective in helping them improve motor skills and develop motivation to participate in PA (Soltani, Figueiredo, & Vilas-boas, 2020). However, different results reported by the study of Wu, Li, & Theng, (2015) found that exergame can cause lower motivation compared to traditional training methods for exercise and exergame can also cause poor motor skills (Gao, Zeng, Pope, Wang, & Yu, 2019), so it is difficult to repair (Pedersen, Cooley, & Cruickshank, 2016) it is less clear whether they can provide skill acquisition benefits that are similar to those found in traditional physical education. Purpose: In a previous experiment from our laboratory, we found that deliberate practice can significantly reduce the planning time required for lateral arm movements. The purpose of this study was to determine if exergames can produce a similar effect, by reducing the processing time required for children to initiate arm movements to the contralateral and ipsilateral space. Participants and setting: Thirty children (boys = 15, girls = 15). Then recent studies have shown that exergames have an inconsistent impact on children's motor skill competence in the short term (Hulteen et al., 2018). With the results of previous exergame with the gap, it is the reason for us to uncover this problem. Many previous studies have examined exergame (Vernadakis et al., 2015; Villafaina et al., 2020; Polechoński, Dębska, & Dębski, 2019). However, there is no research that explores how the effects of exergames on PA and FMS of students during COVID-19 era. The this study will implicated the development of PA and FMS provide information knowledge to teachers, lecturers and practitioners about the benefits obtained from the exergames. Therefore, the aim of this study was to test the effectiveness of exergames to increase PA and FMS student during the COVID-19 era.

Materials and Methods

Study participants

All subject came from two primary school in the region Indonesia. The school was selected because it has quality teachers and one of the largest and most structured schools with ideal facilities for implementing sports games and for offering PE classes three times a week of 60 minutes each. Subject are first explained about the rules for carrying out research and asked to make written agreements. The sampling technique used to select subject was random assignment. Subject characteristics are presented in Table 1.

Instruments

Physical Activity Levels. To measure PA students can use the ActiGraph GT9X Link accelerometer, namely ActiGraph light and resembles a watch. This instrument is valid and reliable. Students are instructed to use the accelerometer in their arms every time they go to school. The activity counts recorded were interpreted using empirically based cut points

Table 1. Socio-demographic of subjects

Variables	n(%)
Gender	
Male	50(41.67%)
Female	70(58.33%)
Age (y)	
10	35(29.17%)
11	27(22.50%)
12	58(48.33%)
Weight (kg)	
25	30(25.00%)
30	38(31.67%)
35	52(43.33%)
High (cm)	
125	37(30.83%)
130	40(33.33%)
135	43(35.83%)
School	
Primary School 1 Karawang	60(50.00%)
Primary School 2 Karawang	60(50.00%)
Class	
5	46(38.33%)
6	74(61.67%)

that defined different intensities (sedentary: 0820; light PA: 8212830; moderate-to-vigorous PA (MVPA): 2831 for ActiGraph vector magnitude) of preschool children's PA. Student average percentages of time in MVPA at school were used as the outcome. Notably, the accelerometers were not allowed to be taken home given the following considerations: (1) additional burden for underserved families, (2) possibility of lost or stolen devices, and (3) incomplete and inaccurate measurements. Therefore, only PA during school time was used for the current study (Gao, Zeng, Pope, Wang, & Yu, 2019).

Fundamental Movement Skill. Test of Gross Motor Development-3rd Edition (TGMD-3). The TGMD-3 is comprised of locomotor (run, skip, leap, hop, and horizontal jump) and object-control (catch, kick, underhand roll, one-hand strike and two-hand strike) skill subtests. While the TGMD is a common assessment tool used in many studies worldwide, some would criticise the lack of a stability component. To this end, a subtest of the Bruininks–Oseretsky Test of Motor Proficiency 2 (BOT-2) Short Form was utilised to assess the participants' balance. The balance assessment consists of two tasks, walking forward along a straight line, and standing on one leg (Behan et al., 2019)complex movements required to participate in physical activity. This study examined FMS proficiency across the full range of Irish primary school children (n = 2098, 47% girls, age range 5-12 years. Each FMS in TGMD-3 is accompanied by performance criteria. For example locomotor motion with criteria if the movement of running, leap, jumping, and jumping horizontally is done correctly according to the assessment norm, then it gets a value of 1 to 4 and if it does not match the assessment norms it is given a value of 0. As for control objects, there are three performance criteria to capture: a) the preparatory phase in which the hands are in front of the body and the elbows are bent, b) the arms are outstretched as they reach the ball as it comes in, and, c) the ball is caught with the hands only. Each child is evaluated against these criteria. If the performance criteria are met, grades 1 to 4 are assigned. If a performance criterion is not met, a score of 0 is assigned. Meanwhile, the assessment for stability component balance is by assessing how long the child can do walking straight lines, and standing on one leg. Each child tried two experiments for each movement skill and was assessed based on performance criteria (Vernadakis et al., 2015). The total score of the child (the sum of their individual scores) is calculated.

Study organization

This research has been approved by the Ethics Committee of Public primary school, Karawang, Indonesia (approve number: 126/11/2021) and this research is in accordance with Helsinki declaration. Parental consent forms and subject' consent forms regarding participation in this study were collected before the intervention program began. This research was conducted in the new normal era and implemented the COVID-19 protocol, where each child was checked for body temperature first, then given a hand sanitizer. Subjects from the primary school 1 Karawang entered the experimental group (n = 60), namely getting treatment in the form of exergame and subjects from primary school 2 Karawang were included in control group II (n = 60) who did not receive any treatment and only carried out physical education learning activities. The intervention program was carried out for 7 weeks, three times per week and 60 minutes per week. The intervention program began with pre-test activities on November and ended in post-test on December, 2021. All data collection procedures were recorded via video, then the video would be analyzed by researchers and experts. Flow studies are presented in Figure I.

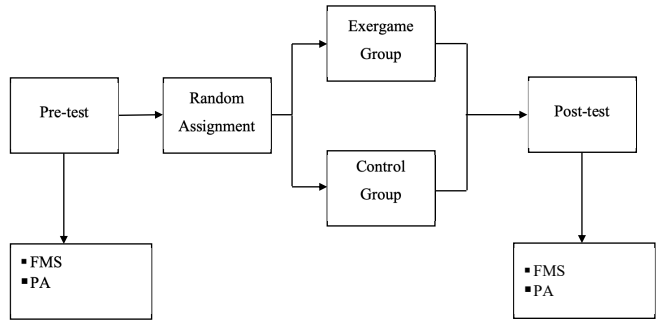

Fig. 1. Study flow

Exergame Program. For the experimental group, the exergame was conducted on Thursday, Friday and Saturday from 08.00-09.00 hours, for 7 weeks, it aims to develop PA and FMS owned by children aged 10-12 years. The program is carried out in the gym three times a week for 60 minutes. The Exergame program is presented in Table 2.

Table 2. Exergame program

Training component	Exercise activities	Duration
Warm-up	Proprioceptive neuromuscular facilitation (PNF) and jogging.	10 min
Focus on practice	The Exergame program items used are (1) Volleyball, (2) Tennis games, (3) Basketball games, (4) Standing twists games, (5) Running games, (6) Dancing games.	40 min
Cool-down	Stretching.	10 min

Statistical analysis

Statistical analysis was performed using the IBM SPSS application Version 25.0 for Windows. Descriptive statistic was presented as mean±standard deviations. The normality of the data was evaluated using the Shapiro-Wilk test. If the normal distribution is found to be parametric, the statistics are used analysis. Paired samples t-test are used to determine differences between baseline values. The statistical significance level was set a $p < 0.05$ for all analyses.

Results

The results of the normality test of the data in this study were declared normal. The statistical descriptive values in the exergame and control groups are presented in Table 3.

Table 4 shows that exergames have a significant effect on increasing PA and FMS ($p < 0.05$). While Table 5 shows the opposite result, namely the control group has no effect on increasing PA and FMS ($p > 0.05$).

Table 3. Descriptive statistics

	Pre-Test	Post-Test
	M(SD)	M(SD)
Exergames (n = 60)		
MVPA (min/day)	49.23(7.97)	58.37(8.79)
FMS	52.03(8.37)	63.18(10.82)
Control (n = 60)		
MVPA (min/day)	47.67(9.77)	47.82(9.18)
FMS	45.18(8.20)	46.33(9.38)

Note: M = Mean; SD = Standar deviasi; MVPA = Moderate-to-vigorous physical activity; FMS = Fundamental movement skills

Discussion

The purpose of this study was to examine the effects of exergame and traditional game interventions on increase PA and FMS in student during the COVID-19 era. The results of this study showed that exergame intervention can improve the PA component. The increase in PA occurred because exergames had interesting games (e.g., bowling games, tennis games, basketball games, standing twists games, running games, dancing games), so that through these games inactive students became more enthusiastic (Huang, 2020) few studies investigated whether combining exergaming with VR would be more effective. This study seeks to (a and have the motivation to move (Soltani, Figueiredo, & Vilas-boas, 2020). One of the keys to changing PA behavior is because exergames offer an interesting, safe game experience that can be played at home, so students can continue to actively move. The results of this study support previous research which reported that exergame can be used as a tool to encourage students to participate in PA (Soltani, Figueiredo, & Vilas-boas, 2020).

The second finding in this study proves that exergame can positively increase the FMS of students during the COVID-19 era to be higher. Exergame had the characteristics of a very fun game, easy to play and can be done at any time (Lee, Kim, Park, & Peng, 2017) complex movements required to participate in physical activity. This study examined FMS proficiency across the full range of Irish primary school children (n = 2098, 47% girls, age range 5-12 years, so that children who are not interested in sports activities become more enthusiastic and actively move in PE class. Fogel, Miltenberger, Graves, & Koehler, (2010) confirmed that exergame can provide opportunities to engage in higher physical activity than doing standard exercise programs. Exergame had been proven to be an effective game and worthy of use in PE class, because it has the power to trigger interest, motivation and the ability to move children to sustainably participate in sports activities. Previous studies conducted in a school context have identified that the exergames practice can increase physical activity, mental health, and motor skill competence in children (Andrade et al., 2020) complex movements required to participate in physical activity. This study examined FMS proficiency across the full range of

Table 4. Differences values in pre-post of PA, FMS in exergames group (n = 60)

		Paired Samples Test					t	df	Sig
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
PA	Pre-Test Post-Test	-9.133	5.936	0.766	-10.667	-7.600	11.918	59	0.000
FMS	Post-Test Pre-Test	-11.150	7.876	1.017	-13.185	-9.115	10.966	59	0.000

Note: PA = Physical activity; FMS = Fundamental movement skills

Table 5. Differences values in pre-post of PA, FMS in control group (n = 60)

		Paired Samples Test					t	df	Sig
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
PA	Pre-Test Post-Test	-0.150	10.581	1.366	-2.883	2.583	-0.110	59	0.913
FMS	Post-Test Pre-Test	-1.150	9.260	1.196	-3.542	1.242	-0.962	59	0.340

Note: PA = Physical activity; FMS = Fundamental movement skills

Irish primary school children (n = 2098, 47% girls, age range 5-12 years as well as becoming a potential educational tool today. Exergame is a great activity for children to use in the long term and on a sustainable basis. The results of this study are in line with the research of Vernadakis et al., (2015) who reported that the XbK-based balance exergame program was significantly more enjoyable than traditional physiotherapy. The main reason why exergame programs were more fun than traditional physiotherapy was that exergames provide more interesting challenges for athletes. Exergame activities are fun psychological teaching activities for children that can help improve their physicality (Van Santen et al., 2018). According to Mohold et al., (2017b) the use of fun exergames can be a useful strategy for promoting physical activity, especially for those who were less motivated by traditional sports. The results of this study support previous research that has shown that children's FMS was more developed through exergame than traditional sports (Moholdt et al., 2017b) and that subject PA levels were higher for exergames than traditional activities. One reason for answering these results is because children in the current era are more familiar with exergame than traditional games, besides that the number of children's movement activities is more often in exergame than traditional games.

Conclusions

The main conclusion in this study shows that the implementation of exergame can positively improve PA and FMS student during the COVID-19 era, but not for the control group. The limitations in this study are: (1) the sample of the study is relatively small, (2) the subjects only are only from two urban primary school in region (Indonesia). Then the further must use more subjects and come from several elementary schools in Indonesia. Apart from the limitations of this study, several implications arise from this study, namely that exergame can be used as an effective pedagogical tool to increase PA and FMS in student during the COVID-19 era, besides that the results of this study provide important information for teachers, lecturers and practitioners about the advantages of exergame. The findings of this study could potentially be applied to future studies involving exergame with other platforms, such as: Wii (Nintendo, Kyoto, Japan) Just Dance for Kids (Ubisoft, San Francisco, CA, USA), Wii Nickelodeon Fit (Nickelodeon, New York, NY, USA), and Just Dance or using other games such as: biking, yoga, walking, weight training, softball.

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Conflict of interest

No conflict of interest.

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ПІДВИЩЕННЯ РІВНЯ ФІЗИЧНОЇ АКТИВНОСТІ ТА ОСНОВНИХ РУХОВИХ НАВИЧОК УЧНІВ ПОЧАТКОВИХ КЛАСІВ ПІД ЧАС ПАНДЕМІЇ COVID-19 ШЛЯХОМ ЗАСТОСУВАННЯ ФІТНЕС-ГРИ

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Реферат. Стаття: 7 с., 4 табл., 1 рис., 33 джерела.

Мета дослідження. Низький рівень фізичної активності та основних рухових навичок учнів в епоху COVID-19 є прогалинами в цьому дослідженні. Це дослідження має на меті вивчити вплив фітнес-гри на фізичну активність та основні рухові навички учнів в епоху COVID-19.

Матеріали та методи. У цьому дослідженні було використано кількісний аналіз із застосуванням експериментальних методів. Учаниками цього дослідження були учні початкових шкіл № 1 і № 2 міста Караванг, Індонезія (n = 120). Учасники з початкової школи № 1 міста Караванг увійшли до експериментальної групи (n = 60), а саме отримували експериментальні процедури у формі фітнес-гри, а учасники з початкової школи № 2 міста Караванг були включені до контрольної групи (n = 60), які не отримували експериментальних процедур та проводили лише навчальну діяльність із фізичного виховання. Інтервенційну програму проводили протягом семи тижнів. Для вимірювання фізичної активності учнів використовували акселерометр ActiGraph GT9X Link, а основні рухові навички дітей оцінювали за допомогою тесту на розвиток великої моторики TGMD-3.

Результати. Результати показали, що впровадження технології фітнес-гри статистично значуще покращує рівень фізичної активності ($p < 0,05$), і ті самі результати показують, що фітнес-гра має статистично значущий вплив на основні рухові навички ($p < 0,05$). При цьому в контрольній групі підвищення рівня фізичної активності та основних рухових навичок не спостерігалося ($p > 0,05$).

Висновки. Це дослідження є доказом того, що фітнес-гра є ефективним інструментом для покращення показників фізичної активності та основних рухових навичок учнів під час пандемії COVID-19.

Ключові слова: фітнес-гра, основні рухові навички, фізична активність, експериментальний.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF MOVEMENT GAMES ON THE LEVEL OF PHYSICAL FITNESS AND MENTAL HEALTH OF STUDENTS WITH DISABILITIES: MIXED METHOD

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Abstract

Study purpose. This study aims to investigate the effects of movement games as an effort to increase the level of physical fitness and mental health of students with disabilities during COVID-19.

Materials and methods. This study adopted a mixed method. The participants involved in this study were students with disabilities who came from two special schools students with disabilities in Karawang Regency, Indonesia (n=40). Participants were divided into an experimental group who carried out a movement game program (n=20) and a control group (n=20) who followed routine learning without participating in any activities. After implementing the movement game program, 20 participants were interviewed about the experiences, advantages and disadvantages of the movement game program. Quantitative research instruments used muscular strength, muscular endurance and cardiorespiratory fitness tests. Meanwhile, the qualitative research instrument used in-depth interviews for 30 minutes. Analysis of quantitative data used IBM SPSS, and analysis of qualitative data used thematic analysis.

Results. The quantitative study results showed that there was a significant increase in the level of physical fitness and mental health in the experimental group ($p<0.05$), and no increase was found in the control group ($p>0.05$). In addition, the qualitative study results showed that the majority of participants acknowledged that the movement game program was a fun method of education and had a positive effectiveness.

Conclusions. After carrying out this research, we confirm that the movement game activity is an education method that has a great effect on the increase in the physical fitness level and mental health of students with disabilities during COVID-19.

Keywords: movement games, physical fitness, mental health, mixed method.

Introduction

The current COVID-19 pandemic crisis has attacked several aspects including physical fitness among the community (Rasheed, Abduljawad, Mabrouk, Jdaitawi, Abdulmonem, 2021; Gultom, Baharuddin, Ampera, Fibriasari & Sembiring, 2022), including students with disabilities. A survey study reported that 80% of Indonesian people have low physical fitness (Kusuma et al., 2021). Data reported several factors induce the lowering physical fitness levels such as isolation/lock down (Kamyuka, Carlin, McPherson & Misener, 2020), work and school from home (Kaur, Singh, Arya & Mittal, 2020; Liskustyawati, Riyadi, Sabarini, Waluyo & Shidiq, 2020),

physical activity was limited and significantly reduced (Hillyard, Sinclair, Murphy, Casson, Mulligan, 2021). Physical fitness is an important aspect for students to learn at school during the COVID-19 crisis (Dao, 2021), because a high level of physical fitness could support students to perform various activities without experiencing excessive fatigue and obtain an optimize learning outcomes. On the other hand, low levels of physical fitness will hinder the students in the learning process and consequently decreasing their achievement (Gultom, Baharuddin, Ampera, Fibriasari & Sembiring, 2022).

Recently, COVID-19 has attacked the mental health of all people in the world (Suarez-Balcazar et al., 2021; Yang, Li & Yu, 2021; Essadek et al., 2022), including students with disabilities who has high risk to being affected by COVID-19 so that it often affects their level of mental health (Sharpe et al., 2021; Walton, Medhurst, Madhavan & Shankar, 2022). Mental health is a condition of someone who does not experience a mental disorder, such as depression, high anxiety and stress, a mood disorder or refers to a state of well-being of a person who can overcome pressure in life (Buckley et al., 2020; Sokić et al., 2021). According to Huang, (2021) mental health refers to the emotional, psychological and social well-being of a person. Students with high mental health will have motivation and independence in learning, on the other hand students with low mental health are less motivated to learn, so academic achievement will decrease drastically and they are likely to drop out from school (Grubic, Badovinac & Johri, 2020). A recent study reported that the impact of COVID-19 has affected all fields, especially education, in which the learning system has shifted from offline to online (Jumareng et al., 2022). Several obstacles in online learning, such as platforms that incompatible with technology that used to teach visually impaired students and poor internet connection (Jumareng et al., 2021), coupled with the lack of recreational activities that can be conducted at home have been proved as factors that cause students with disabilities felt frustration or mental health impairment (Patel, 2020). According to Grubic, Badovinac and Johri, (2020), cessation of teaching and learning activities in schools, loss of routine and social connections among students are factors that worsen mental health conditions. Given the importance of physical fitness and mental health for students with disabilities, an appropriate and effective teaching is needed for them, namely through movement games.

Movement games are activities that involve various kinds of movement activities (e.g., Walking Paper Color, Trampoline, Hoolahoop), in fun games for students with disabilities (Kamyuka, Carlin, McPherson & Misener, 2020). According to Dao, (2021) movement games involved motor skills such as jumping, crawling, running, walking. This game presents a lot of movement in a game as a powerful tool to increase the overall potential of students. Previous research has reported that game-based sports have a positive effect on improving athlete performance (Gabbett, Jenkins & Abernethy, 2009). This movement game provides various benefits that have been reported by previous studies (Chou, Chen, Huang & Tu 2020). Unfortunately there is still limited literature on this movement game and there was no previous studies have reported on the effect of movement games to change physical fitness levels. and mental health of children with disabilities during COVID-19. This research offers something different from previous research, namely investigate the effects of movement games through mixed research, in order to reveal the effects of movement games with quantitatively and qualitatively. It is expected that this research could contribute to the development of movement games in the physical education, to improve the level of physical fitness and mental health of students with disabilities in the current pandemic crisis era. Therefore, the purpose of this study was to examine the effect of movement games to increase the level of physical fitness and mental health of students with disabilities.

Materials and Methods

Study participants

This research adopted mixed methods, namely research that combined quantitative and qualitative method. Research with mixed method aims to reveal the problem through two analyzes between quantitative and qualitative (Gani et al., 2022).

The participants in this study were students with disabilities who came from several special schools with disabilities in Karawang Regency (Indonesia). The recuitment method is as following: (1) researchers conducted a survey to two schools for children with disabilities in Karawang Regency, (2) researchers sent invitations to participate in research via Whatsapps to parents and students, (3) researchers recorded how many students were willing to participate in the research, (4) students were provided with information about the research and required to make a statement about their willingness to participate in all activities in the intervention program, (5) students who participated in the study were given a $15 gift as a thank you for participating. Participants were allocated to the experimental group (n=20), which received treatment in the form of movement games and partly to the control group (n=20), where participants carried out their usual daily learning activities. The characteristics of the participants are presented in Table 1.

Instruments

Quantitative Instruments

Instruments to assess the physical fitness level of disabled students were adopted from the American College of Sports Medicine (ACSM), including: muscular strength,

Table 1. Characteristics of Participants

Variables	n(%)
Gender	
Boys	20(50.0%)
Girls	20(50.0%)
Age (y)	
9	20(50.0%)
10	20(50.0%)
Weight (kg)	
30	12(30.0%)
35	15(37.5%)
40	13(32.5%)
High (cm)	
130	16(40.0%)
135	19(47.5%)
140	5(12.5%)

muscular endurance and cardiorespiratory fitness (Wouters, Evenhuis & Hilgenkamp, 2020).

Muscular strength. This test aims to assess the muscle strength of students aged 4-10 years using throwing bags. In this test, the participant stood behind the line and then lifted a 4 kg bag over his head and thew the bag as far as possible. The throwing distance of the bag was measured in cm. Participants had three chances and the final score was the best score of three repetition. This test has an Intraclass Correlation Coefficients (ICC) =0.76.

Muscular endurance. This test aims to assess students' muscular endurance by using the stair climbing test. Participants walked as fast as they can to go up and down as many steps as possible in 30 seconds. The score was determined based on the number of steps in 30 seconds. The participants had three chances and the final score was the best score of the three repetition. This test has an ICC = 0.92.

Cardiorespiratory fitness. Participants walked as far as possible by crossing a 20 m track for 6 minutes. After that, their heart rate was checked using Polar.

Instruments to assess the mental health level of students with disabilities adopted from previous studies (Gilmore, Campbell & Shochet, 2022), including:

Revised Children's Manifest Anxiety Scale (RCMAS). This instrument aims to assess anxiety in children with disabilities aged 6 to 19 years. This instrument has 37 items with subscales of Physiological Anxiety, Excessive Anxiety, Sensitivity, and Social Anxiety/Concentration. This instrument is assessed using a scale of 1 = "yes" and 0 = "no".

Strengths and Difficulties Questionnaire (SDQ). This instrument has 25 items with subscales: hyperactivity, emotional symptoms, peer problems, behavioral problems and pro-social behavior. This instrument was rated using a scale of 1 = "not true", 2 = "somewhat true", 3 = "of course".

Intellectual Disability Mood Scale (IDMS). This instrument was developed for children with disabilities aged 10 to 18 years and has been used frequently by previous studies and has been validated with Cronbach ranging from 0.63 to 0.77. This instrument has 12 question items with subscales: Anger, Confusion, Depression, Fatigue, Tension. This instrument was assessed using a Likert scale from a value of 1 to 5.

Qualitative Instruments

The instrument for qualitative research used in-depth interviews with participants with a duration of 30 minutes per individual. Interviews were conducted directly via Whatsapps and Bahasa language.

Research Program. This research was conducted in January-February at Singaperbangsa University Karawang (Indonesia) with approval number: 261.174/SP2H/UN64.10/LL/2022 and the 2 schools involved also approved this research. In addition, the research follows the guidelines of the World Medical Association Code of Ethics (Helsinki Declaration for humans). In this quantitative study there were several meetings, namely the first meeting on January 1, 2022, all participants carried out a pre-test (physical fitness and mental health test). The second meeting on January 5, 2022, the experimental group carried out the movement game program and the control group only carried out their usual daily activities until the 15th meeting (February 11, 2022). At the 16th meeting (12 February 2022), all participants carried out final exam activities, namely physical fitness and mental health tests. The movement game program was carried out on Wednesday, Friday and Saturday in the morning from 08.00-09.00 in the field located at Singaperbangsa University Karawang (Indonesia). This study strictly applied the COVID-19 health protocol, for example all participants and the research team were checked for body temperature and used hand sanitizers and are vaccinated before the intervention program. While the qualitative research was conducted on 16 and 17 February 2022, the movement game intervention group was interviewed for 30 minutes and the interviews were conducted using Bahasa language. The movement game program is presented in Table 2.

Table 2. Program movement games

Training Unit Components	Activities	Duration
Warm-up	Prestretch and warm-up	5 min
Program movement games	1. Boucce 2. Walking paper colour 3. Frog jump 4. Trampoline 5. Hoolahoop One movement game is done with a duration of 10 minutes.	50 min
Cool-down	Cardiorespiratory cool down and the poststretch.	5 min

Statistical analysis

Quantitative analysis. Quantitative data were analyzed using IBM SPSS version 25.0 statistical software version 25.0 (Armonk, NY: IBM Corp) to find descriptive statistics (mean±standard deviation) and data normality. Paired-samples t-tests were used to test the scores of physical fitness and mental health before and after in the experimental and control groups (Xu, Yao, Kang & Duan, 2020). The level of significance used is 0.05.

Qualitative analysis. The qualitative analysis in this study was qualitative thematic, namely the results of in-depth interviews were coded and categorized into three themes, namely: theme 1: Experience of movement games, theme 2: Benefits of movement game and theme 3: Disadvantages of movement games.

Results

In this study, the normality test of data was declared normal ($p>0.05$). Statistical descriptive tests are presented in Table 3. While the results of the paired-samples t-tests showed that the experimental group that movement games was proven to have a significant positive effect on increase the level of physical fitness and health of students with disabilities ($p<0.05$), but there was no significant effect in the control group ($p>0.05$) (Table 4).

While the results of qualitative research through in-depth interviews with the experimental group obtained the following answers:

Table 3. Descriptive Statistics of PF and MH in the EG and CG groups

Dependent Variable	EG				CG			
	Boys (n =10)		Girls (n =10)		Boys (n =10)		Girls (n =10)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
	M(SD)	M(SD)	M(SD)	M(SD)	M(SD)	M(SD)	M(SD)	M(SD)
PF								
MS	63.50(8.32)	71.50(8.77)	62.20(7.06)	67.50(7.73)	63.20(8.32)	61.40(7.91)	62.70(7.11)	62.30(6.46)
ME	14.10(1.79)	16.20(1.22)	10.50(1.08)	14.00(1.56)	14.60(2.59)	13.80(2.57))	12.40(1.71)	11.80(1.47)
CF	62.50(3.80)	66.90(3.21)	68.20(3.76)	76.00(4.34)	70.30(3.82)	69.20(3.99)	71.00(3.46)	70.30(2.83)
MH								
RCMAS	27.803.76)	26.50(3.47)	30.60(3.97)	27.20(4.07)	27.80(3.76)	29.70(4.11)	28.90(4.08)	28.10(3.24)
SDQ	22.10(2.05)	20.60(2.11)	21.10(3.95)	19.50(3.71)	22.10(2.02)	21.80(2.57)	23.30(3.09)	22.80(3.36)
IDMS	30.00(3.26)	26.70(2.005)	29.70(2.35)	21.80(2.82)	27.40(3.74)	28.10(4.30)	26.90(3.95)	27.40(4.03)

Note. PF: Physical Fitness, MH: Mental Health, MS: Muscular Strength, ME: Muscular Endurance, CF: Cardiorespiratory fitness, RCMAS: Revised Children's Manifest Anxiety Scale, SDQ: Strengths and Difficulties Questionnaire, IDMS: Intellectual Disability Mood Scale, M: Mean, SD: Standard Deviation, EG: Experimental Group, CG: Control Group, n: participant.

Table 4. Differences values in pre-test and post PF and MH in the EG and CG groups

Dependent Variable	EG (n = 20)						CG (n = 20)					
	Pre-Post Boys M(SD)	t	p	Pre-Post Girls M(SD)	t	p	Pre-Post Boys M(SD)	t	p	Pre-Post Girls M(SD)	t	p
PF												
MS	8.30 (4.32)	6.073	0.000	5.30 (3.26)	5.129	0.001	1.80 (4.21)	1.352	0.209	0.40 (3.95)	0.320	0.756
ME	2.10 (1.19)	5.547	0.000	3.50 (2.01)	5.496	0.001	0.80 (1.47)	1.714	0.121	0.60 (1.71)	1.108	0.297
CF	4.40 (1.71)	8.124	0.000	7.80 (2.70)	9.136	0.000	1.10 (2.13)	1.632	0.137	0.70 (2.00)	1.105	0.298
MH												
RCMAS	1.30 (1.05)	3.881	0.004	3.40 (1.35)	7.965	0.000	1.90(5.74)	1.046	0.323	0.80 (2.25)	1.124	0.290
SDQ	1.50 (1.43)	3.308	0.009	1.60 (.516)	9.798	0.000	0.30 (1.49)	0.635	0.541	0.50 (1.17)	1.342	0.213
IDMS	3.30 (2.16)	4.825	0.001	7.90 (2.33)	10.718	0.000	0.70 (2.79)	0.793	0.448	0.50 (.972)	1.627	0.138

Note. PF: Physical Fitness, MH: Mental Health, MS: Muscular Strength, ME: Muscular Endurance, CF: Cardiorespiratory fitness, RCMAS: Revised Children's Manifest Anxiety Scale, SDQ: Strengths and Difficulties Questionnaire, IDMS: Intellectual Disability Mood Scale, M: Mean, SD: Standard Deviation, EG: Experimental Group, CG: Control Group, n: participant.

Theme 1: Gesture game experience

Experience is an important point that must be clearly disclosed, obtaining information related to the experiences of students with disabilities in participating the movement game program proved that this game provides many benefits for the development of physical fitness and mental health. Some participants argued that:

> Honestly, we feel happy and lucky to be able to join this movement game program. We will continue to use this program even after the research activities have been completed (opinions of 10 female participants).

Some of them mentioned that:

> We will never forget this interesting movement game program. We hope that our physical education teachers in schools can use this program to change our level of physical fitness and mental health to gain improvement (opinions of 10 male participants).

Theme 2: The advantages of movement games

To observe the effectiveness of a program, it is necessary to conduct interviews with participants to obtain information about the advantages of the program. Several participants gave their perception about the movement game program, namely:

> In our opinion, the advantage of this movement game program is fun and provides us with lots of physical activities or movement experiences. Thus our physical fitness began to improve and our mental health became better than before (the opinion of 5 male participants).
>
> In our opinion, this movement games provide several advantages, such as it is easy to play, it can be played anywhere and anytime. For example, this game can be played in the yard and can be done individually (the opinion of 5 female participants).

Furthermore, the participants explained that:

> According to our perception, this program has benefit in promoting physical activity that is fun and can engourage us to be active. We like this program (the opinion of 5 female participants).
>
> We are lucky to be able to participate in this movement game program, because this program provides advantages that it can be done at home safely and protected from the Corona virus. In addition, this program has proven to

be effective in increasing the level of our physical fitness and mental health to be positive (the opinion of 5 male participants).

Theme 3: Lack of movement games

To optimize the education program, it is necessary to know the shortcomings of the program. Thus, these deficiencies can be evaluated and minimized. Participants gave perceptions related to the shortcomings of the movement game program, including:

> We all agree that the main drawback in this program is students with disabilities need a close supervision from a teacher when they are performing the physical activity. Because there were 2 students who were injured while doing this program. In our opinion, the implementation of this program is limited or cannot be carried out by all students with disabilities (the opinions of 10 participants are male and 10 are female).

Discussion

The quantitative findings in our study show that the movement game program has positive power to increase the physical fitness level of students with disabilities in the experimental group to a higher level. This is because movement games have game-focused characters and provide movement experiences. For example, crocodile crawling, frog jumping, trampoline and hoolahoop games are effective tools to improve physical fitness components, such as muscular strength, muscular endurance and cardiorespiratory (Polevoy, 2021). According to Dao, (2021) games or activities that provide entertainment and satisfaction elements and require students to walk, jump or crawl can facilitate the gradual development of students' physical fitness (Chou, Chen, Huang, Tu & Huang, 2020). Thus, the study results support previous studies reported the simiilar results, where a movement game program was proven to be implemented in physical education classes to improve aspects of physical fitness in elementary school students (Cocca, Verdugo, Cuenca & Cocca, 2020). As for the control group, no significant effect was found in this study. Qualitative research findings show that all disabled students in the experimental group provided diverse and positive perceptions about the application of an effective movement game program in increasing physical fitness levels.

The second finding of this study shows that the movement game program also has a positive effect on the mental health development of students with disabilities. This is because movement games promote an element of entertainment to students with disabilities and it causes them to enjoy doing all the activities in the program (Dao, 2021; Sokic, Popov, Dinic´ & Rastovic, 2021). In this method, the mental health of students with disabilities will change to a better result. For example, students with high levels of anxiety, anger, depression, tension and anger begin to decrease because they enjoy the activities. In addition, issues regarding negative behavior among students with disabilities have turned towards positive behavior (Cocca, Verdugo, Cuenca & Cocca 2020). Different results were shown by the control group, where the students did not experience significant changes in their mental health. The qualitative research also shows the similar results, all students with disabilities provide an overview that the movement game program is an effective way to change negative mental health into positive.

Conclusions

The conclusion in the study confirms that the movement game program based on quantitative and qualitative analysis has been proven to be effective in increase the level of physical fitness and mental health of students with disabilities to be better than before during the COVID-19 period. In addition, this research is able to contribute and provide information for teachers or lecturers about the importance of using movement games for students with disabilities. Further studies with larger sample sizes need to be carried out in order to compare movement game programs with traditional sports, or improve other aspects such as the fundamental movement skills of students with disabilities.

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Conflict of Interest

All authors declare that there is no conflict of interest whatsoever in this study.

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ВПЛИВ РУХЛИВИХ ІГОР НА РІВЕНЬ ФІЗИЧНОЇ ПІДГОТОВКИ ТА ПСИХІЧНОГО ЗДОРОВ'Я УЧНІВ З ІНВАЛІДНІСТЮ: ЗМІШАНИЙ МЕТОД

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Реферат. Стаття: 7 с., 4 табл., 1 рис., 28 джерел.

Мета дослідження. Це дослідження має на меті вивчення впливу рухливих ігор як спроби підвищити рівень фізичної підготовки та психічного здоров'я учнів з інвалідністю під час пандемії COVID-19.

Матеріали та методи. У цьому дослідженні використовували змішаний метод. Учасниками цього дослідження були учні з інвалідністю з двох спеціальних шкіл для учнів з інвалідністю, розташованих у регіоні Караванг, Індонезія (n=40). Учасників розподілили на експериментальну групу, яка виконувала програму рухливих ігор (n=20), і контрольну групу (n=20), яка дотримувалася усталеного режиму навчання без участі в заходах. Після реалізації програми рухливих ігор 20 учасників були опитані про досвід і враження, переваги та недоліки програми рухливих ігор. Вимірювальні засоби кількісного аналізу дослідження використовували тести на м'язову силу, м'язову витривалість і кардіореспіраторну витривалість. Тоді як вимірювальний засіб якісного аналізу використовував глибинні інтерв'ю протягом 30 хвилин. Для аналізу кількісних даних використовували програмне забезпечення IBM SPSS, а для аналізу якісних даних використовували тематичний аналіз.

Результати. Результати кількісного дослідження показали достовірне підвищення рівня фізичної підготовленості та психічного здоров'я в експериментальній групі ($p<0,05$), а в контрольній групі підвищення не виявлено ($p>0,05$). Крім того, результати якісного дослідження показали, що переважна більшість учасників визнала, що програма рухливих ігор була цікавим методом навчання та мала безсумнівну ефективність.

Висновки. Провівши це дослідження, ми підтверджуємо, що рухлива ігрова діяльність є методом навчання, який має значний вплив на підвищення рівня фізичної підготовки та психічного здоров'я учнів з інвалідністю під час пандемії COVID-19.

Ключові слова: рухливі ігри, фізична підготовленість, психічне здоров'я, змішаний метод.

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ORIGINAL SCIENTIFIC ARTICLE

PHYSICAL ACTIVITY OF PROSPECTIVE PHYSICAL EDUCATION TEACHERS DURING THE COVID-19 PANDEMIC

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Abstract

The study purpose was measuring the physical activity of prospective physical education teachers in Palembang city during the COVID-19 pandemic.

Materials and methods. 552 participants (M: 307; F: 245) with a minimum age of 19 (21.27±1.66) participated in this study. The method of this study was survey, using IPAQ-SF to assess physical activity and energy expenditure levels based on MET. Data collection was carried out through an online survey using Google Forms.

Results. The results of this study show that the majority of the participants combined the moderate and high levels of physical activity (88.77%) and only a small number of the participants were in the low level category (11.23%). The results of this study showed that the pandemic conditions do not prevent people from doing sufficient PA to maintain their health, but daily habits and knowledge differences related to health and physical activity might be the distinguishing factor between students majoring in sports and society in general.

Conclusions. This study shows that most of prospective PE teacher candidates from three universities in Palembang combined the moderate and high PA levels. While there were some student athletes, non-athlete students also have the awareness to live a healthy life even though there is no demand for them to achieve certain targets.

Keywords: physical activity, physical education, COVID-19.

Introduction

The COVID-19 pandemic has hit the world in recent years and is still threatening even though the world's conditions have begun to gradually recover. Physical activity (PA) may be a solution to alleviate the effects of the COVID-19 pandemic and related limitation on daily affect (Do et al., 2021), although some studies recorded that PA level were low during the pandemic (Martínez-de-Quel et al., 2021; Solahuddin et al., 2021). The implementation of COVID-19 preemptive measures are likely to have resulted in a number of unintended consequences including the decreased PA (AlDukhail & Bahdila, 2022; Deshmukh et al., 2022). The preemptive measures occur globally and have an impact in the implementation of the education system.

The government of Indonesia has prompted several unprecedented measures to control the spread of COVID-19 (Adli et al., 2022), one of which through the circular letter number 4 of 2020 issued by the Minister of Education and Culture of the Republic of Indonesia concerning the implementation of education policies during COVID-19 pandemic. Education in Indonesia at all levels was carried out online during the pandemic (Fitria et al., 2021), and all theoretical and practical activities were carried out at home. More than 60 million students in Indonesia have been affected by the COVID-19 pandemic, because of the disappearance of in-class learning (Victorian et al., 2021).

However, in a study conducted at a university in Palembang city, Indonesia, the PA level of the students majoring in sports was actually high (Bayu et al., 2021). This is intriguing, whether this condition occurs only in certain environments or generally occurs in students of sports related majors, because another study showed there was a tendency that the PA level of productive age population in Palembang was low (Solahuddin et al., 2021).

Palembang is one of largest city in Indonesia, in which there are four universities that have sports related majors. The online classes in these universities was started in March 2020, after several cases of COVID-19 emerged in Palembang. In addition to the restrictions on activities in public places, lectures (which are mostly practical) cannot be carried out so that PA level of the students was questioned. This study specifically examines the PA level of students majoring in physical education (PE), because they are prospective teachers who will teach PE at various levels of education. As prospective PE teachers, they are expected to be able to promote active and healthy lifestyle to their future students (Harris, 2014).

Materials and methods

Study participants

This study measured the physical activity of prospective PE teachers in Palembang city during COVID-19 pandemic. A total of 1145 prospective PE teachers in Palembang from three universities (Sriwijaya University, PGRI Palembang University, and Bina Darma University) have filled out the International Physical Activity Questionnaire–Short Form (IPAQ-SF) instrument which has specifications used for 15-year-old respondents and above. IPAQ-SF has predictive validity, concurrent validity, convergent validity, criterion validity, discriminant validity which is appropriate as a research tool, and a good test-retest as a sign that the instrument is reliable (Craig et al., 2003; Papathanasiou et al., 2010). PA contents were calculated using the following formula:

MET+(3,3×day×light activity time)+(4×day×moderate activity time)+(8×day ×vigorous activity time) (1)

The results of Metabolic Equivalent of Task (MET) were then converted using the rule that MET<600 is in the low category, 600≤MET<3,000 is in the medium category, and MET≥3,000 is in the high category (Fogelholm et al., 2006; Hagströmer et al., 2006).

Study organization

Data collection was carried out through an online survey using Google Form which was sent in a structured manner via WhatsApp Broadcast. There were 552 respondents, out of all the 1145 respondents who filled out the survey, whose data were declared eligible for analysis with the characteristics that can be seen in table 1 as follows:

Statistical analysis

The data analysis used is descriptive statistics for physical activity data based on MET.

Results

Table 2 below contains the frequency distribution of prospective PE teachers in Palembang City doing PA in one week.

At the high intensity category, the highest percentage is 25.18% students did PA for 3 days in a week. Meanwhile, in moderate intensity, the highest percentage is 21.38% students did PA 1 day a week. Low intensity category is dominated by 27.17% of students did PA 3 days a week.

Table 3 below contains the frequency distribution of prospective PE teachers in Palembang City doing PA based on duration (minutes) in a week.

In high intensity category, most students (29.17%) did PA for 31-60 minutes. In moderate intensity category, most

Table 1. Participant Demographics

	Category	Frequency	Percent
Gender	Men	307	55.62
	Women	245	44.38
Age	Max	25	
	Min	19	
	St. Deviation	1.66	
	Average	21.27	
Athlete/Non-Athlete	Athlete	124	22.46
	Non-Athlete	428	77.54
Domicile	Country side/Inland	257	46.56
	City/ Around the regional administration center	295	53.44
Univ	Sriwijaya University	204	36.96
	PGRI Palembang	259	46.92
	Bina Darma	89	16.12

Table 2. Distribution of Physical Activity Frequency by Intensity

Total Days in a Week	High Intensity		Moderate Intensity		Low Intensity	
	N	%	N	%	N	%
0	100	18.12	95	17.21	14	2.54
1	86	15.58	118	21.38	69	12.50
2	96	17.39	111	20.11	40	7.25
3	139	25.18	80	14.49	150	27.17
4	85	15.40	70	12.68	55	9.96
5	13	2.36	23	4.17	63	11.41
6	8	1.45	10	1.81	31	5.62
7	25	4.53	45	8.15	130	23.55
Total	552	100	552	100	552	100

Table 3. Distribution of Physical Activity Frequency by Duration

Total duration in a week (minutes)	High Intensity		Moderate Intensity		Low Intensity	
	N	%	N	%	N	%
<10	123	22.28	123	22.28	38	6.88
10-30	39	7.07	57	10.33	86	15.58
31-60	161	29.17	184	33.33	204	36.96
61-149	142	25.72	122	22.10	128	23.19
150-299	58	10.51	39	7.07	41	7.43
>299	29	5.25	27	4.89	55	9.96
Total	552	100	552	100	552	100

Table 4. MET Descriptive Statistics

	Kategori	Frequency	Percent
Metabolic Equivalent of Task (MET)	Max	89460	
	Min	33	
	St. Deviation	7884.63	
	Average	4964.67	
MET Category	Low	62	11.23
	Moderate	242	43.84
	High	248	44.93

students (33.33%) did PA for 31-60 minutes. In low intensity category, most students (36.96%) did PA for 31-60 minutes.

Table 4 below contains descriptive statistics on MET data.

The average MET of physical activity for prospective PE teachers in Palembang City is 4964.67, SD of 7884.63 is in the category of high PA, the highest MET of 89460 is in the category of high PA, and the lowest MET of 33 is in the category of low PA.

Discussion

Physical inactivity has been believed as one of the top causes of global death (Priambodo et al., 2020), and although PA has a number of health benefits, the lack of PA level problem still occurs. Previous studies which were taken before COVID-19 pandemic in Palembang show that the majority of the participants had low PA level (Bonita et al., 2017; Ridwanmo et al., 2020), and the condition in Palembang was getting worse when the pandemic stroke the world (Solahuddin et al., 2021).

However, PA level of the PE teacher candidates in a university in Palembang was high according to another study (Bayu et al., 2021), and this condition is in accordance with this study. Low PA level of 552 PE teachers candidates in Palembang city, who participated in this study, only reach 11.23%, while the combination of moderate and high PA level reach 88,77%. 131 or 23.74% students, who were mostly student athletes, did high intensity PA 4 times a week or more. This might be happened because they were in preparation for the inter-regional competition which held some time after this research occured. Apart from student athletes, non-athlete students also have the awareness to live a healthy life even though there is no demand for them to achieve certain targets. The number of non-athlete students who have PA in the moderate and high categories reached 366 students, or around 66.30%.

Another study found a decrease in PA levels of Hungarian citizen university students as a result of university closures (Lukács, 2021), and another study even showed that about half of medical students who participated in the study, who should have had knowledge of health, had low PA levels (Chootong et al., 2022). The results of this study showed that the pandemic conditions do not prevent people from doing sufficient PA to maintain their health, but daily habits and knowledge differences related to health and physical activity might be the distinguishing factor between students majoring in sports and society in general.

PE teachers are the vanguard for setting the example of living a healthy lifestyle to their students (Stelzer, 2005). Their involvement with students in PE settings regularly facilitates the opportunity to influence positive lifestyle attitudes. The awareness of students in this study is quite a relief because they are prospective PE teachers who will later be directly involved with school students. Even though they are in a covid pandemic condition, most of PE teacher candidates still maintained the PA level, although a small number of students were still at a low PA level.

Due to limited funds and time, this study was implemented only in universities located in Palembang city. Further study can seek extensive information, either in a wider scope of participants or participants who have the same background with this study but in different areas.

Conclusions

PA level in general was decreasing during COVID-19 pandemic. However, this study shows that most of prospective PE teacher candidates from three universities in Palembang were in the combination of moderate and high PA level. While there were some student athletes, non-athlete students also have the awareness to live a healthy life even though there is no demand for them to achieve certain targets. PE teachers are the vanguard for setting the example of living a healthy lifestyle, so the PE teacher candidates have the opportunity to regularly facilitates the opportunity to influence positive lifestyle attitudes in the future.

Conflict of interest

No conflic of interest.

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ФІЗИЧНА АКТИВНІСТЬ МАЙБУТНІХ УЧИТЕЛІВ ФІЗИЧНОГО ВИХОВАННЯ ПІД ЧАС ПАНДЕМІЇ COVID-19

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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., 20 джерел.

Метою дослідження було вимірювання фізичної активності майбутніх учителів фізичного виховання в місті Палембанг (Індонезія) під час пандемії COVID-19.

Матеріали та методи. У дослідженні брали участь 552 учасника (Ч: 307; Ж: 245) мінімальним віком 19 років (21,27±1,66). Методом дослідження було опитування з використанням «Міжнародного опитувальника з фізичної активності – Коротка форма» (IPAQ-SF) для оцінки рівнів фізичної активності та витрат енергії на базі метаболічного еквівалента фізичної активності (MET). Збір даних здійснювали шляхом онлайн-опитування за допомогою ПЗ Google Форми.

Результати. Результати цього дослідження показують, що більшість учасників поєднували помірний і високий рівні фізичної активності (88,77%) і лише невелика кількість учасників була в категорії низького рівня (11,23%). Результати цього дослідження показали, що умови пандемії не перешкоджають людям здійснювати достатній обсяг ФА для підтримки їхнього здоров'я, але щоденні звички та відмінності в знаннях, пов'язані зі здоров'м і фізичною активністю, можуть бути фактором, що відрізняє студентів, які навчаються на спортивних спеціальностях, і суспільство в цілому.

Висновки. Це дослідження показує, що більшість потенційних кандидатів у вчителі фізичного виховання з трьох університетів у місті Палембанг поєднували помірний і високий рівень ФА. Тоді як були деякі студенти-спортсмени, студенти, які не є спортсменами, також усвідомлюють необхідність вести здоровий спосіб життя, навіть якщо від них немає попиту на досягнення певних цілей.

Ключові слова: фізична активність, фізичне виховання, COVID-19.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTIVENESS OF ZUMBA EXERCISE ON MAXIMUM OXYGEN VOLUME, AGILITY, AND MUSCLE POWER IN FEMALE STUDENTS

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Abstract

The study purpose was to prove the effectiveness of zumba exercise on VO_2max, agility, and muscle power in students at Universitas Nusantara PGRI Kediri, East Java, Indonesia.

Materials and methods. This research is a pre-experimental research design with One group Pretest-Posttest Design. A total of 15 female students from the Student Activity Unit aerobic dance exercise at Universitas Nusantara PGRI Kediri, East Java, Indonesia, aged 19-24 years, body mass index (BMI) 19.0-24.0 kg/m^2, normal blood pressure, resting heart rate normal, normal oxygen saturation (SpO_2), voluntarily participated in the study. Zumba exercise was carried out for 30 minutes/session with an intensity of 80% HRmax with a frequency of 3x/week for 8 weeks. The measurement of maximum oxygen volume (VO_2max) used the Multi-Stage 20-m Shuttle Run Fitness Test. The measurement of leg muscle power used the vertical jump test, while the arm muscle power was evaluated using the medicine ball throw test. Data analysis used Paired Sample t-Test with a significance level of 5%.

Results. The results obtained: mean VO_2max between pretest vs post-test (26.64±4.25 vs. 30.76±4.20 mL/kg/min; $p \leq 0.001$), average agility between pretest and post-test (15.76±1.24 vs. 14.55±1.27 seconds; $p \leq 0.001$), average limb muscle power between pretest vs posttest (394.21±66.36 vs. 411.09±67.45 joule; $p \leq 0.001$), and the average arm muscle power between pretest vs posttest (123.45±17.12 vs. 138.21±13.92 joule; $p \leq 0.001$).

Conclusions. Based on the results of the study, it was concluded that Zumba exercise carried out for 30 minutes/training session, with an intensity of 80% HRmax, frequency 3x/week for 8 weeks increased VO_2max, agility, and muscle power in students at Universitas Nusantara PGRI Kediri, East Java, Indonesia.

Keywords: VO_2max, muscle power, agility, zumba exercise.

Introduction

Sports and physical activity have a good role in improving the quality of health (Granero-Jiménez et al., 2022; Pranoto et al., 2020). In addition to the good health benefits of physical activity, exercise can also provide a forum for engagement in challenging matters, exploration, skill-building, and social integration (Barber & Weichold, 2007). Zumba is a physical exercise adapted from Latin dance which was first developed in Columbia by a fitness trainer named Alberto "Beto" Perez. Zumba is a combination of salsa, cumbia, reggaeton, mambo, chachacha, soca, bhangra, belly dance, flamenco, hip hop, tango and samba dances (Suminar et al., 2018). Zumba exercises are very effective in the teaching

and learning process of physical, of adults and adolescents of school and university age are not sufficiently active (Soleiman et al., 2021).

Zumba exercises combine many sports steps that are easy to apply and help a person move many body muscles, such as arms, back, legs, and chest. This includes aerobic exercise that can increase energy expenditure (Packyanathan & Preetha, 2020). Zumba exercises help stimulate the heart and lungs, improve overall fitness, and move circulation faster. In addition, Zumba exercises can also increase the amount of oxygen sent to muscles and other body organs (Soleiman et al., 2021).

Zumba exercises do not follow traditional training methods but use all elements of essential fitness during training modules. Zumba exercises use physical strength, and all parts of the body are moved from head to toe (Parial et al., 2022). Therefore, Zumba exercises are quite important for students because regular Zumba exercises can affect psychological and social outcomes, reduce body weight and increase movement strength and blood flow to muscles. Zumba exercises positively affect the development of attributes and skills, muscle strength levels, cardiovascular endurance, and weight management (HajGhanbari et al., 2013). Several studies have stated that a motor training program accompanied by music (Zumba) has a positive contribution to weight loss (Rossmeissl et al., 2016). Zumba exercises have a positive impact on psychological and social outcomes. Based on the studies that have been carried out, higher scores were found on several physical elements (periodic respiratory endurance, motor balance, flexibility, leg strength, and neuromuscular compatibility) in students who participated in Zumba training compared to students who did not participate. Zumba exercise intervention improves health and physical fitness in women (Krishnan et al., 2015).

One way to assess a person's cardiorespiratory endurance is to measure the maximal oxygen volume level (VO_2max) to measure the capacity of the heart, lungs, and blood to carry oxygen to working muscles and measure the use of oxygen by muscles (Nugraheni et al., 2017). The most common measurement for VO_2max prediction is the Multi-Stage 20-m Shuttle Run Fitness Test (Paradisis et al., 2014; Sugiharto et al., 2022). This test is widely used by exercise scientists, teachers, coaches, and fitness advisors because it requires limited equipment, is relatively easy to perform, and is suitable for the assessment of a large number of subjects. As with all tests and measurements used to assess the components of physical fitness, critical questions must be asked regarding the repeatability and validity of the Multi-Stage 20-m Shuttle Run Fitness Test (Cooper et al., 2005). Maximum oxygen uptake is assessed by establishing an oxygen recovery curve based on the results of the Multi-Stage 20-m Shuttle Run Fitness Test (Paradisis et al., 2014). On this basis, this study aims to prove the effectiveness of Zumba exercise on VO_2max, agility, and muscle power in students at the Universitas Nusantara PGRI Kediri, East Java, Indonesia.

Materials and Methods

Study participants

This research is a pre-experimental research design with One group Pretest-Posttest Design. A total of 15 women students from the Student Activity Unit (UKM) aerobic exercise at Universitas Nusantara PGRI Kediri, East Java, Indonesia, aged 19-24 years, body mass index (BMI) 19.0-24.0 kg/m^2, normal blood pressure, resting heart rate normal, normal oxygen saturation (SpO_2) voluntarily participated in the study. All respondents received information both orally and in writing before conducting the research and respondents also stated that they were willing to participate in the research by signing informed consent. All procedures performed in our study complied with the Declaration of the World Medical Association of Helsinki on the ethical conduct of research involving human subjects.

Study organization

The Zumba exercise program is implemented and supervised by professional officers from the Faculty of Health and Sciences, Universitas Nusantara PGRI Kediri, East Java, Indonesia. Zumba exercise was carried out for 30 minutes/session with an intensity of 80% HRmax with a frequency of 3x/week for 8 weeks. Monitoring heart rate during zumba exercise using a polar heart rate monitor (Polar H10 Bluetooth Heart Rate Sensor & Fitness Tracker, Polar, Kempele, Finland) (Andarianto et al., 2022).

Data collection for measuring body height using a Stadiometer (Seca Corporation, CHINO, California, USA) (Rejeki et al., 2021). Bodyweight was measured using a digital scale (OMRON HN-289, Osaka, JAPAN) (Sugiharto et al., 2022). BMI is calculated using body weight (kg) divided by body height (m^2) (Raharjo et al., 2021). Measuring blood pressure using a digital sphygmomanometer (OMRON Model Deluxe HEM-8712 BASIC, JAPAN) on the non-dominant arm 3 times in a row with a 2-minute rest interval between the two measurements, then the average value of the three measurements was taken (Andarianto et al., 2022; Raharjo et al., 2021). Measurement of heart rate rest (HR-rest) and oxygen saturation (SpO_2) using the Beurer Pulse Oximeter PO-30 (Rejeki et al., 2021). Measurement of maximum oxygen volume (VO_2max) using the Multi-Stage 20-m Shuttle Run Fitness Test (Paradisis et al., 2014). Measurement of leg muscle power using the vertical jump test (García-Ramos et al., 2017; Cuk et al., 2014), while arm muscle power was evaluated using the medicine ball throw test (Leite et al., 2020). Measurements of VO_2max, agility and muscle power were carried out pretest and 1x24 hours posttest for 8 weeks of zumba exercise intervention.

Statistical analysis

Data analysis used Statistical Package for Social Science (SPSS) version 21 software. Shapiro-Wilk test was used for normality test analysis with a significant level ($p \geq 0.05$). Paired Sample t-Test was used to compare the average VO_2max, agility, and muscle power between the pretest and post-test. The data is displayed with Mean ± Standard Deviation (SD). All statistical analyzes use the significant level ($p \leq 0.05$).

Results

The results of the descriptive analysis of research respondents' characteristics which include demographics, and anthropometry are presented in Table 1.

Table 1. The results of the descriptive analysis of the characteristics of research respondents

Parameters	n	Mean	Std. Deviation
Age (yrs)	15	21.13	1.69
Body height (m)	15	1.56	0.04
Bodyweight (kg)	15	53.47	5.53
Body mass index (kg/m^2)	15	22.04	1.57
Systolic blood pressure (mmHg)	15	115.80	2.93
Diastolic blood pressure (mmHg)	15	75.87	2.90
Heart rate rest (bpm)	15	76.27	2.91
Oxygen saturation (%)	15	97.33	1.11

Based on the results of the descriptive analysis of the characteristics of the respondents, the research shows that the respondents' average age (21.13±1.69 yrs), bodyweight (53.47±5.53 kg), body height (1.56±0.04 m), body mass index (22.04±1.57 kg/m^2), systolic blood pressure (115.80±2.93 mmHg), diastolic blood pressure (75.87±2.90 mmHg), heart rate rest (76.27±2.91 bpm), oxygen saturation (97.33±1.11 %). The results of the analysis of the average maximum oxygen volume (VO_2max), agility, and muscle power between pretest vs. posttest are presented in Figure 1.

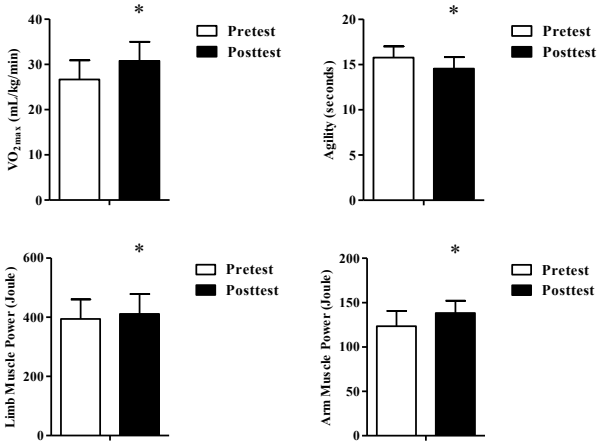

Fig. 1. The results of the analysis of the average VO_2max, agility, and muscle power between pretest vs. posttest. Description: Maximum oxygen volume (VO_2max). Data presented with Mean ± standard deviation (SD). *Significant vs. Pretest ($p \leq 0.001$). The p-value is obtained using the Paired Sample t-Test.

Based on Figure 1, it can be seen that there is a change in the average maximum oxygen volume (VO_2max), agility, and muscle power between pretest vs post-test. The results of the Paired Sample t-Test show that there is a significant difference in the mean VO_2max between the pretest vs. posttest (26.64 ± 4.25 vs. 30.76 ± 4.20 mL/kg/min; $p \leq 0.001$), mean agility between pretest vs. posttest (15.76 ± 1.24 vs. 14.55±1.27 seconds; $p \leq 0.001$), the mean limb muscle power between pretest vs. posttest (394.21 ± 66.36 vs. 411.09 ± 67.45 joule; $p \leq 0.001$), and the mean arm muscle power between pretest vs. posttest (123.45 ± 17.12 vs. 138.21 ± 13.92 joule; $p \leq 0.001$).

Discussion

This study aims to determine the effectiveness of zumba exercise on maximum oxygen volume (VO_2max), agility, and muscle power in students at Universitas Nusantara PGRI Kediri. The main finding in our study was that there was a significant increase in zumba exercise on VO_2max, agility, and muscle power between pretest and posttest. These findings provide the support that zumba exercise has many health benefits, including increasing VO_2max, agility, and muscle power. These results are in line with the results of research conducted by Donath et al. (2014) concluded that zumba exercise improves well-being, aerobic fitness level, and neuromuscular function in female students. Vendramin et al. (2016) found evidence that zumba exercise was effective in increasing aerobic capacity. VO_2max is the main parameter of aerobic capacity (Poole & Jones 2017). Poor cardiorespiratory fitness has been linked to chronic disease and premature death (Ricci et al., 2020). Exercise and physical activity, such as dancing, have a significant effect on improving mental health, although evidence suggests that many psychological, physiological, and biochemical processes may be involved (Domene et al., 2016; Teychenne et al., 2008; Crone et al., 2006; Salmon, 2001). Zumba exercise has been shown to reduce the risk of chronic disease by increasing VO_2max through many adaptations of the body by physical activity such as increasing cardiac size, cardiac output, stroke volume, or the number of mitochondria and mitochondrial function (Chavarrias et al., 2020; Bacon et al., 2013; Wilson et al., 2016). Since the whole body is trained at moderate to vigorous intensity and includes jumps, moves, core exercises, and choreography with exaggerated arm movements, among other things, increases in muscle strength can be possible from low starting levels (Barranco-Ruiz & Villa-González, 2020).

The World Health Organization (WHO) recognizes physical inactivity as a global public health burden, representing the fourth leading risk factor for global death, above high blood pressure, smoking, and high blood glycemia (Barranco-Ruiz & Villa-González, 2020; Benjamin et al., 2017). In addition to the health hazards associated with the metabolic changes and increased belly fat that usually accompany menopause, many women experience weight gain as a function of aging (Rossmeissl et al., 2016; Al-Safi et al., 2015; Lovejoy, 2009). Weight gain accompanied by a tendency to increase central fat distribution is common in middle-aged women. These changes are a result of aging, decreased estrogen levels after menopause, and other unique effects on postmenopausal women that interfere with adopting a healthy lifestyle (Kapoor et al., 2017).

Zumba exercise is the second most popular physical activity after walking for women of all ages (25 to 75 years and over) (Fan et al., 2013). Regular physical activity is considered one of the most important factors for lifestyle, maintaining good health, and increasing life expectancy, especially in the elderly (Douka et al., 2019). Public health professionals around the world should emphasize the need to increase activity levels during leisure time, as well as the need to incorporate physical activity into activities of daily living (Lee et al., 1997). Norouzi et al. (2020) described that aerobic exercise and zumba exercise could be recommended in addition to standard care to improve working memory and reduce the severity of depressive symptoms among female patients with

fibromyalgia. On the other hand, exercise therapy has become more widely used because of its benefits for the cardiovascular system, emotional state, and systemic function (Xie et al., 2020). Lack of physical activity has a hugely adverse effect on health all over the world. Reducing or eliminating these unhealthy behaviors can substantially improve health (Lee et al., 2012). Zumba exercise is considered an activity that offers different sensory engagements and connects movement to music with self-expression and applies different aspects of personality (Kaufmann, 2011; Studer-Lüthi & Züger, et al., 2012). Sports and daily activities can not be separated from skeletal muscle activity, the most important attribute of skeletal muscle is the ability to generate power, the product of strength and speed of movement (Kraemer & Newton, 2000). So that zumba exercises can be used as an effective sports activity to improve various components of health for the body.

Conclusion

In general, it can be concluded that the Zumba exercise which is carried out for 30 minutes/training session, with an intensity of 80% HRmax, which is carried out 3x/week for 8 weeks significantly increases the maximum oxygen volume (VO_2max), agility, and muscle power in the students of Universitas Nusantara PGRI Kediri, East Java, Indonesia. Based on the results of the study, it can be suggested that Zumba exercise can be an alternative non-pharmacological approach to improving an active lifestyle as an effort to improve health quality.

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Conflict of interest

No conflic of interest.

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ЕФЕКТИВНІСТЬ ВПЛИВУ ВПРАВ ЗУМБИ НА МАКСИМАЛЬНЕ СПОЖИВАННЯ КИСНЮ, СПРИТНІСТЬ І М'ЯЗОВУ СИЛУ У СТУДЕНТОК

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

Реферат. Стаття: 7 с., 1 табл., 1 рис., 45 джерел.

Метою дослідження було довести ефективність впливу вправ зумби на максимальне споживання кисню VO2max, спритність і м'язову силу у студенток Кедірійський університет Нусантара Асоціації вчителів Індонезії, Східна Ява, Індонезія.

Матеріали та методи. Це дослідження є передекспериментальною схемою дослідження з планом попереднього та підсумкового тестування на одній групі. Загалом у дослідженні добровільно брали участь 15 студенток зі студентської секції танцювальної аеробіки в Кедірійський університет Нусантара Асоціації вчителів Індонезії, Східна Ява, Індонезія, віком 19-24 роки, індекс маси тіла (ІМТ) 19,0-24,0 кг/м^2, артеріальний тиск нормальний, показник ЧСС у стані спокою нормальний, нормальне насичення киснем (SpO_2). Вправи зумби проводили по 30 хвилин/заняття з інтенсивністю 80% максимальної ЧСС (HRmax) із частотою 3 рази/тиждень протягом 8 тижнів. Для вимірювання максимального споживання кисню (VO_2max) використовували багатоетапний фітнес-тест човникового бігу на 20 метрів. Для вимірювання сили м'язів ніг використовували тест «Вертикальний стрибок», тоді як силу м'язів рук оцінювали за допомогою тесту «Кидок медболу». Для аналізу даних використовували t-критерій Стьюдента для парних вибірок за рівня значущості 5%.

Результати. Одержані результати: середній показник VO_2max у попередньому тестуванні порівняно з підсумковим (26,64±4,25 проти 30,76±4,20 мл/кг/хв; $p \leq 0,001$), середній показник спритності у попередньому тестуванні порівняно з підсумковим (15,76±1,24 проти 14,55±1,27 секунди; $p \leq 0,001$), середній показник сили м'язів кінцівок у попередньому тестуванні порівняно з підсумковим (394,21±66,36 проти 411,09±67,45 джоуля; $p \leq 0,001$) і середній показник сили м'язів рук у попередньому тестуванні порівняно з підсумковим (123,45±17,12 проти 138,21±13,92 джоуля; $p \leq 0,001$).

Висновки. За результатами дослідження було зроблено висновок, що вправи зумби, які проводили по 30 хвилин/заняття з інтенсивністю 80% максимальної ЧСС (HRmax) і частотою 3 рази/тиждень протягом 8 тижнів, підвищили показники VO_2max, спритності та сили м'язів у студенток Кедірійський університет Нусантара Асоціації вчителів Індонезії, Східна Ява, Індонезія.

Ключові слова: VO_2max, м'язова сила, спритність, вправи зумби.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF THE TRAINING MODEL AND BALANCE ON STUDENTS' SEPAK SILA SKILLS ON SEPAK TAKRAW EXTRACURRICULAR IN FIRST MIDDLE SCHOOL

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Abstract

Study purpose. This study aimed to examine the wall and pair models: (1) the difference in the effect of wall and pair exercises on Sepak sila (2) the difference between the high and low balance on Sepak sila (3) the interaction of wall and pair models with a high and low balance on Sepak sila skills.

Materials and methods. The method used in this research was a 2×2 factorial experiment. The research participants included 24 male students who took extracurricular sepak takraw aged 14-15 years with a height of 153-170± centimeters and a weight of 50-60 kilograms. The instruments used in this study were modified bass test balance instruments and Sepak sila instruments. Data collection techniques consisted of observation and tests. The data obtained were analyzed using a two-way Anova with the help of SPSS 20.

Results. (1) There was a significant difference in effect between the wall and pair training models on Sepak sila skills with F 19.698 and sig. 0.000 <0.05. Based on the findings, the paired model was found to be better with an average of 46.17 compared to the model on the wall which obtained an average of 41.50. (2) It was found that there was a significant difference in effect between the high and low balance on Sepak sila skills where high balance was better with an average of 46.33 compared to low balance with an average of 41.33. (3) It was found that there was a significant interaction between the wall-mounted and paired exercise models with a high and low balance on Sepak sila skills with F 130.251 and sig. 0.000<0.05.

Conclusions. In conclusion, the paired exercise model is better than the wall exercise model. As a result, it is advised to use a paired model to strengthen the fundamental technical skills of Sepak sila.

Keywords: pair practice, Sepak sila, sepak takraw, first middle school students.

Introduction

Sepak takraw is an original game sport from Asia (Wibisono, Indriarti & Daniati, 2020; Syam, 2019). This game was initially only played in the kingdom, but it developed into a recreational and achievement sport over time (Zulkifli, Asmawi, Hanif, & Bon, 2019). "Sepak" means kick "takraw" means ball made of rattan which the word comes from the Thai language (Zarei & Ramkissoon, 2021). The game of sepak takraw is played by two competing teams where each team has three players named tekong, feeder, and spiker who are separated by a net (Wibisono, Indriarti & Daniati, 2020).

When it comes to process success, several aspects influence it. Technique mastery is one of the aspects that determine the improvement of achievement in sepak takraw. According to studies, to be successful in sepak takraw, players must first master basic methods before learning more advanced strategies (Asmawi, Hanif, & Bon, 2019; Čoh et al., 2004; Sukmana, Mutohir & Muhyi, 2021). Another study states that to be skilled at playing sepak takraw, each individual must master basic techniques including heading, serving, smash, blocking, as well as kicking techniques including sepak badek, sepak kuda, sepak cungkil, and Sepak sila

(Adrian & Heru, 2020; Rohman Hidayat, 2018; Heriansyah, Adelian & Suhartiwi, 2017; Muhyi et al., 2021).

The main technique in sepak takraw is Sepak sila. Sepak sila is a kicking technique using the inside of the foot (Sucipto & Sugiyanto, 2017). Another theory states that the main basic technique in the game of sepak takraw is Sepak sila, remembering that when individuals master the technique of Sepak sila, it can make it easier for them to receive, control the ball, and withstand the opponent's attacks (Zulman, Umar & Atradinal, 2018). Saputra and Supriyadi (2017) stated that the basic technique that is important to master is Sepak sila, because, in the game of sepak takraw, most use the Sepak sila technique to pass and receive the ball well.

When viewed more closely, the basic practices of Sepak sila require balance. Novrianto (2013) conducted a study titled "Study on the association between balance and sila skills in the game of sepak takraw." His investigation discovered a substantial link. Tahmrin (2011) found that balance and leg muscle endurance contributed to Sepak sila in his study. The researcher might conclude from the findings of the two studies that technical skills are directly related to an individual's balance.

Efforts to improve the fundamental techniques of Sepak sila in sepak takraw, of course, necessitate the use of a good and appropriate program and approach. When testing a method, trainers are required to experiment. The teaching methods with reflections on the wall and the pair training method are two that are frequently used to teach basic concepts in sepak takraw (Riska, 2020; Mardela & Rahman, 2017; Tambunan, 2014; Khozali, 2015; Fadli & Yudi, 2019).

The application of the reflection method to the wall and in pairs has been tested and is considered to have a significant effect on improving basic techniques in sepak takraw. From his study, it was found that there was a significant effect of pair passing practice on the skills of passing the ball in takraw extracurricular students. Furthermore, Riska (2020), and Mardela and Rahman (2017) stated that there was a significant effect of practicing soccer skills using individual and pair training methods. However, other studies have stated that exercises with reflected media on the wall do not have a significant improvement compared to the hanging ball training method (Ermanto, 2013). Although the research from Ermanto (2013) provides strong evidence, Khozali (2015) refutes Ermanto's findings based on the results of his research that the paired method, wall reflecting media, and hanging media have an equally significant increase. Therefore, it becomes an empirical problem that requires re-testing by applying the exercise method using wall media and pairs supported by observation.

Observations were carried out at four junior high schools that had sepak takraw extracurricular activities. Researchers at this stage observe the practice process, the coach gives instructions to students to hold the ball themselves and then play the takraw ball so it doesn't fall with the correct soccer technique. However, additional observation reveals that students' use of the inner foot when performing the sila technique is not faultless. Many students continue to strike the heel, toe, and outside of the foot. Furthermore, motivation to practice versions of the kick model is still very low, as seen by students' mastery of basic movement skills for rocking and kicking during extracurricular activities. Individual exercises with the practice system of holding the ball once and then catching it are also common among students in this case. Kicking or holding the ball is a mandatory requirement that must be mastered by students so that the practice method using reflection media on the wall and in pairs needs to be done to optimize basic techniques, especially silage.

Based on the description described above, it can be understood that there are problems regarding the application, understanding, and motivation to practice the basic techniques of playing sepak takraw in first middle school extracurricular participants. To overcome this, the researchers will apply the exercise method with reflection media on the wall and in pairs. The purpose of this study was to test the exercise method with reflections on the wall and the pair practice method to improve the basic techniques of Sepak sila in terms of low and high balance in junior high school extracurricular participants in West Sleman Regency, Yogyakarta Province. This study hypothesizes that there are differences in wall exercises and pair exercises on Sepak sila skills, there are differences in high balance and low balance on Sepak sila skills, and there is an interaction between wall and pair exercises as well as balance on Sepak sila skills.

Table 1. Factorial Experiment Design 2×2

Balance (K)	Practicing (L)	
	Sepak sila Practice with Walls (L1)	Sepak sila Practice in Pairs (L2)
High (K1)	(L1K1)	(L2K1)
Low (K2)	(L1K2)	(L2K2)

Where: L1: Sepak sila Practice with Walls; L2: Sepak sila Practice in Pairs; K1: High balance; K2: Low balance; (L1K1): Sepak sila practice with the wall on high balance; (L1K2): Sepak sila practice with the wall on low balance; (L2K1): Sepak sila practice in pairs on high balance; (L2K2): Sepak sila practice in pairs on low balance.

Table 2. Instructions for the Sepak sila Skills Test Implementation

Facilities used
a. Spacious and flat sepak takraw field
b. Takraw ball
c. Net
d. Stopwatch
e. Meter
f. Duct tape
g. Stationary
h. Whistle
Implementation
a. The ball is kicked using a Sepak sila technique (inner foot).
b. The ball that falls to the ground can be used again, but the score on the second shot is determined from the start and is valid every time after the ball has fallen until the available time runs out.
c. Balls that are kicked using other techniques (other than Sepak sila) can still be used but the score does not count and as long as the ball has not fallen to the floor.
d. The ball that counts must be at chest level.
e. The area of the control field is not limited.
f. The time limit applied is one minute.
Scoring
a. The score is taken from the number of Sepak sila that can be taken in one minute.
b. Every three kicks are counted with a value of one and so on.
c. Kicks that are not at chest level will not count.
d. The overall score is obtained by adding up all the kick scores that have been divided by three.

Table 3. Practicing program of Sepak sila

Sepak sila Practice in Pairs	Sepak sila Practice with Walls	Meeting
a. Flexibility training b. The ball is thrown with a parabolic dish to the student who is the partner. The partner accepts and kicks the ball with Sepak sila 1 time and catches it. The ball is thrown back to the opponent. c. Dosage: 20 minutes. 3 sets × 8 reps, 30 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball is bounced off the wall and then juggled once with the Sepak sila technique before being caught. c. Dosage: 20 minutes. 3 sets × 8 reps, 30 seconds recovery d. 15 minutes Games	1,2
a. Flexibility Training b. The ball is thrown with a parabolic dish to the student who is the partner. The partner accepts and juggles the ball with Sepak sila 1 time and catches it. The ball is thrown back to the opponent. c. Dosage: 20 minutes. 3 sets × 11 reps, 30 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball is bounced off the wall and then juggled once with the Sepak sila technique before being caught. c. Dosage: 20 minutes. 3 sets × 11 reps, 30 seconds recovery d. 15 minutes Games	3,4
a. Flexibility training b. The ball is thrown with a parabolic dish to the student who is the partner. The partner accepts and juggles the ball with Sepak sila 2 times and catches it. The ball is thrown back to the opponent. c. Dosage: 20 minutes. 4 sets × 13 reps, 35 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball is bounced off the wall and then juggled 2 times with the Sepak sila technique before being caught. c. Dosage: 20 minutes. 4 sets × 13 reps, 35 seconds recovery d. 15 minutes Games	5,6
a. Flexibility training b. The ball is thrown with a parabolic dish to the student who is the partner. The partner accepts and juggles the ball with Sepak sila 2 times and catches it. The ball is thrown back to the opponent. c. Dosage: 20 minutes. 4 sets × 16 reps, 35 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball is bounced off the wall and then juggled 2 times with the Sepak sila technique before being caught. c. Dosage: 20 minutes. 4 sets × 16 reps, 35 seconds recovery d. 15 minutes Games	7, 8
a. Flexibility training b. The ball is thrown with a parabolic dish to the student who is the partner. The partner accepts and juggles the ball with Sepak sila 3 times and catches it. The ball is thrown back to the opponent. c. Dosage: 20 minutes. 5 sets × 18 reps, 40 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball is bounced off the wall and then juggled 3 times with the Sepak sila technique before being caught. c. Dosage: 20 minutes. 5 sets × 18 reps, 40 seconds recovery d. 15 minutes Games	9, 10
a. Flexibility training b. The ball is thrown with a parabolic dish to the student who is the partner. The partner accepts and juggles the ball with Sepak sila 3 times and catches it. The ball is thrown back to the opponent. c. Dosage: 20 minutes. 5 sets × 21 reps, 40 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball is bounced off the wall and then juggled 3 times with the Sepak sila technique before being caught. c. Dosage: 20 minutes. 5 sets × 21 reps, 40 seconds recovery d. 15 minutes Games	11, 12
a. Flexibility training b. The student juggles the ball using the Sepak sila technique 2 times and then feeds it to his partner and juggles it 2 times without the ball falling c. Dosage: 20 minutes. 6 sets × 23 reps, 45 seconds recovery d. 15 minutes Games	a. Flexibility training b. The ball bounces off the wall and juggles it parabolically 3 times and horizontally 1 time c. Dosage: 20 minutes. 6 sets × 23 reps, 45 seconds recovery d. 15 minutes Games	13, 14
a. Flexibility training b. The student juggles the ball using the Sepak sila technique 2 times and then feeds it to his partner and juggles it 2 times without the ball falling d. Dosage: 20 minutes, 6 sets × 25 reps, 45 seconds recovery, 25 reps × 2 sets of target serve behind, overhead, and in front. c. 15 minutes Games	a. Flexibility training b. The ball bounces off the wall and juggles it parabolically 3 times and horizontally 1 time c. Dosage: 20 minutes. 6 sets × 25 reps, 45 seconds recovery d. 15 minutes Games	15,16

Materials and methods

Study participants

This research is experimental research with field testing (Yulianto & Yudhistira, 202; Wicaksono et al., 2022). The experimental approach used is a 2×2 factorial involving two independent variables given treatment, one dependent variable, and one controlled attribute variable (Collins et al., 2014; Rogers & Revesz, 2020). The sampling technique used was purposive sampling with the criteria (1) participants were extracurricular junior high school (SMP) students in West Sleman Regency, Yogyakarta Province, (2) actively participated in sepak takraw training, and (3) male. Based

on these criteria, there were 24 takraw extracurricular participants aged 14-15 years with a height of 153-170± and a weight of 50-65± kilograms.

A total of 24 participants will be divided into four groups by testing the modified bass balance test (Jazi et al., 2012). The results of the balance test will apply the Match Subject Ordinal Pairing (MSOP) pattern with the A-B-B-A pattern so that the group becomes balanced. Based on the test, it was found that 12 students who had high and low balance would be given Sepak sila training with bouncing the ball against the wall media, and 12 other students were given Sepak sila training with media where students pair up with each other. In detail, one group consists of 12 students who are divided into 2 teams, each consisting of 6 students who have a low balance and 6 students who have high balance Sepak sila practice by bouncing the ball against the wall media and in pairs. The factorial design is presented in the table 1.

The next procedure is to do a pretest on the Sepak sila group with wall media and in pairs. The instrument used was a Sepak sila skills test instrument from Ramadhan (2015) with a validity coefficient of 0.71 and a reliability of 0.68. The study explains that the Sepak sila skills test validity coefficient with a value of 0.70 and above has a level of measurement accuracy (Guntur et al., 2020; Dewangga & Tomoliyus, 2020; Yudhistira et al., 2021), while a reliability coefficient of 0.6 to 0.7 indicates moderate accuracy (Choubin et al., 2019). Therefore, the test of Sepak sila skills can be used in research. The procedure for the Sepak sila test is presented in the table 2.

Study organization

The participants were 24 students divided into two groups so each group consisted of 12 students. Students are given treatment using wall media by bouncing the ball on the wall and in pairs with the number of training frequencies 3 times a week for 16 meetings. The researcher was assisted by four assistants to observe the pretest time during the exercise in 16 meetings and the post-test was taken after the 16th training meeting. The exercise program is presented in the table 3.

Statistical analysis

The data was processed with the help of SPSS version 20 (Wicaksono et al., 2022). The data analysis used was a two-way ANOVA analysis. If there is an interaction, the analysis will be continued using the Tukey test with a significance level of 0.05 (Liang, Hiley & Kanosue, 2019). However, before applying the analysis, it is necessary to carry out prerequisite tests including tests for normality and homogeneity of the data. Thus, when the data is said to be normal and homogeneous, the test can be continued.

Results

If it is displayed in the form of a diagram, the data on Sepak sila skills can be presented as shown in the following graph.

Based on the graph above, shows that the Sepak sila skills of the group (L1K1) who applied wall media and have high balance obtained an average pretest score of 35.00 and

Table 4. Analysis Results in Description of Pretest-Posttest

Practicing	Balance	Pretest	Posttest
Sepak sila Practice with Walls	High (L1K1)	35 ± 1.26	38 ± 1.10
	Low (L1K2)	35.53 ± 1.37	45 ± 4.15
Sepak sila Practice in Pairs	High (L2K1)	36 ± 0.89	54.67 ± 0.47
	Low (L2K2)	34.50 ± 1.38	37.67 ± 2.25

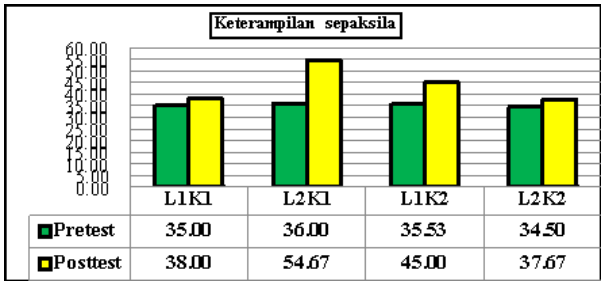

Fig. 1. Graphics of soccer skills

increased at the post-test to 38.00. The group (L2K1) of Sepak sila in pairs who has high balance obtained an average pretest score of 36.00 and increased at post-test to 54.67. The group (L1K2) of Sepak sila with wall media which has a low balance obtained an average pretest score of 35.53 and increased at post-test to 45.00. The group (L2K2) of Sepak sila in pairs who have low balance obtained an average pretest score of 34.50 which increased to 35.67 at the posttest.

Table 5. Data Normality Test Results

Group		p	significance	Information
Pretest	L1K1	0,713	0,05	Normal
	L2K1	0,968		Normal
	L1K2	0,801		Normal
	L2K2	0,976		Normal
Posttest	L1K1	0,573		Normal
	L2K1	0,986		Normal
	L1K2	0,996		Normal
	L2K2	0,920		Normal

Based on the statistical analysis of the normality test that has been carried out using the Kolmogorov Smirnov test, it was found that all the pretest and posttest data on Sepak sila were normally distributed with a significance value of p>0.05.

Table 6. Data Homogeneity Test Results

F	Df1	Df2	Significance
2.134	3	20	0.128

Based on the statistical analysis of the homogeneity test that has been carried out using the Levene test, a significance value of > 0.05 was found. This result indicates that the data has a homogeneous variance.

According to the Anova test, the F value is 19,698 and the significance value is 0.000 <0.05. In other words, there is

Table 6. ANOVA Test Results for Paired Exercise and Wall Exercises

Source	Type III Sum of Squares	df	Mean Square	F	Sig
Exercise Method	130.667	1	130.667	19.698	0.000

a significant difference in the effect between exercises with wall media and in pairs on Sepak sila skills. Paired group analysis got a score of 46.17 and the group with wall media got 41.50 so the post-test difference was 4.67. These results indicate that the group with paired exercises produced better results. The first hypothesis, that there is a significant difference in the effect of pair practice and wall media practice on soccer abilities, has thus been proved.

Table 7. ANOVA Test Results on Differences in High Balance and Low Balance on Sepak sila Skills

Source	Type III Sum of Squares	df	Mean Square	F	sig
Balance	150.000	1	150.000	22.613	0.000

Based on the ANOVA test above, it is presented that the F value is 22.613 and the significance value is 0.000 < 0.05 which indicates a significant difference in influence on the Sepak sila skills between extracurricular students who have high balance and low balance. Based on the results of the analysis, students who have high balance get a score of 46.33 and students who have low balance get a value of 41.33, and students who have high balance are better. Thus, the second hypothesis which states that there is a significant difference in the effect between students who have high balance and low balance on Sepak sila skills has been proven.

Table 8. ANOVA Test Results on the Interaction of Paired Exercises and Wall Exercises with Balance (High and Low) on Sepak sila Skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig
Exercise Method * balance	864.000	1	864.000	130.251	0.000

Based on the ANOVA test results, the F value is 130.251 and the significance value is 0.000 <0.05, indicating an interaction. The third hypothesis, that there is a substantial interaction between pair practice and wall media exercises with high and low balance on Sepak sila skills, has thus been proved.

Based on the Tukey test, the asterisk (*) can be explained that the pair having an interaction. Interactions are found in (1) L1K1-L1K2 (Sepak sila practice with wall media for students with high balance – Sepak sila practice with wall media for students with low balance). (2) L1K1-L2K1 (Sepak sila practice with wall media for students with high balance – Sepak sila practice in pairs for students with high balance). (3) L1K2-L2K1 (Sepak sila practice with wall media for students with low balance – Sepak sila practice in pairs for students with high balance), (4) L1K2-L2K2 (Sepak sila practice with wall media for students with low balance – Sepak sila practice in pairs for students with low balance), (5) L2K1-L2K2 (Sepak sila practice with wall media for students with low balance – Sepak sila practice in pairs for students with low balance).

Table 9. Post Hoc Test Results

Group	Interaction	Mean Difference	Std. Error	Sig
L1K1	L1K2	-7.0000*	1.48698	0,001
	L2K1	-16.6667*	1.48698	0,000
	L2K2	0.3333	1.48698	0,996
L1K2	L1K1	7.0000*	1.48698	0,001
	L2K1	-9.6667*	1.48698	0,000
	L2K2	7.3333*	1.48698	0,000
L2K1	L1K1	16.6667*	1.48698	0,000
	L1K2	9.6667*	1.48698	0,000
	L2K2	17.0000*	1.48698	0,000
L2K2	L1K1	-0.3333	1.48698	0,996
	L1K2	-7.3333*	1.48698	0,000
	L2K1	-17.0000*	1.48698	0,000

Discussion

Efforts to improve abilities and skills in sepak takraw must be carried out through well-planned exercises and appropriate training methods. This is following several studies which state that training aims to improve competence and skills individually and in teams (Sulistiyono et al., 2021; Khudolii et al., 2020; Henry, 2013). Reinforced by other studies, it is stated that achieving success in the field of sports is the dream of every athlete so maximum coaching and approaches are needed (Nur, Ilham & Kamaruddin, 2021). Moreover, sepak takraw is considered a team sport that utilizes the mastery of qualified skills (Musa et al., 2020). The basic technique is important because various movements in sepak takraw require a perfect technique to win a match.

Coaches play an important part in the success of sepak takraw extracurricular students because sepak takraw extracurricular require specific attention not only for complete attendance but also for achievement sports. According to Nur, Ilham, and Kamaruddin (2021), sport is intended to give broader educational engagement and contribution, which necessitates an improvement in sports achievement in schools.

According to a previous study, coaches become like heroes with variable roles who can become facilitators, motivators, and parents, and always update knowledge so that the athlete's competence can dramatically rise (Wicaksono et al., 2022). According to Tirtawirya and Tomoliyus (2020), getting better at sporting activities is not easy, and it is required to pay attention to numerous elements such as physically, physically, and technically setting up an exercise program.

One of the most important basic techniques in sepak takraw is soccer. The study explains that the Sepak sila technique is the mother of the sepak takraw game because of its very vital function, namely to receive kicks from the opponent's service, feed to teammates, and as a ball carrier to the opponent (Suprayitno, 2018). Therefore, the role of the coach is needed to develop a good method to optimize the basic techniques of this Sepak sila in sepak takraw.

There are numerous training methods used in team sports that are carried out in certain games. That is, the training method used is appropriate for the competitive conditions (Said & Syam, 2022). The media training method of bouncing the ball against the wall and the pair training method are utilized in sepak takraw. These are two options for improving the fundamental techniques of sepak takraw, particularly the Sepak sila technique. According to a prior study, the exercise strategy used alone and in pairs attempts to develop the technique to be reached (Said, & Syam, 2022).

Based on the ANOVA test, the first hypothesis which states that there is a significant difference in the effect between pair practice and wall media practice on Sepak sila skills has been proven with an F value of 19,698 and a significance value of 0.000 <0.05. The analysis of the post-test results in the group with pair practice got a score of 46.17 and the group with wall media got a score of 41.50. Thus, the posttest difference is 4.67. In other words, the training method in the group with paired exercises produces better results.

Based on the Anova test, the second hypothesis which states that there is a significant difference in influence between students who have high balance and low balance on Sepak sila skills has been proven, which is indicated by an F value of 22,613 and a significance value of 0.000 < 0.05. In the analysis of post-test results, students who have high balance get a score of 46.33, and students who have low balance get a score of 41.33. These results indicate that students who have high balance are better than students who have low balance in doing the silage technique.

Based on the Anova test, the third hypothesis which states that there is a significant interaction between pair exercise and exercises with wall media with high and low balance can be said to have been proven with an F value of 130.251 and a significance value of 0.000 < 0.05. Based on the Tukey test, the interacting groups are (1) L1K1-L1K2 (Sepak sila practice with wall media for students with high balance – Sepak sila practice with wall media for students with low balance). (2) L1K1-L2K1 (Sepak sila practice with wall media for students with high balance – Sepak sila practice in pairs for students with high balance). (3) L1K2-L2K1 (Sepak sila practice with wall media for students with low balance – Sepak sila practice in pairs for students with high balance), (4) L1K2-L2K2 (Sepak sila practice with wall media for students with low balance - Sepak sila practice in pairs for students with low balance), (5) L2K1-L2K2 (Sepak sila practice with wall media for students with low balance – Sepak sila practice in pairs for students with low balance). In the end, the results have been obtained that all the hypotheses proposed by the researcher have been proven. This is reinforced by a study from Jaka (2014) which explains that training with individual and pair methods has a significant effect on soccer skills where the paired method is found to be better.

Conclusions

Based on the results and discussion above, the researchers found that (a) there was a significant effect between exercises with wall media and pairs on Sepak sila skills where training with the paired method was found to have better results, and (b) there was a significant effect between students who have a high and low balance on the Sepak sila skills where high balance results in better performance, (c) there was a significant interaction between training with wall media and paired with high and low balance. The findings of this study can be used as a reference that to improve the basic technical skills of Sepak sila, it is recommended to use the paired method.

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Conflict of interest

All authors declare no conflict of interest.

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ВПЛИВ ТРЕНУВАЛЬНОЇ МОДЕЛІ ТА РІВНОВАГИ НА НАВИЧКИ УЧНІВ ВИКОНУВАТИ ТЕХНІКУ СЕПАК СИЛА НА ФАКУЛЬТАТИВНИХ ЗАНЯТТЯХ СЕПАК ТАКРО В ПЕРШІЙ СЕРЕДНІЙ ШКОЛІ

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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., 1 рис., 38 джерел.

Мета дослідження. Це дослідження мало на меті вивчити моделі тренувань на стіні та в парах: (1) різницю у впливі вправ на стіні та в парах на виконання техніки Сепак сила (2) різницю між високою та низькою рівновагою на виконання техніки Сепак сила (3) взаємний вплив моделей тренувань на стіні та в парах із високою та низькою рівновагою на навички виконання техніки Сепак сила (жонглювання м'ячем на нозі в ножному волейболі – Сепак такро).

Матеріали та методи. У цьому дослідженні використовували метод факторного експерименту за схемою 2×2. Учасниками дослідження були 24 учні чоловічої статі, які відвідували факультативні заняття Сепак такро, віком 14-15 років, зростом 153-170± сантиметрів і вагою 50-60 кілограмів. Вимірювальними засобами, які використовували в цьому дослідженні, були вимірювальні засоби модифікованого тесту Басса на динамічну рівновагу та вимірювальні засоби техніки Сепак сила. Методи збору даних складалися зі спостереження та тестів. Одержані дані були проаналізовані з використанням двофакторного дисперсійного аналізу за допомогою програмного забезпечення SPSS 20.

Результати. (1) Було встановлено статистично значущу різницю між моделями тренувань на стіні та в парах у впливі на навички Сепак сила з показником F 19,698 та значущістю 0,000 <0,05. На підставі цих отриманих даних модель тренувань у парах із середнім показником 46,17 виявилася кращою, порівняно з моделлю тренувань на стіні, яка отримала середній показник 41,50. (2) Було встановлено статистично значущу різницю між високою та низькою рівновагою у впливі на навички Сепак сила, де висока рівновага була кращою із середнім значенням 46,33, порівняно з низькою рівновагою із середнім значенням 41,33. (3) Було встановлено наявність значущої взаємодії між моделями настінних тренувань і тренувань у парах із високою та низькою рівновагою у впливі на навички Сепак сила з показником F 130,251 та значущістю 0,000<0,05.

Висновки. Підсумовуючи, ми доходимо висновку, що модель парних вправ краща за модель вправ на стіні. Тому рекомендується використовувати парну тренувальну модель для зміцнення основних технічних навичок Сепак сила.

Ключові слова: парні вправи, Сепак сила, Сепак такро, учні першої середньої школи.

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DEVELOPMENT OF BASIC MOVEMENT SKILLS TEST INSTRUMENTS FOR EARLY CHILDHOOD

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Abstract

Study purpose. The aim of the study was to develop a manual and easy test instrument for basic movement skills in early childhood.

Materials and methods. In this work, we use a research and development (R&D) method. The research procedures are: (1) the first stage is a preliminary study in the form of potential problems, data collection, and needs analysis, (2) the second stage is instrument development planning, and (3) the third stage is trial, expert evaluations, and product revisions, and (4) the fourth stage is model implementation. A total of 155 children aged 4-6 years participated in this study. Statistical analysis used is the product-moment correlation for the validity test and Cronbach alpha for the reliability test. Data were analyzed using the SPSS application.

Results. The results of this study are 1) the creation of a basic movement skill test instrument that can measure three components, namely locomotor, non-locomotor, and manipulative. 2) Based on this validity test, from 15 research instruments of basic movement skills (Y) tested, 15 items were obtained with r-count > 0.133 and were declared valid to be used in capturing research data. 3) The results obtained were r-count = 0.676 and r table 0.133, so the value of r arithmetic > r table, then this instrument is declared reliable and can be used as a data collection tool.

Conclusions. The development of basic motion test instruments produce instruments that can measure and evaluate the basic movement skills of children aged 4-6 years which include three components, namely, locomotor, non-locomotor, and manipulative.

Keywords: physical activity, motor skills, test instrument, children.

Introduction

The basis of the development of motion becomes the foundation for each individual to understand the scope of motion, namely related to the understanding of the development of motion, the principles of motion development, and the purpose and function of the development of motion. Some literature recommends that physical education programs should provide intensive guidance on the basic movement skills needed to support various physical activities (O'Brien et al., 2016). Motion skills are closely related to motor development. Motor development discusses changes in movement behavior over time, including all behaviors during life, where the underlying processes of the changes we see, and the factors that affect motor behavior (Haywood et al., 2012). In humans, the development of motion is a change from the ability of motion in infants to adults involving various aspects of behavior and ability to move, aspects of behavior and development of motion affect each other. The development of basic motion or motor skills in children is shaped and influenced by their environment (Zhang & Cheung, 2019). One of the developments of motor skills in children is eruptions at different levels, some children can be enriched, but others are not ready, some can route, while others are not visually ready.

The importance of motor skills as the main basis for improving special motor skills, especially in general sports

(Komaini et., al 2022). However, to date, research on the relationship between basic and specialized motor skills in movement has been very rarely reported (Kokstejn & Musalek, 2019). The effectiveness of movement is often overlooked because it is a natural part of human life. However, it is essential for children's physical, cognitive, and social development. In addition, experience strongly supports the learning and development of fundamental movement skills. The foundation of these skills is laid in childhood which is important to encourage lifestyle active behavior (Bouffard, 2016).

Basic motor skills are divided into three categories, namely locomotor, non-locomotor, and manipulative. Non-locomotor abilities are performed on the spot, without an adequate range of motion. Non-locomotor abilities such as stretching, bending, lifting, pulling, folding, twisting, dragging, coiling, soaring, and others. The locomotor ability is used to move an object from one place to another. in addition to locomotor abilities such as jumping, walking, and running. Meanwhile, manipulative abilities are developed when children master various objects. Manipulative abilities involve more hands and feet, but other parts of our body can also be used. Object manipulation is far superior to the coordination of the ankles and eyes of the hand, where this coordination is important enough for the process of walking in the motion space, the forms of manipulative abilities consist of, the movement of pushing (throwing and hitting, kicking), the movement of receiving (capturing) objects is an important ability taught by using plastic balls made of rubber pads (medical balls) or plastic balls with bouncing and dribbling movements. Movement actions such as catching, kicking, and running appear to have a stronger relationship with children's functional abilities (Capio et al., 2011). Low competence in fundamental motor skills is associated with lower levels of cardiorespiratory fitness and physical activity in children and adolescents. Characteristics of students who have competence in movement skills differ in gender and skills (Hardy et al., 2012). One study reported that children's movement and object control skills were not correlated with their BMI levels. In addition, most of the correlation coefficients between BMI and locomotor skills, as well as the correlation between BMI and object control skills were not significant (Kim & Lee, 2016).

Movement skills are fundamental as a term related to physical activity (Basman, 2019). Fundamental motor skills are defined as a series of organized basic movements involving a combination of movement patterns from two or more segments of the body (Hardy et al., 2012). The development of children's fundamental motor skills is shaped by the surrounding environment (Cheung & Zhang, 2020). Recent evidence reports that children have the developmental potential to master most of the fundamental motor skills by the age of 6 years during physical education, physical activity, and sports (O'Brien et al., 2016). However, 61% of teachers indicated they were aware of their current limitations and thus requested professional development opportunities related to early childhood physical activity (Sevimli-Celik & Johnson, 2013). Adequate development of fundamental motor skills in children can result in participation in more varied physical activities (Gu, 2016). Schools that include learning experiences of fundamental motor skills that are in line with developments delivered by highly trained physical education teachers significantly increase the fundamental skills of motor skills in adolescents (Morgan et al., 2013). Children who don't learn fundamental motor skills are more likely to become unskilled adults who don't innovate much (Johnson et al., 2019). Children who move very rarely are at risk for developmental disorders in the cognitive, motor, linguistic, behavioral, and social domains. In addition, several environmental factors are known to be the main triggers (Mürner-Lavanchy and Anderson, 2018). Low competence in fundamental motor skills is associated with lower levels of cardiorespiratory fitness and physical activity in children and adolescents (Hardy et al., 2012). The results found that girls had higher levels of motor skills compared to boys of the same age (Nikolić et al., 2016). In addition, inaccurate perceptions of motor competence can jeopardize children's involvement in physical activity (Almeida et al., 2017).

The measuring instrument for the test of movement skills is considered indispensable to determine the motor development of children. Several measuring tools to measure the development of human movement such as (1) Motor test für vier bis sechsjahrige Kinder (MOT 4-6) which is a coordination assessment tool for preschool children recommended for educational research purposes due to a certain age range. To assess children at the age of 4 years to 6 years 11 months. This test kit comes from Germany and has been developed to contribute to the measurement of fundamental motor skills development. In addition, this tool opens up opportunities for early detection of delays or deficiencies in fundamental motor skills (Bouffard, 2016). Furthermore, the measurement of movement skills for children using the movement-ABC test is a revision of the Motor Test Drop derived from the Oseretsky scale for children's motor capacity. This tool is suitable for children aged 4 to 12 years and is very useful in exploring problems of functional integration of motor control or problems that often first arise in the late early preschool and elementary school years (Hu et al., 2021). Furthermore, Peabody Developmental Motor Scales-Second Edition (PDMS-2) is a motor skills assessment tool that measures gross and fine motor skills. This tool focuses on assessing children with disabilities and also determines the balanced development of fine and gross motor movement skills, identifies skill deficits, and evaluates progress. Furthermore, the Deutsche Motoric Test (DMT) is to objectively assess quantitative aspects of movement skill patterns in addition to the performance of qualitative movement skills such as flexibility, balance, and strength (Gruber et al., 2020). Assessment of basic motor skills remains an important tool in classifying a person's level of basic motor skill proficiency. Fundamental motor skills performance collection for assessment and monitoring has remained unchanged over the past few years (Ward et al., 2017). The test distinguishes between children with normal motor behavior and without normal motor behavior. Each measuring instrument has a certain classification or function because each measuring instrument is not suitable for every age, it is necessary to understand the appropriate measuring instrument used so that the measuring instrument used is valid or appropriate.

Instrument Development is very important to do. Research is needed to examine the efficacy of such techniques in real-world settings, which could change our perspective on the potential of technology to enable children's physical motion activity and fundamental motor skills (Barnett et

al., 2013). The test has important implications for implementing freely available, manageable, fun, interventional, and interactive motion learning to help children improve their manual dexterity skills (McGlashan et al., 2017). It also developed measuring instruments such as PERF-FIT that can measure fitness related to motor skills in children aged 5 to 12 years in a variety of settings and help doctors monitor the level of basic motor skills (throwing, bounce, catching, jumping , and balancing) (Smits-Engelsman et al., 2021). But for some of the tools that have been described definitely require adequate technology. In order to answer a challenge in the development of tests that are felt to make it easier for parents or teachers to know the child's motor skills, it is necessary to develop senior test equipment. In addition to being a test, the instrument can also be used as one of the learning media. To achieve this, a greater understanding of the process of assessing human movement skills is required (Ward et al., 2017).

Materials and methods

Study Design

This study used a Research and Development (R&D) approach. The research procedure is: (1) the first stage is a preliminary study in the form of potential problems, data collection, and analysis of needs, (2) the second stage is the planning of instrument development, and (3) the third stage is trials, expert evaluation, and product revision, and (4) the fourth stage is the implementation of the model.

Participants

A total of 155 children aged 4-6 years participated in this study.

Statistical Analysis

Statistical analysis used is the product-moment correlation for validity test and Cronbach alpha for reliability test. Data were analyzed using the SPSS application.

Results

Product Description

Basic Motion is a skill that involves large muscles, and muscle strength involving arms and legs that are used to achieve an exercise or movement goal. The muscles that play a role include arm muscles, limb muscles, shoulder muscles, back muscles, and abdominal muscles. Basic moves are performed in the form of walking, tiptoeing, jumping, running, rolling, catching, throwing, twisting, kicking, and bouncing the ball. The instrument developed includes three components: 1) Locomotor movement consists of a) Running, stepping quickly, until there is a movement where both legs float briefly in the air, b) Gallop – performing horse steps quickly, c) Hops – jumping within the minimum distance on each foot, d) Leap – carrying out related skills by jumping over objects with one foot, e) Horizontal jump – performing horizontal jumps from standing positions forward as far as possible, f) Slide – sideways movement on a straight line from one point to another, 2) Non-locomotor movement consists of a) jumping in a place with two legs, b) jumping in a place with one leg, three times in a row, c) standing with one leg for 10 seconds, d) movement resembling an airplane, e) and climbing stairs in turn, and 3) Manipulative movements include: a) throw the ball with one hand, b) catch the ball with two hands, c) kick the ball, d) roll the ball, e) bounce the ball.

The Basic Movement Skills Test instrument grid includes 3 (three) components, namely Locomotor, Non-locomotor, and Manipulative (see Table 1). The results of the development of basic movement skills test instruments (see Table 2).

Expert Improvement Advice Data

The next step is to seek opinions and advice from experts. Experts' opinions and suggestions are used to improve the quality of products made. The following opinions and suggestions from experts on the draft motor learning model for early childhood (see Table 3).

Based on expert input, the basic motion instrument development model underwent several improvements. Improvements were made to the instructions for implementing

Table 1. Development of Basic Motion Skills Instrument Grid

Variable	Sub variable	Indicator	Sub Indicator	Test Items
Early Childhood Basic Motion	Locomotor	1. Run 2. Gallop 3. Walk 4. Hop 5. Leap	1. Running Straight 2. Horse Run 3. Jinjit walk 4. Jump forward with two legs 5. Jumping in different directions	1, 2, 3, 4, 5
	Non-Locomotor	1. Skip 2. Balance 3. Movement 4. Coordination	1. Jump in place with two feet 2. Jump in place with one foot 3. Stand on one leg 4. Move like an airplane 5. Go up and down stairs	6, 7, 8, 9, 10
	Manipulative	1. Hand Gestures 2. Foot movement	1. Throw the ball with one hand 2. Catch the ball with one hand 3. Kick the ball with one foot 4. Rolling the ball with one hand 5. Bounce the ball	11, 12, 13, 14, 15

Table 2. Basic Motion Skills test instruments

MOTOR SKILLS TEST FUNDAMENTAL FORM				
Note: this form is used to perform basic motion skills tests for Early Childhood				
Test Dates:				
Name:		Date of birth:		
Gender:		School/Kindergarten Origin:		
Address:		Parent Name:		
Anthropometry				
Weight				
Height				
Arm Circumference				
Head Circumference				
	I. LOCOMOTOR COMPONENTS	**Bs**	**Bdb**	**Tb**
1	Running back and forth on a 10-meter straight line			
2	Horse Run (Gallop) back and forth Bali On a straight line for 10 meters			
3	Walk back and forth with the tips of the toes for 5 meters			
4	Jumping forward with two legs 5 times			
5	Jump to the left and right sides and back and land on two legs simultaneously twice			
	II. NON-LOCOMOTOR COMPONENTS	**Bs**	**Bdb**	**Tb**
6	Stand on one leg with eyes closed for 10 seconds			
7	The attitude resembles an airplane that is one of the legs raised, both hands stretched out and then slowly wrapped around the body for 5 seconds			
8	Rotate half the body where the position of both legs remains, and the limbs from the waist to the head are directed to the left and right sides alternately			
9	Bend the body to duck and squat			
10	Rotate the Body by changing the position of the legs to change the position of the body facing in different directions.			
	III. MANIPULATIVE COMPONENTS	**Bs**	**Bdb**	**Tb**
11	Throw the ball with one hand			
12	Catch the ball with two hands			
13	Kicking a Ball with one foot			
14	Rolling the ball with one hand			
15	Bounce the ball with one hand			

Table 3. Expert advice and input

Number	Material Experts	Feedback on Learning Models
1	Expert 1	1. The instructions for the implementation of the test need to be clarified. 2. Explanation of the test item
2	Expert 2	1. Instruments need to be clarified. 2. Balance of test items between components, namely locomotor, non-locomotor, and manipulative
3	Expert 3	1. Research criteria must be made 2. Terms must be given a description

activities, instruments, and objectives. The next step after the repair is product trial.

Product Test Results
Validity

Based on the validity test, of the 15 basic movement skills research test instruments tested, 15 items were obtained whose r-count > 0.133 and were declared valid to be used in research data collection.

Reliability

Calculation of reliability of regulatory variable instruments using Cronbach alpha formulas by comparing the calculated r-value with the r table. The criteria if the value of r count > r table, then the instrument is declared reliable. The results obtained at the calculated r-value = 0.676 and the r table value is 0.133, so the calculated r-value > r table, so this instrument is declared reliable and can be used as a tool to collect data.

Discussion

This research produces a product in the form of a basic movement skill test instrument. This product is recommended to be used to measure basic movement skills aged 4-6 years. If children are to live physically active lives, we need to help them acquire the motor skills that enable them to participate in a variety of physical activities. In addition, monitoring the level of development of basic movement skills needs more attention. Previous research reported that children given physical education showed higher standard motor skill scores than children given recreation (Lemos et al., 2012). These results explain that regular, structured physical education improves motor skills in early childhood.

There are several things needed to increase the physical activity of preschoolers: (1) improving teacher knowledge through both service training and in-service training, (2) creating classrooms, schools, and playrooms that allow children to move and play safely, and (3) developing teacher self-efficacy through health-related fitness activities, (4) encouraging parental involvement by educating parents about their role in physical-child behavior, and (5) collaborated and work with colleagues in other departments to share ideas, resources, and methods in terms of the implementation of physical activity in early years children (Tandon et al., 2015).

This test instrument has gone through a trial phase to calculate its validity and reliability level. Validity in research is something that shows accuracy or truth (Rifki et al., 2022). A valid instrument has high validity (Nurhasanah et al., 2022). Otherwise, an instrument that is less valid means it has low validity. The validity of content is the rate at which a test measures the scope of the intended content. The validity of the item point to the question of whether the test items represent the size of the scope of the desired content, and the validity of the sampling point at how well the test represents the entire scope of the overall content (Smits-Engelsman et al., 2021). It has been explained the importance of reliability and validity through a test. As for testing item validity (construct validity), expert opinion can be used. In this case, after the instrument has been constructed, the aspects to be measured are based on certain theories, then the experts are consulted. After the construction testing from experts and based on empirical experience in the field was completed, it was continued with instrument testing.

Based on the results of the study is known to have high reliability enough to be used as an instrument test in the motoric assessment of children. High reliability demonstrates consistency in such measurements (Smits-Engelsman et al., 2021). In addition to being an instrument for motor tests, it can also be used as a learning tool to continuously train and improve children's motors.

Conclusions

The development of basic motion test instruments produce instruments that can measure and evaluate the basic movement skills of children aged 4-6 years which include three components, namely, locomotor, non-locomotor, and manipulative.

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Conflict of interest

There is no conflict of interest in this study.

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РОЗРОБКА ІНСТРУМЕНТІВ ТЕСТУВАННЯ БАЗОВИХ РУХОВИХ НАВИЧОК ДЛЯ ДІТЕЙ МОЛОДШОГО ВІКУ

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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., 28 джерел.

Мета дослідження. Мета цього дослідження полягала в тому, щоб розробити ручний і зручний тестувальний інструмент для базових рухових навичок у дітей молодшого віку.

Матеріали та методи. У цій роботі ми використовуємо метод дослідження та розробки (R&D). Дослідницькі процедури: (1) перший етап – це попереднє дослідження у формі потенційних проблем, збору даних та аналізу потреб, (2) другий етап – планування розробки інструмента, (3) третій етап – випробування, експертні оцінки та доопрацювання продукту, (4) четвертий етап – впровадження моделі. У цьому дослідженні брали участь загалом 155 дітей віком 4–6 років. Як статистичний аналіз використовували коефіцієнт кореляції Пірсона для тесту на валідність та альфу Кронбаха для тесту на надійність. Аналіз даних здійснювали з використанням програмного забезпечення SPSS.

Результати. Результати цього дослідження полягають у 1) створенні інструмента тестування базових рухових навичок, який може вимірювати три компоненти, а саме локомоторний, нелокомоторний та маніпуляційний. 2) На підставі цього тесту на валідність із 15 протестованих дослідницьких інструментів для базових рухових навичок (Y) було отримано 15 елементів зі значенням r-count > 0,133 та визнано їх дійсними для використання при зборі даних досліджень. 3) Одержані результати були r-count = 0,676 та r table 0,133, тому значення r arithmetic > r table, тоді цей інструмент оголошено надійним і його можна використовувати як засіб збору даних.

Висновки. Розробка інструментів для тестування базових рухів створює інструменти, які можуть вимірювати та оцінювати базові рухові навички дітей віком 4–6 років, які включають три компоненти, а саме: локомоторний, нелокомоторний та маніпуляційний.

Ключові слова: фізична активність, рухові навички, тестувальний інструмент, діти.

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DEVELOPING AN ALGORITHM FOR BUILDING INDIVIDUAL TRAINING PROGRAMS FOR HIGHLY QUALIFIED MULTI-SPORT ATHLETES AT THE STAGE OF DIRECT PREPARATION FOR WINTER SEASON COMPETITIONS

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Abstract

The purpose of the study was to develop and experimentally justify the effectiveness of the algorithm for building individual training programs for highly qualified multi-sport athletes at the stage of direct preparation for the main competitions of the winter season.

Materials and methods. Five highly qualified multi-sport athletes, whose sports qualification is the Master of Sports of Ukraine, took part in the pedagogical experiment. The mean age of the participants was (M±SD) 25.2±1.79 years. The main goal of the formative stage of the experiment (2020-2021) was to develop programs for the structural units of the training process (training classes, microcycles, mesocycles, and the stage of direct preparation for the main competitions) based on the developed algorithm for building individual programs. We have developed six consecutive steps for the purpose of achieving full preparation of athletes for major competitions.

Results. The implementation of an individual program at the stage of direct preparation for winter season competitions is effective and enables qualified multi-sport athletes to reach the peak of their sports form during participation in the competitions of the Ukrainian indoor heptathlon championship. This is evidenced by the achieved statistically significant differences ($p<0.05$) in all indicators of physical and functional fitness compared to the ascertainment stage of the experiment. The increase in indicators was 2.8-4.4% in the running tests, 4.0-4.2% in the tests reflecting speed and strength abilities, 6.6 % in the strength control exercise. We note a statistically significant ($p<0.05$) positive increase during the formative stage in the indicators of physical performance of multi-sport athletes within the range of 5.8-6.0 % and in the indicators of aerobic productivity within the range of 4.4-4.5%.

Conclusions. The use of the algorithm for building an individual program of preparation for competitions of highly qualified multi-sport athletes orients the coach and athlete towards achieving the desired sports result in the shortest way with economical and rational use of training equipment at the most difficult and responsible stage of direct preparation for the main competitions. Compliance with the stated provisions of the algorithm made it possible to rationally plan and choose the best option for building the training process.

Keywords: combined events, multi-sport athletes, training process, programming, stage of direct preparation, algorithm.

Introduction

Modern trends in the development of combined events are primarily characterized by a significant variety and scale of competitions, continuous development, financial and rating incentives. In this regard, the search for actual approaches to improving the system of training athletes in order to increase the effectiveness of the training process and achieve high competitive results constitutes a primary task (Guthrie, 2003; Platonov, 2006; Ganse & Degens, 2021).

To date, domestic decathletes have not yet come close to the high positions of the world ranking, as evidenced by

the existing records of Ukraine in certain types of combined events. Over the last decade, only one decathlete, Oleksii Kasianov, represented the Ukrainian team at the European, World and Olympic Games. Other leading multiathletes managed to reach during this time only the level of Master of sports of Ukraine. Therefore, the situation that has developed recently in Ukrainian combined events is characterized by an obvious contradiction between the desire of coaches and athletes to find new technologies for building the training process and the insufficient scientific base and outdated methodological provisions of athletic combined events (Bobrovnik, 2014; Kutek & Akhmetov, 2018; Platonov, 2020).

The domestic practice of training highly qualified track and field athletes, compared to the international practice (Thompson, 2009) has a number of organizational and technological inconsistencies. In particular, this refers to the insufficient observance in the preparatory period of the principles of overload, reversibility and specificity in the training process in order for the purpose of improving sports results (Bompa, Haff, 2009; DeWeese et al., 2015; Kutek et al., 2018), the lack of orientation of athletes towards the adequate use of mechanisms of energy provision of training loads (Wilmore et al., 2012; Liang, Xiao, 2014; Santos et al., 2021), lack of adequate control of adaptive mechanisms for the development of physical performance of athletes in the prevention of overfatigue, overtraining and sports injuries (Zemper, 2005; Meron & Saint-Phard, 2017), focusing on the identification and priority development of individual successful competitive disciplines (Kenny et al., 2005; Bilić & Balić, 2015; Pavlović & Idrizović, 2017).

Analysis of the available literature indicates the prospects of using an individual approach in the training process of highly qualified athletes. In particular, Kozina et al. (2015) presented the concept of individualization based on the definition of the leading factors in the individual structure of preparedness and individual dynamics of competitive activity, on the basis of which appropriate technologies for increasing the focus of the training process were individually implemented. In their work, Kozlova et al. (2020) analysed and compared individual anthropometric characteristics and biomechanical indicators of long jump technique by athletes from Ukraine and China. As for athletics combined events, the research by Dobrynska (2015) substantiates the modelling of competitive activity as a basis for individualizing the construction of multi-year training of women in heptathlon.

Taking into account the fact that combined events is technically the most difficult and physically demanding athletics discipline, as well as taking into account the limited number of thorough national studies of the problem of individualizing the training process of multiathletes at the stage of direct preparation for competitions, there is a natural need to develop an algorithm for building individual training programs for highly qualified multiathletes.

Research hypothesis: it was assumed that the development of an algorithm for building individual training programs for highly qualified multiathletes for the main competitions will allow to systematically and purposefully influence the adaptive resources of athletes to obtain delayed training effects and high sports results.

The purpose of the study was to develop and experimentally justify the effectiveness of the algorithm for building individual training programs for highly qualified multiathletes at the stage of direct preparation for the main competitions of the winter season.

Material and methodology

Participants

5 highly qualified multiathletes, whose sports qualification is the Master of Sports of Ukraine, took part in the pedagogical experiment. The mean age of the participants was (M±SD) 25.2±1.79 years. The study was approved by the ethics committee of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, and all procedures were in accordance with the Declaration of Helsinki. Informed consent for participation in the experiment was obtained from the participants.

Research organization

The study was conducted from 2019 to 2021. The scheme of a sequential pedagogical experiment was used.

During the ascertainment stage of the experiment (2019-2020), pedagogical observation of the training process was carried out in combination with timing of training work. This made it possible to determine the volume of training loads and their distribution for different types of training of multiathletes (Adamchuk et al., 2021).

The main goal of the formative stage of the experiment (2020-2021) was to develop programs for the structural units of the training process (training classes, microcycles, mesocycles, the stage of direct preparation for the main competitions) based on the developed algorithm for building individual programs. The basis of the development of the algorithm of the individual program is based on the analysis of data from the literature, own long-term experience of direct participation in training and competition activities in athletics combined events, the results of the ascertainment stage of the experiment regarding the peculiarities of the athletes' response to the groups of training tools used and their combination and influence on the energy supply systems of the training process. Thus, we have developed six consecutive steps for the purpose of achieving full preparation of athletes for major competitions (Fig. 1).

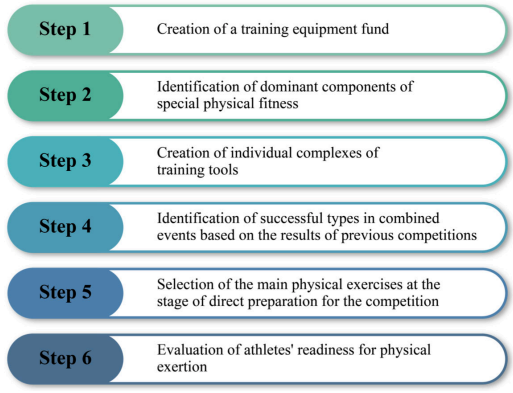

Fig. 1. Algorithm for building an individual training program for competitions of highly qualified multiathletes in combined events

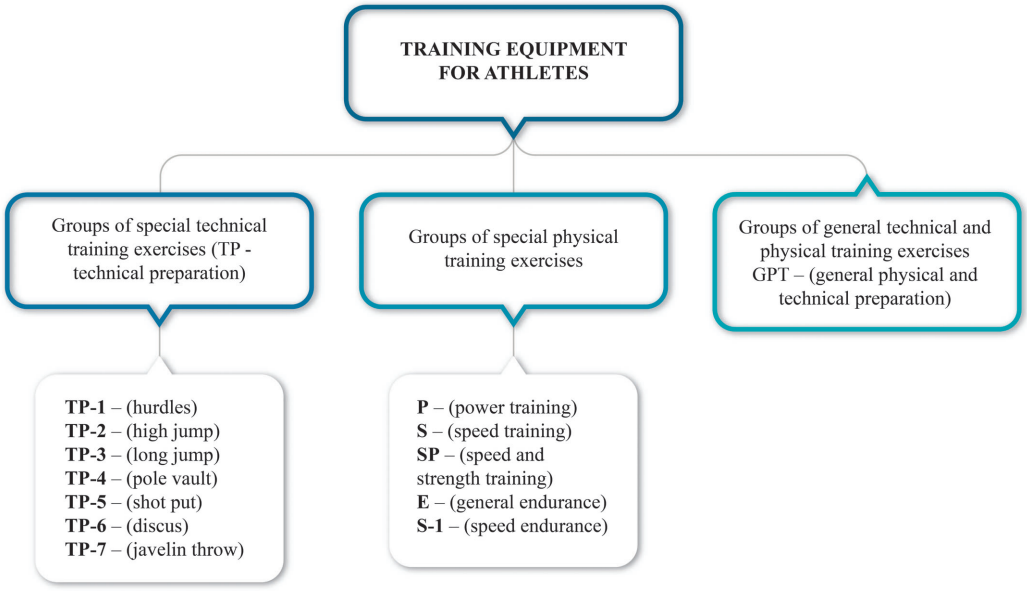

Fig. 2. Classification of means of training work in athletics combined events

Step 1. The selection of physical exercises was determined by the specifics of athletics combined events disciplines and previous experience in their use. The unequal response of different athletes to the same physical loads (Drozdovska, 2013), as well as the existence of individual growth limits of adaptation to certain physical loads were also taken into account. As this limit is approached in the process of training, the rate of increase in function slows down and stops at a certain amount of load. Any further continuation of training causes a disruption of adaptation, that is, the development of a state of overtraining. Therefore, in the developed algorithm, the requirement of creating individual training funds based on a overall, long-term and comprehensive assessment of the impact of special physical exercises on the athlete's body is met.

When forming the classification of training tools of qualified multiathletes, the division of physical exercises into groups of special training, which is used in foreign practice (Guthrie, 2003; Thompson, 2009) was used (Fig. 2).

Step 2. It is known that for highly qualified athletes in the period of preparation for the competition, the main attention should be focused on increasing performance in the sports to which the athlete has a pronounced tendency to develop. But on the way to achieving this goal, uneven development of special physical qualities is often observed in such athletes during the standard training process. Discrepancies in the variability of the used means of different predominant orientations within a specific athletics discipline revealed by specialists determine the distribution of athletes according to the type of group models of competitive activity: the first type of athletes includes multiathletes who are mainly able to achieve high results in athletics throws and who possess a high level of strength and speed-strength capabilities; the second type includes athletes who achieved high results in the running types of the program and have high speed or endurance; the third type is characterized by achieving high results in athletics jumps, possessing high capabilities of the alactic and lactic energy supply system as well as a high level of speed and strength qualities (Dobrynska, 2015).

In our study, only the second and third types of mutiathletes were found. The obtained data were used for planning the content and ratio of training tools at the stage of direct preparation for the main competitions of the winter season. The results of the previous macrocycle tests were used to determine the individual dominance of the components of the athletes' special physical fitness.

Step 3. On the basis of selected types of competitive activity and dominant components of special physical fitness, individual sets of training tools are created for the stage of direct preparation for the competition. During the formation of individual programs, the logical sequence of performing exercises of different orientations was necessarily taken into account, and namely: special endurance exercises were performed after speed exercises, general endurance exercises were performed after speed-strength exercises, special endurance exercises were performed after general endurance exercises and strength exercises were performed after speed exercises. Training exercises were combined into groups by taking into account the energy systems of muscle activity, effects on basic physical qualities, improvement of technical skills in individual types of multiathetes, competitive disciplines in general.

Taking into account that the stage of direct preparation for the competitions of the winter season of multiathetes consisted of two mesocycles – a control-preparatory one (included a 7-day introductive microcycle, 7-day impact microcycle, 7-day recovery microcycle and 3-day impact microcycle) and a pre-competition one (included a 4-day restorative microcycle, 3-day impact microcycle, 4-day restorative microcycle); in tab. 1, we give an example of a rational combination of groups of special exercises in the pre-competitive mesocycle.

Step 4. For optimal individual training of track and field athletes, it is recommended to focus mainly on the development of successful disciplines, while maintaining at the

Table 1. Variants of a rational combination of groups of special physical exercises in training sessions of the pre-competition mesocycle

Options for combination of physical exercises	Directions of influences			
	Energy systems	Basic physical qualities	Technical skills	Competitive disciplines
S TP – 5 TP – 2	Alactic Alactic Alactic	Speed,speed and strength quality	Sprint, putting, jumping	100 m, shot put, high jump
TP - 1 TP - 4 SP	Alactic Alactic Alactic	Speed, speed and strength qualities, coordination	Hurdles, jumping	110 m hurdles, pole vault
TP - 3 S-1	Alactic Lactic	Speed and strength qualities, speed endurance	Jumping, running	Long jump, 400 m
TP – 3 TP 6/7 P	Lactic Alactic Alactic	Speed and strength qualities, power qualities	Jumping, throwing	110 m hurdles, javelin throw or discus throw
TP 6/7 E	Alactic Aerobic	Speed and strength qualities, general endurance	Throwing, running	Javelin throw or discus throw, 1500 m

Notes: TP – special technical preparation: TP-1 – hurdles; TP-2 – high jump; TP-3 – long jump; TP-4 – pole vault; TP-5 – shot put; TP-6 – discus; TP-7 – javelin throw; P – power training; S – speed training; SP – speed and strength training, E – general endurance; S-1 – speed endurance

Table 2. Program of the 7-day impact microcycle of the control-preparatory mesocycle

Types of training	Days of the microcycle						
	1st	2nd	3rd	4th	5th	6th	7th
General physical training (GPT)	GPT 1.1(a) – 25^{4}	GPT 1.1(a) – 25^{4}	GPT 1.1(a) – 25^{4}	–	GPT 1.1(a) – 25^{4}	GPT 1.1(a) – 25^{4}	–
Special physical preparation (P, S, S-1, SP, E)	S-1.4(b) – 20^{10}	P 1.4(a) –15^{4} P 1.5(a) –15^{5}	S-1-1.7 – 15^{14}	–	SP-1.2 – 10^{6} SP-1.3 – 10^{6}	P1.2 – 8^{7} P1.4(a) – 8^{7}	–
Technical preparation (TP)	TP-3.3(a) – 15^{7} TP -3.7 – 15^{10} TP-5.1(b) – 5^{5} TP-5.2(b) – 25^{6}	TP-4.3(a)–40^{7} SP-1.5 – 25^{10}	TP-2.3 – 15^{7} TP-6.1– 20^{5} TP-6.2– 22^{6}	–	TP-1.14 – 30^{10} TP-7.1(b) – 10^{4} TP-7.2(b) – 15^{5}	S-1.1(a) – 25^{7} S-1.6(a) – 15^{8}	–
Competitions	–	–	–	–	–	–	–
Σ of the training work, min	105	120	97	–	100	81	–
VLC*, points	730	765	647	–	635	507	–
ICtl**, points/min	6.95	6.38	6.67	–	6.35	6.25	–

Notes: * VLC – value load coefficient was calculated as a result of multiplication of the duration of the exercise by its intensity in points depending on the heart rate (Kostiukevich, Shchepotina, Shynkaruk et al., 2020): intensity of exercise with the heart rate 114 bpm was evaluated in 1 point; 120 bpm – 2 points; 126 bpm – 3 points; 132 bpm – 4 points; 138 bpm – 5 points; 144 bpm – 6 points; 150 bpm – 7 points; 156 bpm – 8 points; 162 bpm – 10 points; 168 bpm – 12 points; 174 bpm – 14 points; 180 bpm – 17 points; 186 bpm – 21 points; 192 bpm – 25 points; 198 bpm – 33 points; ** ICtl – intensity coefficient of training load was determined as a ratio between CVL and the duration of a training session in minutes (Adamchuk et al, 2021); record of the exercise TP-3.7 – 1510: TP-3.7 – code of the training exercise; 1510 – duration of exercise in minutes (15) and intensity of exercise in points depending on the heart rate (10); GPT – general physical training; P – power training; S –speed training; SP – speed and strength training, E – general endurance; TP – special technical preparation: TP-1 – hurdles; TP-2 – high jump; TP-3 – long jump; TP-4 – pole vault; TP-5 – shot put; TP-6 – discus; TP-7 – javelin throw; S-1 – speed endurance

achieved level the disciplines lagging behind in the results shown (Dobrynska, 2015). Individual successful combined events disciplines are identified on the basis of the analysis of the results of repeated responsible competitions. We analysed the competitive activity of a group of multiathletes and identified successful disciplines for each of them based on the results of competitions at different levels.

Step 5. In order to achieve the highest sports result in the algorithm, it is determined to be expedient during the stage of direct preparation for the main competitions of the season to concentrate efforts on increasing adaptation only to the most successful individual competitive disciplines and dominant components of special physical and technical training using the minimum number of basic physical exercises in

the main part training class. This is motivated by preventing the dissipation of energy expenditure on the simultaneous development of adaptation to several competitive disciplines in one session. A sample of a microcycle program with an accented effect on leading physical qualities (speed-strength quality) is presented in the table 2.

Step 6. The experience of training multiathletes in track-and-field at the current stage shows that an indispensable condition for achieving the highest results in responsible competitions is the performance of training and competitive loads at the level of the maximum physical capabilities of the body, which in sports of higher achievements is defined as training in the overload mode. In practice, this means that during intensive training, the athlete makes maximum use of hidden energy resources which is demonstrated by the increase in fatigue. Therefore, when determining the functional state of athletes after completing a certain stage of training according to an individual program based on the developed algorithm, an assessment of their physical state is necessary.

Experimental substantiation of the effectiveness of the developed algorithm was carried out with the help of pedagogical testing using the following test exercises (Adamchuk et al., 2021; Kostiukevych, Lazarenko, Shchepotina et al., 2021):

- *30 m sprint (assessment of speed abilities):* starting 10-15 m run and then running over a distance of 30 m with time taken into account; the best result from two attempts was taken into account, the rest interval was 3-5 min;
- *running for 200 m and 200 m after 1 min of rest (speed endurance assessment):* overcoming two segments of the distance of 200 m with a rest interval of 1 min; the total time of overcoming two sections was determined; the test was performed once;
- *triple long jump from a standing position (assessment of speed and strength qualities):* alternately pushing off with one leg and the other from the starting line, 3 consecutive jumps were performed, the last of which was into the pit for landing; the total length from the starting line to the landing place was measured; the best result from three attempts was taken into account;
- *throwing a shot with two hands from below (assessment of speed and strength qualities):* from the starting position, standing facing the direction of throwing, holding the ball with two hands from below, feet at shoulder width apart with the front part of the foot on the segment; throwing the core was performed from below-forward; the best result from three attempts was taken into account;
- *squatting with a barbell on the shoulders (assessment of strength qualities):* squatting and standing up to the starting position with the maximum weight for each athlete; 1 attempt was given;
- *the running version of the* $PWC_{170(V)}$ test (estimation of physical capacity and aerobic productivity of the body): according to the method for conducting a run-based variant of the test $PWC_{170(V)}$ the athletes performed two 5-minute run loads by overcoming the distances of 700-900 and 1100-1300 m accordingly, with their heart rate being recorded at the end of the first and second load (the period of rest between run loads made 5 minutes). $PWC_{170(V)}$ was determined using the formula:

$$PWC_{170(V)} = V_1 + (V_2 - V_1)\frac{170 - f_1}{f_2 - f_1}, \quad (1)$$

whereas: V_1 and V_2 represent run speed during the first and second run loads (determined as a ratio between the distance length and the time for overcoming the distance), m/s;

f_1 and f_2 represent heart rate immediately after the first and second run load, bpm.

The following formula was used to convert $PWC_{170(V)}$ in m/s into PWC_{170} in kgm/min:

$$PWC170=417 \cdot PWC_{170(V)}-83, \quad (2)$$

Absolute index of maximum oxygen consumption (VO_2max, ml/min) was determined using the formula:

$$VO_2max=1{,}7 \cdot PWC_{170}+1240, \quad (3)$$

Relative index of maximum oxygen consumption (VO_2max(rel), ml/min/kg) was determined as a ratio of an absolute index to the body mass of the studied athletes.

Pedagogical testing of athletes was carried out at the beginning and at the end of the stage of direct preparation for competitions in the process of performing the main training work.

Statistical analysis

Mathematical processing of the results was carried out using the "Data Analysis" package of the MS Office Excel computer program (Albert et al., 2017; Byshevets et al.., 2019; Kostiukevych, Lazarenko, Vozniuk et al., 2020). Descriptive statistics were used, which included the determination of the arithmetic mean (M) and the mean square deviation (SD). Statistical reliability in the difference between the results of pedagogical testing of multiathletes at the beginning and at the end of the ascertaining and formative stages of the pedagogical experiment was determined by the non-parametric Wilcoxon T-test. Differences between groups were considered statistically significant at $p<0.05$.

Results

In order to objectively evaluate the advantages of the used algorithm for building individual training programs for highly qualified multiathletes at the stage of direct preparation for competitions, a comparative analysis of the indicators of physical and functional fitness of athletes was carried out in a formative experiment (table 3).

The autumn-winter period of preparation for the competition had a slightly shorter duration than the spring-summer period, but despite this, we obtained positive changes in the indicators of physical and functional readiness, which appeared to be greater than those determined at the ascertainment stage of the experiment.

The analysis of the obtained data allows us to note that there were positive changes in all indicators of physical fitness, but at the stage of the formative experiment they were more significant when compared to the stage of the ascertaining experiment. As we can see, the increase in results

Table 3. Indicators of physical and functional preparedness of multiathletes at the stage of direct preparation for winter season competitions at different stages of the experiment

Indicators of physical and functional fitness	Research phase	Output data		Final data		Changes (ΔM)		T	p
		M	SD	M	SD	Absolute	%		
Running for 30 m on the move, s	AE	3.05	0.17	2.96	0.09	0.09	2.9	0	<0.05
	FE	2.98	0.07	2.85	0.08	0.13	4.4	0	<0.05
Running 200 m and 200 m after 1 min of rest, s	AE	49.95	1.15	49.89	1.00	0.06	0.1	2	>0.05
	FE	49.70	0.64	48.33	0.52	1.37	2.8	0	<0.05
Triple jump from a place, m	AE	8.88	0.54	8.98	0.46	0.10	1.1	1	>0.05
	FE	8.89	0.18	9.25	0.27	0.36	4.0	0	<0.05
Throwing a shot with two hands from below, m	AE	15.05	0.52	15.72	0.44	0.67	4.5	0	<0.05
	FE	15.54	0.34	16.20	0.79	0.66	4.2	0	<0.05
Squatting with barbell, kg	AE	134.0	6.4	135.0	4.3	1.00	0.7	4	>0.05
	FE	136.0	25.7	145.0	12.9	9.00	6.6	0	<0.05
$PWC_{170(V)}$, m/s	AE	4.65	0.71	4.76	0.64	0.11	2,3	1	>0.05
	FE	4.79	0.59	5.07	0.54	0.28	5.8	0	<0.05
PWC_{170}, kgm/min	AE	1856.6	293.5	1902.9	269.6	46.3	2.4	1	>0.05
	FE	1914.5	245.9	2030.0	225.4	115.5	6.0	0	<0.05
VO_2max, ml/min	AE	4396.2	498.9	4474.9	458.3	78.7	1.8	1	>0.05
	FE	4494.6	418.0	4691.0	383.1	196.4	4.4	0	<0.05
VO_2max (rel) , ml/min/kg	AE	52.8	7.5	53.7	8.0	0.9	1.7	1	>0.05
	FE	53.8	5.3	56.2	4.9	2.4	4.5	0	<0.05

Notes: $PWC_{170(V)}$ is a running version of the test; PWC_{170} is an indicator of physical working capacity; VO_2max is an absolute indicator of maximum oxygen consumption; VO_2max(rel) is a relative indicator of maximum oxygen consumption; AE is an ascertainment experiment; FE is a formative experiment; AE – ascertaining experiment; FE – forming experiment

at the stage of the ascertainment experiment ranges from 0.1-4.5% without significant changes ($p>0.05$) in such tests as running 200 m and 200 m after 1 min of rest, triple jump from a standing position and barbell squats. At the same time, at the stage of the formative experiment, the final indicators, in comparison with the initial ones, improved by 2.8-6.6% with a significant difference ($p<0.05$). At the same time, the increase in indicators in running tests was 2.8-4.4%, in tests reflecting speed and strength abilities it was 4.0-4.2%, in strength control exercise it was 6.6%.

Today, an idea of the functional fitness of athletes has already been clearly formed, which is defined as a set of those characteristics and properties of the body that directly or indirectly determine work performance in competitions. Achieving a high level of functional fitness is ensured by specific adaptation to the appropriate type of sports activity. The importance of understanding the content and control of functional readiness is determined by the fact that the capabilities of an athlete are the capabilities of his body. The training process is aimed at their training and modification which will ensure an increase in working capacity (Wilmore et al., 2012; Karaulova et al., 2018; Shchepotina et al., 2021; Bezmylov et al., 2022).

Indicators characterizing the functional preparedness of multiathletes demonstrate positive dynamics both during the ascertaining and formative stages of the experiment. In particular, the increase in results at the ascertainment stage ranges from 1.7 to 2.4% without significant changes ($p>0.05$). We note a statistically significant ($p<0.05$) positive increase during the formative stage in the indicators of physical performance of multiathletes within the range of 5.8-6.0% and in the indicators of aerobic productivity within the range of 4.4-4.5%. It should be taken into account that, as scientists note, the absolute indicator of maximum oxygen consumption VO_2max is more important for athletes who perform at short and medium distances, and the relative one is more important at long and ultra-long distances. The reliability of the change in the results in the formative experiment was determined by all indicators ($p<0.05$) which indicates the success of using individual programs that were developed according to the outlined algorithm in combined events at the stage of direct preparation for competitions.

Discussion

In connection with the lack of standard training programs for multiathletes at the stage of maximum realization of individual capabilities, experts give priority to an individual approach to building an annual training cycle for highly qualified athletes (Platonov, 2006; Bompa & Haff, 2009). This primarily concerns the selection and differentiated use of training tools. But the development of this direction has not received a comprehensive theoretical-methodical and practical solution until recently. Competitive athletics exercises that exist in multiathletes differ in structure, nature of energy supply, duration and force of action, therefore they

make extremely high and diverse demands on the systems of the athlete's body. Given the lack of generally accepted principles of building an individual training program at the stage of maximum realization of individual capabilities in athletics combined events, athletes and coaches of their own choice form individual complexes of training tools or try to borrow training methods of European or world record holders.

Qualified multiathletes use in their training from 300 to 400 physical exercises, but the applied groups of exercises are the individual assets of successful athletes and, as a rule, cannot be successfully used by other athletes (Guthrie, 2003; Bobrovnik, 2014). This was confirmed during a confirmatory experiment, when standard sets of physical exercises for various types of athletics were not effective enough in training multiathletes participating in the study (Adamchuk et al., 2021). Thus, in the developed algorithm, unified approaches to the selection of adequate training tools are defined by creating individual funds of special physical exercises and individual training complexes for use at the stage of direct preparation for important competitions.

In the studies of many authors, it is emphasized that the most important modern problems of successful training of multiathletes are the study of the physiological mechanisms of adaptation of the body to intense physical exertion and the justification of effective methods of programming and management of the training process in relation to the assessment of the functional state of athletes (Kenny et al., 2005; Thompson, 2009; Wilmore et al., 2012). These provisions are taken into account when developing an algorithm for building individual programs for the stage of direct preparation for competitions and programming models for training sessions, microcycles and mesocycles. In training sessions, we followed the principles of overload, reversibility and specificity as the main conditions for achieving the highest sports results (Platonov, 2020). In the training programs, an expedient distribution of the size and intensity of the training load was planned, depending on the individual response of the athletes.

The developed and experimentally substantiated algorithm represents a significant contribution to the scientific work regarding the theoretical and methodological foundations and features of the practical implementation of an individual approach in the process of training highly qualified athletes (Dobrynska, 2015; Kozina et al., 2015; Kozlova et al., 2020).

The obtained results indicate a significant improvement of the studied indicators of functional and physical fitness at the stage of the formative experiment which we associate with the balanced distribution of work and rest in training classes, the positive influence of all qualitative and quantitative components of training tools due to the algorithm we developed for building individual programs of highly qualified multiathletes at the stage of direct preparation for competitions. In general, the obtained results complete the available scientific data regarding the peculiarities of the construction of the training process of highly qualified multiathletes during the stage of direct preparation for competitions and the dynamics of indicators of physical and functional fitness of athletes (Zwols & Sierksma, 2009; Bilić & Balić, 2015; Dobrynska, 2015).

In general, the approach to programming the training process of athletes tested in previous studies (Shchepotina et al., 2021) was also implemented in the process of training highly qualified multiathletes. Thus, the developed algorithm for building individual programs at the stage of direct preparation for competitions can be recommended for use in the practice of training multiathletes.

Conclusions

1. The use of the algorithm for building an individual program of preparation for competitions of highly qualified multiathletes orients the coach and athlete towards achieving the desired sports result in the shortest way with economical and rational use of training equipment at the most difficult and responsible stage of direct preparation for the main competitions. Compliance with the stated provisions of the algorithm made it possible to rationally plan and choose the optimal option for building the training process.

2. The implementation of an individual program at the stage of direct preparation for winter season competitions is effective and enables qualified multiathletes to reach the peak of their sports form during participation in the competitions of the Ukrainian indoor heptathlon championship. This is evidenced by the achieved statistically significant differences ($p<0.05$) in all indicators of physical and functional fitness compared to the ascertainment stage of the experiment. The increase in indicators in the running tests was 2.8-4.4%, in the tests reflecting speed and strength abilities – 4.0-4.2%, in the strength control exercise – 6.6%. We note a statistically significant ($p<0.05$) positive increase during the formative stage in the indicators of physical performance of multiathletes within the range of 5.8-6.0% and in the indicators of aerobic productivity within the range of 4.4-4.5%.

Prospects for further research can be seen in the development of individual training programs for multiathletes at the stages of multi-year training.

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Conflict of interests

The authors state that there is no conflict of interests.

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РОЗРОБКА АЛГОРИТМУ ПОБУДОВИ ІНДИВІДУАЛЬНИХ ПРОГРАМ ПІДГОТОВКИ ВИСОКОКВАЛІФІКОВАНИХ БАГАТОБОРЦІВ НА ЕТАПІ БЕЗПОСЕРЕДНЬОЇ ПІДГОТОВКИ ДО ЗМАГАНЬ ЗИМОВОГО СЕЗОНУ

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Реферат. Стаття: 10 с., 3 табл., 2 рис., 33 джерела.

Мета дослідження – розробити й експериментально обґрунтувати ефективність алгоритму побудови індивідуальних програм підготовки висококваліфікованих багатоборців у легкій атлетиці на етапі безпосередньої підготовки до головних змагань зимового сезону.

Матеріал і методи. Основною метою формувального етапу експерименту (2020-2021 рр.) була розробка програм структурних одиниць тренувального процесу (тренувальних занять, мікроциклів, мезоциклів, етапу безпосередньої підготовки до головних змагань) на основі розробленого алгоритму побудови індивідуальних програм. Нами розроблено шість послідовних кроків для досягнення повноцінної підготовленості спортсменів до головних змагань.

Результати. Виконання індивідуальної програми на етапі безпосередньої підготовки до змагань зимового сезону є ефективним і дає змогу кваліфікованим багатоборцям вийти на пік спортивної форми на час участі в змаганнях чемпіонату України у приміщенні з семиборства. Про це свідчать досягнуті статистично значущі відмінності ($p<0,05$) в усіх показниках фізичної та функціональної підготовленості, в порівнянні з констатувальним етапом експерименту. Приріст показників у бігових тестах склав 2,8-4,4%, у тестах, що відображали швидкісно-силові здібності – 4,0-4,2%, у силовій контрольній вправі – 6,6%. Відзначаємо статистично достовірний ($p<0,05$) позитивний приріст упродовж формувального етапу в показниках фізичної працездатності багатоборців у межах 5,8-6,0% і в показниках аеробної продуктивності в межах 4,4-4,5%.

Висновки. Використання алгоритму побудови індивідуальної програми підготовки до змагань висококваліфікованих легкоатлетів-багатоборців орієнтує тренера і спортсмена на досягнення бажаного спортивного результату найбільш коротким шляхом при економному та раціональному використанні тренувальних засобів на найбільш складному та відповідальному етапі безпосередньої підготовки до головних змагань. Дотримання викладених положень алгоритму дозволило раціонально спланувати й обрати оптимальний варіант побудови тренувального процесу.

Ключові слова: легкоатлетичне багатоборство, багатоборці, тренувальний процес, програмування, етап безпосередньої підготовки, алгоритм.

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ORIGINAL SCIENTIFIC ARTICLE

A SIX-WEEK PLYOMETRIC TRAINING PROGRAM IMPROVES EXPLOSIVE POWER AND AGILITY IN PROFESSIONAL ATHLETES OF EAST JAVA

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Abstract

The study purpose was to prove the effectiveness of a plyometric training program in increasing explosive power and agility in professional athletes of East Java.

Materials and methods. This study is a pre-experiment with a research design of One Group Pretest-Posttest. A total of 15 male athletes from athletics and swimming at the Pusat Pendidikan dan Pelatihan Olahraga Pelajar (PPLP) East Java, Indonesia, aged 15-17 years, body mass index (BMI) 18.5-24.0 kg/m^2, normal blood pressure, normal resting heart rate, voluntarily participated in the study. The plyometric training program (hurdle-box jumps) was carried out for 30 minutes/training session with an intensity of 80-90% HRmax with a frequency of 3x/week for six weeks. Measuring the explosive power of the horizontal leg muscles used the Standing Broad Jump Test, while measurement of the explosive power of the vertical leg muscles used the Digital Jump Meter Test. Measurement of agility used Shuttle Run Test, and explosive power and agility were measured during pre-training and six weeks post-training. Data analysis used the Paired Sample T-Test with a significance level of 5% using the Statistical Package for Social Science (SPSS) version 21 software.

Results. The results of the study showed that there was a significant difference in the average increase in explosive power horizontally, vertically, and agility between pre-training vs. post-training ($p \leq 0.001$).

Conclusions. In general, it can be concluded that the plyometric training program (hurdle-box jumps) carried out 3x/week for six weeks effectively increases the explosive power of the horizontal leg muscles, the explosive power of the vertical leg muscles, and increases agility.

Keywords: plyometric training, hurdle-box jumps, explosive power, agility.

Introduction

Plyometrics is a popular form of physical conditioning for healthy individuals and has been studied extensively over the past few decades (Slimani et al., 2016). Plyometrics are jumping training that involve the action of the stretch-shortening cycle muscles (Bedoya et al., 2015; Markovic & Mikulic, 2010; Meylan & Malatesta, 2009). Plyometrics are effective for increasing tendon stiffness, improving jumping performance, and strength of the lower body (Ramírez-delaCruz et al., 2022). In addition, plyometrics providing to increases agility (Haj-Sassi et al., 2011; Thomas et al., 2009). Plyometric training are usually bodybuilding training that involve stopping, starting, and explosively changing directions. This movement is a component that can help in developing agility (Miller et 2006; Craig, 2004; Miller et al., 2001; Parsons & Jones, 1998; Yap & Brown, 2000; Young et al., 2001).

During sports and daily physical activities, the most attribute of skeletal muscle is the ability to generate power, the product of strength and speed of movement (Kraemer & Newton, 2000). Sports, such as football, handball, basketball, and rugby which are required the ability to make changes in direction quickly (Change-of-direction) (Nygaard Falch et al., 2019). Results by (Kozinc et al., 2021) stated that the strength of several muscles of the lower leg, in particular the hip abductors and adductors, trunk muscles, hip rotators, extensors, and flexors, as well as knee and ankle flexors and extensors should be considered when aiming to improve change-of-direction performance. This proves that explosive

power and agility are important, especially in supporting athlete performance.

Optimal plyometric program design requires control over training level, type of training surface, type of training, program duration, volume (sets, repetitions, weights), intensity, rest intervals between sessions, and repetitions between sets (Asadi & Ramírez-Campillo, 2016; Arazi, 2012; Sáez-Sáez de Villarreal et al., 2010). This is intended to achieve the target of the training and reduce the risk of injury. Plyometric training has proven to be a safe training option when programmed properly, especially when given in a supervised setting (Vetrovsky et al., 2019).

Plyometric training have been shown to be beneficial in sports and activities of daily living, but there is little scientific information available to determine whether plyometric training are really effective at increasing explosive power and agility. Therefore, this study aims to prove the effect of a plyometric training program on explosive power and agility in East Java professional athletes. We hypothesize that a six-week plyometric training program can improve explosive power and agility in East Java professional athletes.

Materials and Methods

Study participants

This research is a pre-experimental research design with One Groups Pretest-Posttest Design. A total of 15 male athletes from athletics and swimming at the Student Sports Education and Training Center (PPLP) East Java, Indonesia with inclusion criteria aged 15-17 years, body mass index (BMI) 18.5-24.0 kg/m^2, normal blood pressure, normal resting heart rate and voluntarily participated in the study. All subjects received information both orally and in writing before conducting the research and respondents also gave a statement that they were willing to participate in the research by signing an informed consent. All procedures performed in our study complied with the Declaration of the World Medical Association of Helsinki on the ethical conduct of research involving human subjects.

Study organization

The plyometric training program (hurdle-box Jump) is implemented and supervised by professional officers from PPLP East Java, Indonesia. Plyometric training (hurdle-box Jump) is performed for 30 minutes/session with an intensity of 80-90% of HRmax with a frequency of 3x/week for six weeks. During plyometric training (hurdle-box Jump) heart rate monitoring using a polar heart rate monitor (Polar H10 Bluetooth Heart Rate Sensor & Fitness Tracker, Polar, Kempele, Finland) (Andarianto et al., 2022).

Data collection for height measurement using Stadiometer (Seca Corporation, CHINO, California, USA) (Rejeki et al., 2021). Body weight was measured using a digital scale (OMRON HN-289, Osaka, JAPAN) (Sugiharto et al., 2022). BMI is calculated by dividing weight (kg) by height (m^2) (Raharjo et al., 2021). Measuring blood pressure using a digital sphygmomanometer (OMRON Model Deluxe HEM-8712 BASIC, JAPAN) on the non-dominant arm three times in a row with a 2-minute rest interval between the two measurements, then the average value of the three measurements is taken (Andarianto et al., 2022; Raharjo et al., 2021). Measurement of horizontal leg muscle explosive power using the Standing Broad Jump (SBJ) Test (Tai et al., 2021), while measuring the explosive power of vertical leg muscles using the Jump Meter Digital (MD) Test. Agility measurement using the Shuttle Run Test (Kutlu et al., 2012). Explosive power and agility measurements were carried out pre-training and six weeks post-training.

Statistical analysis

The statistical analysis technique uses the Statistical Package for Social Science (SPSS) version 21 software. The normality test uses the Shapiro-Wilk test, while to compare the difference in mean explosive power and agility between pre-training and post-training, Paired Sample T-Test is used. All statistical analyzes use the significant level ($p \leq 0.05$). All data displayed Mean ± Standard Deviation (SD).

Results

The results of descriptive analysis of the average characteristic data of research subjects including age, height, weight, body mass index, leg length, resting heart rate, systolic blood pressure, and diastolic blood pressure are presented in Table 1.

Table 1. The results of the descriptive analysis of the characteristics of the research subject

Parameters	n	Mean	Std. Deviation
Age (yrs)	15	15.80	0.86
BW (kg)	15	70.67	8.38
BH (m2)	15	1.77	0.05
BMI (kg/m^2)	15	22.62	3.29
Leg Length (cm)	15	98.53	1.77
RHR (bpm)	15	68.87	3.04
SBP (mmHg)	15	115.87	3.83
DBP (mmHg)	15	75.93	4.04

Description: BW: Body weight; BH: Body height; BMI: Body mass index; RHR: Resting heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure

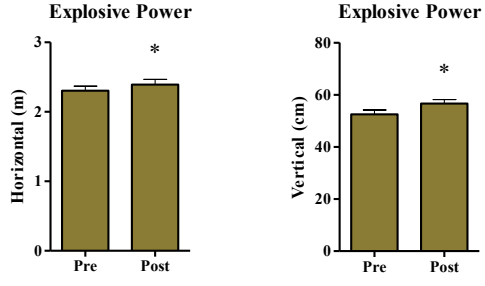

Fig. 1. The results of the analysis of the explosive power of the horizontal and vertical leg muscles between pre-training vs. post-training Note: (*) Significant vs. pre-training ($p \leq 0.001$). p- were obtained by using the Paired Samples T-Test. All data are displayed with Mean±SD

Based on Figure 1, the results of the Paired Samples T-Test show that there is a significant difference in the average increase in horizontal explosive power between pre-training vs. post-training (2.31±0.07 vs. 2.39±0.07 meters (p-values=0.000)). Likewise, the average increase in vertical explosive power before training vs. after training also shows a significant difference (52.47±1.73 vs. 56.67±1.50 centimeter (p-values=0.000)). The results of agility analysis between pre-training vs. post-training are presented in Figure 2.

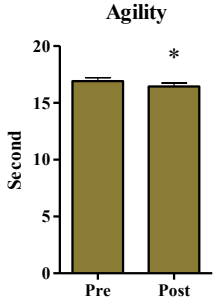

Fig. 2. Results of agility analysis between pre-training vs post-training Note: (*) Significant vs. before practice ($p \leq 0.001$). p- values obtained by the Paired Samples T-Test. All data are displayed with Mean±SD

Based on Figure 2, the results of the Paired Samples T-Test show that there is a significant difference in the average increase in agility between pre-training vs. post-training (16.89±0.31 vs. 16.43±0.30 second (p-values=0.000)).

Discussion

This study aims to determine the effect of six weeks of a plyometric training program on improving explosive power and agility in professional athletes in east java. Our findings show that giving a plyometric training program (hurdle-box Jump) which is done 3x/week for six weeks is effective in increasing explosive power and agility. The results in this study are in line with the results of Kim et al. (2022), that plyometric training carried out for eight weeks has a positive effect on increasing physical fitness, such as maximum strength, agility, and power. Strengthened by (Yáñez-García et al., 2022), that plyometric training can significantly increase explosive power in athletes. Plyometric training are usually bodybuilding training that involve stopping, starting, and explosively changing directions. This training can help in developing agility (Parsons & Jones, 1998; Yap & Brown, 2000; Young et al., 2001).

Plyometric training has proven to be an effective method for improving several physical qualities such as strength and jumping height, running, agility, sprint speed, and endurance (Oxfeldt et al., 2019; Lum et al., 2019; de Villarreal et al., 2008; van de Hoef et al., 2020). In addition, plyometric training can also increase endurance. Results by (Lum et al., 2022) compared the effect of isometric strength training with plyometric training on endurance running performance, showing that both types of training are effective in increasing muscle endurance during running. Plyometric training seem to be an effective and safe training mode for increasing leg muscle volume, thigh muscle volume, thigh and calf circumference, and muscle pennation angle. Therefore, plyometric training are effective for increasing muscle size and architecture, with potential implications in several clinical and training-related contexts (Ramirez-Campillo et al., 2022).

Plyometric training is one of the jumping-type training methods known as the stretch-shortening cycle which is based on neurophysiological mechanisms (Kim et al., 2022; Bedoya et al., 2015). The stretch-shortening cycle increases the ability of the nervous system and muscles to produce maximum strength in a short period, encouraging the use of plyometric training as a bridge between strength and speed (Markovic & Mikulic, 2010). The goal of plyometric training is to increase the strength of subsequent movements by using the natural elastic components of muscles and tendons and the stretch reflex (Bedoya et al., 2015; Meylan & Malatesta, 2009). Plyometric training use the stretch-shortening cycle method by using muscle lengthening (eccentric) movements that are rapidly followed by muscle shortening (concentric) movements (Davies et al., 2015; Chu, 1998; Ebben et al., 2008). de Villarreal (2009) found that a combination of plyometrics using body weight, including countermovement jumps, depth jumps, and squat jumps, resulted in a 4.7% to 15% increase in vertical jump height. The effectiveness of plyometric training may also depend on the training design and the length of the intervention period (Silva et al., 2019; Çankaya et al., 2018). Plyometric training has proven to be a safe training option when programmed properly, especially when given in a supervised setting (Vetrovsky et al., 2019). It can therefore be concluded that both plyometric and resistance training interventions can produce similar effects on overall muscle hypertrophy, at least for the lower extremity muscle groups, in untrained and recreationally trained individuals, and during the short-term intervention period (Grgic et al. al., 2021). In addition, plyometric training can also be an effective training technique to improve an athlete's agility (Cherni et al., 2019).

Conclusion

In general, it can be concluded that giving a plyometric training program (hurdle-box Jump) which is carried out 3x/week for six weeks is effective in increasing the explosive power of horizontal leg muscles, the explosive power of vertical leg muscles, and increasing agility in Athletics and Swimming Athletes At the Pusat Pembinaan dan Latihan Pelajar (PPLP) East Java.

Conflict of interests

The authors state that there is no conflict of interests.

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ШЕСТИТИЖНЕВА ПРОГРАМА ПЛІОМЕТРИЧНИХ ТРЕНУВАНЬ ПОКРАЩУЄ ВИБУХОВУ СИЛУ ТА СПРИТНІСТЬ У ПРОФЕСІЙНИХ СПОРТСМЕНІВ СХІДНОЇ ЯВИ

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

Реферат. Стаття: 8 с., 1 табл., 2 рис., 42 джерела.

Мета дослідження полягала в тому, щоб довести ефективність програми пліометричних тренувань у підвищенні вибухової сили та спритності у професійних спортсменів Східної Яви.

Матеріали та методи. Це дослідження є попереднім експериментом з планом попереднього та підсумкового тестування на одній групі. У дослідженні добровільно взяли участь загалом 15 спортсменів чоловічої статі з легкої атлетики та плавання в Навчально-тренувальному центрі студентського спорту (PPLP), Східна Ява, Індонезія, віком 15-17 років,

індекс маси тіла (ІМТ) 18,5-24,0 кг/м^2, нормальний артеріальний тиск, нормальна ЧСС у стані спокою. Програму пліометричних тренувань (стрибки з перешкодами) проводили по 30 хвилин на тренування з інтенсивністю 80-90% максимальної ЧСС (HRmax) з частотою 3 рази на тиждень протягом шести тижнів. Для вимірювання вибухової сили горизонтальних м'язів ніг використовували тест «Стрибок у довжину з місця», тоді як для вимірювання вибухової сили вертикальних м'язів ніг використовували тест «Цифровий вимірювач висоти вертикального стрибка». Для вимірювання спритності використовували тест «Човниковий біг», а вибухову силу та спритність вимірювали в період до початку тренувань та через шість тижнів після тренувань. Для аналізу даних використовували t-критерій Стьюдента для парних вибірок за рівня значущості 5% із застосуванням програмного забезпечення Statistical Package for Social Science (SPSS) версії 21.

Результати. Результати дослідження показали, що існує статистично значуща різниця в середньому збільшенні вибухової сили по горизонталі, вертикалі та спритності між періодами до та після тренувань ($p \leq 0,001$).

Висновки. Загалом можна дійти висновку, що програма пліометричних тренувань (стрибки з перешкодами), яку проводять 3 рази на тиждень протягом шести тижнів, ефективно збільшує вибухову силу горизонтальних м'язів ніг, вибухову силу вертикальних м'язів ніг і підвищує спритність.

Ключові слова: пліометричні тренування, стрибки з перешкодами, вибухова сила, спритність.

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ORIGINAL SCIENTIFIC ARTICLE

RELATIONSHIP OF SELECTED PHYSICAL AND ANGULAR KINEMATICAL VARIABLES WITH THE PERFORMANCE OF TOE-TOUCH SKILL IN KABADDI

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Abstract

The purpose of this study to find out the relationship of selected physical and angular kinematical variables with the performance of toe-touch skill among male kabaddi players (raiders).

Materials and methods. One hundred male raiders were selected for this study. The age of the participants ranged between 18 and 25 years. The selected physical variable, i.e. lower extremity explosive strength was measured by the standing broad jump test. Selected angular kinematical variables were measured by the software 'Kinovea version-0.9.3'. The toe-touch skill performed by raiders was measured by three experts' rating. The inter-rater reliability of the scores awarded by the experts to the participants was tested by Cohen's Kappa test and the Kappa coefficient was found significant.

Results. Spearman's rank correlation revealed that there was significant correlation in case of lower extremity explosive strength ($r_s = 0.259$, $p = 0.009$), angle at leading leg ankle joint ($r_s = 0.327$, $p = 0.001$) variables and there was no significant correlation in case of angle at trailing leg ankle joint ($r_s = 0.016$, $p = 0.871$), angle at leading leg knee joint ($r_s = 0.23$, $p = 0.823$), angle at trailing leg knee joint ($r_s = -0.171$, $p = 0.089$) and angle at hip joint ($r_s = -0.195$, $p = 0.052$) variables with the performance of toe-touch skill in kabaddi.

Conclusions. The study concludes that lower extremity explosive strength and the angle at the leading leg ankle joint positively contribute to toe-touch skill performance in male kabaddi players.

Keywords: kabaddi, raider, skill, physical variable, angular kinematics.

Introduction

Kabaddi, native to the Indian subcontinent with its history dating back to 4000 years, is a contact sport played by two teams of five to seven players each (Kukreja, 2022). Kabaddi is a game which combines the actions of wrestling, judo, rugby and gymnastics. The important body movements in this game involve catching, holding, locking and jumping (Shobha & Jyoti, 2022).

We all know that physical fitness is the basic foundation that supports athlete achievement. Without adequate physical fitness, athletes cannot perform techniques well and maximally. (Erliana & Hartoto, 2019; Tirtayasa et al, 2020; Piyana et al, 2020). Physical fitness in kabaddi sports consists of cardiovascular endurance, hand muscle strength, leg muscle strength, back muscle strength, shoulder muscle strength, arm muscle endurance, explosive power, agility, and reaction speed (Santika & Subekti, 2020).

The term biomechanics combines the prefix bio, meaning "life," with the field of mechanics, which is the study of the actions of forces. Kinematics and kinetics are further subdivisions of biomechanical studies (Hall, 2019). Angular kinematics describes angular motion, or motion involving

Table 1. List of variables

S.N.	Variables	Explanation
1.	Explosive strength	An ability of the muscle to overcome resistance with high speed
2.	Angle at leading leg ankle joint	A movement of joint where lateral malleolus is an axis and fibular head and fifth metatarsal are two arms.
3.	Angle at trailing leg ankle joint	A movement of joint where greater trochanter is an axis and lateral-epicondyle of femur and midline of the pelvis are two arms.
4.	Angle at leading leg knee joint	A movement of joint where lateral-epicondyle of the femur is an axis and greater trochanter and lateral malleolus are two arms.
5.	Angle at trailing leg knee joint	A movement of joint where lateral-epicondyle of the femur is an axis and greater trochanter and lateral malleolus are two arms.
6.	Angle at hip joint	A movement of joint where greater trochanter is an axis and lateral-epicondyle of femur and midline of the pelvis are two arms.
7.	Toe-touch skill	A skill performed by a raider to touch opponent's toe by his toe.

rotations like swings, spins, and twists. Angular kinematics describes the rotation of the whole body, like when a diver or gymnast performs a spin in the air, or the rotation of individual body segments, like when you bend or straighten your forearm at the elbow (McCaw, 2014).

Biomechanical measurement allows for precise, quantifiable examination of technical features, which then becomes a benchmark of a training program and seems to be a factor in effective training design, particularly if it concerns detecting the degree of performance expertise and assessing it as part of an athlete's growth process, as well as adopting Kinesiological operators and modelling methodical methods" (Akhtar & Bej, 1997).

Researchers have conducted various studies to determine the relationship between physical, anthropometric, physiological and psychological variables and kabaddi players' playing ability (Devaraju & Needhiraja, 2012; Johnson, 2016; Pandey & Sardar, 2016). But the number of studies describing the relationship of particular domain variables with a particular skill performance in kabaddi, is very few. There is a significantly smaller number of biomechanical studies on kabaddi (Ram, 2019a,b; Ram & Singh, 2021a,b). Hence, this study was conducted to determine the relationship between selected physical and angular kinematic variables and toe-touch skill performance (TTSP).

Material and Methods

Study participants

One hundred male raiders who at least participated in inter-college level competition were selected for this study by purposive sampling technique. The age of the participants ranged from 18-25 years. All the participants had knowledge and training experience in kabaddi. They were selected from various kabaddi academies of four states of India: Punjab, Himachal Pradesh, Haryana and Uttarakhand, and one union territory: Chandigarh. Prior permission was taken from coaches of kabaddi academies before data collection. The participants also signed a written consent form to participate in the study.

A total of 6 variables (1 physical + 5 angular kinematical variables) were selected in this study (Table 1).

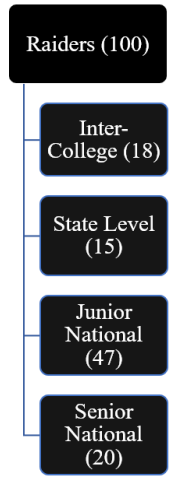

Fig. 1. Description of sampling plan

Procedure

All the participants were informed in detail about the research protocol and the basic characteristics of the study. No unique motivation technique was used to motivate the players before data collection. All the participants executed the same protocol under the same circumstances and were guided by the researcher. The measurement of lower extremity explosive strength was taken with a standardized test, i.e. standing broad jump test, and the measuring unit was centimeter. Each participant got three chances to perform the test, and the best one was taken as a score.

To measure the performance of the toe-touch skill of raiders, instructions were given to raiders that they have to raid on the opponents side and perform a toe-touch skill. Appropriate time was given to raiders and defenders for general and specific warm-ups. A Match situation was created, and the raiders were asked to raid. Three raids were given to every raider, and the best one was considered. The performance of every raid was recorded by Y1-Action Camera with a speed of 240fps (Figure 2).

The measurements of selected angular kinematic variables were extracted from the skill performance videos using

Table 2 Description of selected tools and their measuring units

S.N.	Variable	Tool	Measuring Unit
1.	Explosive strength	Standing broad jump test	Centimeter
2.	Angle at leading leg ankle joint	Kinovea Software	Degree
3.	Angle at trailing leg ankle joint	Kinovea Software	Degree
4.	Angle at leading leg knee joint	Kinovea Software	Degree
5.	Angle at trailing leg knee joint	Kinovea Software	Degree
6.	Angle at hip joint	Kinovea Software	Degree
7.	Toe-Touch Skill Performance	Rating Scale	Points

Fig. 2. Participant performing Toe-Touch skill

the software 'Kinovea version-0.9.3' following the guideline mentioned by Gogoi & Rajpoot (2019).

After completing the data collection process, researchers contacted kabaddi experts and explained the purpose of this study and their role in rating the participants according to their performance. The rating scale was given to each expert before starting the evaluation process (Table 3). The recorded videos of participants' performances were shown to three experts for rating purposes. All experts had a diploma in coaching in kabaddi and participated in national-level competitions. Experts' inter-rater reliability was tested using Cohen's Kappa inter-rater reliability test and found significant (Kvålseth, 1989). The average of the total scores given by the participants was taken as the final performance score for the participants.

Table 3. Explanation of Rating Scale

S.N.	Comment	Score
1.	Very Good	5
2.	Good	4
3.	Average	3
4.	Satisfactory	2
5.	Poor	1

Statistical Technique

Descriptive statistics, i.e., the median, inter-quartile range, was calculated. According to the nature of the data, the non-parametric test 'Spearman Rank Correlation' was employed to find out the relationship between TTSP and anthropometric variables with the help of SPSS-software version 23. The level of significance was set at 0.05 (Zar, 2005).

Results

Table 4 shows the median and inter-quartile range values of skill performance scores and selected physical variables. Median and inter-quartile range values of performance scores and variables are 3 (1) and 229 (25.75) respectively. It also exhibited a significant relationship of lower extremity explosive strength variable (rs = 0.259, p = 0.009) with toe touch skill performance at 0.01 level.

Table 4. The relationship of the selected physical variable with the performance of toe-touch skill

S.N.	Variable	Median	IQR	'r' value	p-value (sig.)
1.	Performance Scores	3	1	–	–
2.	Explosive Strength	229	25.75	0.259	0.009**

Note: IQR= Inter Quartile Range;** Denotes significant relationship at 0.01 level of significance

Table 5 shows the median and inter-quartile range values of skill performance scores and selected angular kinematical variables. Median and inter-quartile range values of performance scores, angle at leading leg ankle joint, angle at trailing leg ankle joint, angle at leading leg knee joint, angle at trailing leg knee joint and angle at hip joint variables are 3 (1), 137 (28.50), 66.50 (20), 173 (10.75), 45.50 (32.75) and 149 (24.50) respectively. It also shows that there is an insignificant relationship of angle at trailing leg ankle joint (rs = 0.016, p = 0.871), angle at leading leg knee joint (rs = 0.023, p = 0.823), angle at trailing leg knee joint (rs = -0.171, p = 0.089) and angle at hip joint (rs = -0.195,

Table 5. The relationship of selected angular kinematical variables with the performance of toe-touch skill

S.N.	Variable	Median	IQR	'r' value	p-value (sig.)
1.	Performance Scores	3	1	–	–
2.	Angle at leading leg ankle joint	137	28.50	0.327	0.001**
3.	Angle at trailing leg ankle joint	66.50	20	0.016	0.871
4.	Angle at leading leg knee joint	173	10.75	0.023	0.823
5.	Angle at trailing leg knee joint	45.50	32.75	-0.171	0.089
6.	Angle at hip joint	149	24.50	-0.195	0.052

Note: IQR= Inter Quartile Range; ** Denotes significant relationship at 0.01 level of significance

p = 0.052) with toe touch skill performance with toe-touch skill performance at 0.05 level of significance and significant relationship of angle at leading leg ankle joint variable (rs = 0.327, p = 0.001) with toe-touch skill performance at 0.01 level of significance

Discussion

There is evidence that physical variables contribute significantly to the playing ability of male kabaddi players and angular kinematical variables contribute to the playing ability of sports events (Devaraju & Needhiraja, 2012; Kelmendi, Miftari & Tekin, 2021).

This study aimed to determine the relationship of selected physical and angular kinematic variables with the performance of toe-touch skills among male kabaddi players (raiders). One physical variable: lower extremity explosive strength, and five angular kinematical variables: angle at leading leg ankle joint, angle at trailing leg ankle joint, angle at leading leg knee joint, angle at trailing leg knee joint and angle at hip joint were taken in this study.

The result showed a significant relationship (rs = 0.259, p = 0.009) between the lower extremity explosive strength variable and TTSP. The result of this finding is supported by the study by Pandey and Sardar (2016), where they found a significant correlation between the lower extremity explosive strength variable and the playing ability of university-level kabaddi players.

The result showed a significant relationship (rs = 0.327, p = 0.001) between angle at leading leg ankle joint variable and TTSP. The result of this finding is supported by the study conducted by Bisht & Kumar (2020) where they found that there was significant correlation between angle at leading leg ankle joint variable during execution phase and accuracy of tennis serve.

The result showed that there was an insignificant relationship (rs = 0.016, p = 0.871) between angle at trailing leg ankle joint variable and TTSP. The result of this finding is supported by the study conducted by Rathod (2018) where he found that there was an insignificant correlation between angle at ankle joint variable and race walk performance.

The result showed that there was an insignificant relationship (rs = 0.023, p = 0.823) between angle at leading leg knee joint variable and TTSP. The result of this finding is supported by the study conducted by Bisht & Kumar (2020) where they found that there was an insignificant correlation between angle at leading leg knee joint during execution phase variable and accuracy of tennis serve.

The result showed that there was an insignificant relationship (rs = -0.171, p = 0.089) between angle at trailing leg knee joint variable and TTSP. The result of this finding is supported by the study conducted by Rathod (2018) where they found that there was an insignificant correlation between angle at knee joint variable and javelin throw performance.

The result showed that there was an insignificant relationship (rs = -0.195, p = 0.052) between angle at hip joint variable and TTSP. The result of this finding is supported by the study conducted by Bisht & Kumar (2020) where they found that there was an insignificant correlation between angle at hip joint variable during preparatory phase and accuracy of tennis serve.

The results of the selected physical variable are similar to studies earlier conducted in kabaddi and showed that explosive strength plays an important role in the playing ability of kabaddi. In the case of angular kinematical variables, no study defines the relationship of angular kinematical variables with kabaddi playing ability. The results of this study state that the angle at the leading leg ankle joint positively correlates with toe-touch skill performance in kabaddi.

Conclusion

The study concludes that increasing the lower extremity's explosive strength positively contributes to toe-touch skill performance in kabaddi. Angle at leading leg positively contributes in toe-touch skill performance in kabaddi. It can help coaches while make training plan for raiders to enhance their raiding performance.

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ЗВ'ЯЗОК ВИБРАНИХ ФІЗИЧНИХ І КУТОВИХ КІНЕМАТИЧНИХ ЗМІННИХ ІЗ ВИКОНАННЯМ ПРИЙОМУ ТОРКАННЯ ПАЛЬЦЯМИ НІГ У ГРІ КАБАДДІ

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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., 2 рис., 23 джерела.

Мета цього дослідження – з'ясувати взаємозв'язок вибраних фізичних і кутових кінематичних змінних із виконанням прийому торкання пальцями ніг серед чоловіків-гравців у кабадді (рейдерів).

Матеріали та методи. Для участі в цьому дослідженні було відібрано сто чоловіків-рейдерів. Вік учасників коливався від 18 до 25 років. Вибрану фізичну змінну, тобто вибухову силу нижніх кінцівок, вимірювали за допомогою тесту «Стрибки в довжину з місця». Вибрані кутові кінематичні змінні вимірювали за допомогою програмного забезпечення «Kinovea version-0.9.3». Прийом торкання пальцями ніг, який виконували рейдери, вимірювали оцінкою трьох експертів. Міжекспертна надійність балів, призначених експертами учасникам, була перевірена за допомогою тесту Коена, і коефіцієнт каппа був визнаний значущим.

Результати. Рангова кореляція Спірмена показала, що існує значуща кореляція у випадку таких змінних, як вибухова сила нижньої кінцівки (rs = 0,259, p = 0,009), кут у гомілковостопному суглобі передньої ноги (rs = 0,327, p = 0,001), і відсутня значуща кореляція у випадку таких змінних, як кут у гомілковостопному суглобі задньої ноги (rs = 0,016, p = 0,871),

кут у колінному суглобі передньої ноги (rs = 0,23, p= 0,823), кут у колінному суглобі задньої ноги (rs = -0,171, p = 0,089) і кут у тазостегновому суглобі (rs = -0,195, p = 0,052), з виконанням прийому торкання пальцями ніг у грі кабадді.

Висновки. Автори дослідження дійшли висновку, що вибухова сила нижніх кінцівок і кут у гомілковостопному суглобі передньої ноги позитивно впливають на виконання прийому торкання пальцями ніг у чоловіків-гравців у кабадді.

Ключові слова: кабадді, рейдер, прийом, фізична змінна, кутова кінематика.

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ORIGINAL SCIENTIFIC ARTICLE

THE SIGNIFICANCE OF STUDENTS' PHYSICAL ACTIVITY FOR THEIR ENGAGEMENT IN LEARNING ACTIVITIES DURING THE COVID-19 PANDEMIC

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Abstract

Study purpose. This study aims to clarify the extent to which students' physical activity is significant for their engagement in the learning process.

Materials and methods. The study sample was composed of 202 7th-10th grade students. The data collection was performed in May 2021. The research participants completed the anonymous questionnaire on an online platform. The standardized Physical Activity Questionnaire for Adolescents and the standardized Student Engagement Scale were used to assess levels of physical activity and affective and behavioural engagement.

Results. The research findings showed that students' physical activity depended on the time they participated in physical activities. The highest level of physical activity was during physical education classes. A statistically significant difference was determined in the boys' and girls' affective and behavioural engagement. The mean for the girls was higher than the mean for the boys. A statistically significant difference in the behavioural engagement of the 9th and 10th grade students was also found: 9th grade students were more engaged than 10th grade students. The multiple linear regression analysis demonstrated that gender ($\beta = 0.332$, $p < 0.0001$) and physical activity ($\beta = 0.323$, $p < 0.0001$) as predictors had a significant moderate effect on behavioural engagement.

Conclusions. The research findings reveal that although the students' physical activity was low during the COVID-19 pandemic period, this phenomenon (physical activity) still remains a predictor, which has a significant moderate effect on behavioural engagement. It was also determined that during the pandemic, the highest physical activity level of students depended mostly on obligatory physical education lessons. Thus, bearing in mind that physical education lessons were the main physical activity-enhancing measures, we would like to emphasise the importance of these lessons and their proper organisation.

Keywords: affective engagement, behavioural engagement, physical activity, physical education lessons.

Introduction

The COVID-19 pandemic has posed numerous challenges to various national systems (education, health, social and others). The changed living environments, distance learning, and social isolation during the pandemic have also had negative consequences for the general and mental health of many adolescents (Zhou et al., 2020), and for their engagement in learning (Steinmayr et al., 2020). According to researchers, one of the most important factors in changes to adolescents' health has been decreased physical activity, as most students have been unable to attend sport clubs or actively exercise during physical education lessons (Moore et al., 2020). It may also be attributed to a transitional stage of physical and psychological development at which this age group is more sensitive to this unprecedented shift from on-site teaching to virtual classrooms (Shen et al., 2020).

Physical activity is defined as any bodily movement produced by skeletal muscles and that requires energy expenditure (NIH Consensus, 1996). It confers strong positive health benefits in youth, including positive effects on metabolic syndrome (Janssen & LeBlanc, 2010), reduction of the risk of suffering chronic illnesses, bone mineral density, weight management and obesity, as well as lower risks of cardiovascular diseases (Haynos & O'Donohue, 2012). Physical activity also has a positive effect on mental health in youth.

There is now substantial evidence that physical activity is positively associated with production of hormones, such as endorphins, while it decreases cortisol levels and improves general mood. During this difficult period, when the number of adolescents complaining of mental problems has increased (Lei et al., 2020), physical activity can become a means of reducing stress, the state of depression, and anxiety levels of adolescents (Dsouza et al., 2020). Scientific studies show that being physically active not only reduces the symptoms of depression in adolescents, but also improves their psychological state, i.e., increases self-esteem and improves cognitive functions. The data demonstrate that life satisfaction among young people increases in proportion to the reported level of physical activity (Lojdová et al., 2021). If physical exercise becomes a routine part of adolescents' lives, their mental health improves and depressive symptoms decrease in the long term (Biddle et al., 2019). Furthermore, recent research found that mental health benefits are only attained if a certain physical activity level is achieved (Maugeri et al., 2020).

The World Health Organization recommends a minimum of 60 minutes a day of moderate to vigorous physical activity for children aged between 5 and 17 years (Piercy et al., 2018). However, despite clear evidence of the potential benefits of being physically active, youth around the world often fail to achieve the recommended 60 minutes of moderate to vigorous physical activity per day. Research reveals that only 10 percent of children meet these recommendations for physical activity (Aubert et al., 2018).

Physical activity has clear links to students' academic achievement (Weston et al., 2020). Physical activity, especially physical education, improves classroom behaviour and benefits several aspects of academic achievement, especially mathematics-related skills, reading, and composite scores (Álvarez-Bueno et al., 2017). Studies on physical activity demonstrate that the more active adolescents are, the higher their academic achievement is, and as students' physical activity increases in leisure time, especially in moderate to vigorous intensity, their cognitive abilities improve (Rodriguez et al., 2020). Furthermore, physical activity, especially aerobic exercise, may also have a positive effect on brain structures and their functions, improving attention, processing speed and concentration capacity, and enabling the achievement of higher academic performance (Donnelly et al., 2016).

Visier-Alfonso et al. (2021) stated that students' cardiovascular state had an influence on their academic achievement. This is supported by other scientists, who claim that adolescents who regularly participate in physical activity and who are aerobically fit (Lagestad, 2019) perform better academically than those who are sedentary. Physical activity is associated with a greater cerebral blood supply; a greater volume in the frontal cortex and the hippocampus (Erickson et al., 2014). Studies indicate that physical activity increases activation in children's prefrontal cortex, which is associated with self-regulatory behaviours, when students are able to better participate in classroom lessons, and this increased engagement is a possible mechanism by which physical activity can have a positive influence on student achievement (Zan, 2013). This is based on the fact that physical activity and cognitive abilities of the student are activated by the same nervous system centres (Mavilidi et al., 2019).

Thus, the problem-based question arises: Has students' physical activity been significant for their engagement in learning during the COVID-19 pandemic? We consider this issue as worthy of exploration as research shows that students have made less academic progress during this pandemic period compared with previous years (Renaissance Learning & Education Policy Institute, 2021). Therefore, it is important to identify factors that may influence student achievement. In this case, engagement is understood as a construct, encompassing commitment to learning, and we assess students' emotional engagement (the presence of task-facilitating emotions, such as interest) and behavioural engagement (their concentration, attention, and effort) (Reeve, 2012). Research demonstrates that engagement is a positive state of learning (energy, dedication, attention) and higher levels of student engagement are associated with higher academic achievement (Harbour et al., 2015). Moreover, adolescents' emotional engagement is related to further learning (Gutman & Schoon, 2018), psychological outcomes (self-esteem and scholastic self-esteem) (Markowitz, 2017), and a sense of being an acknowledged member of the school community (Ulmanen et al., 2016).

Materials and methods

Study participants

The selection of the research sample was carried out in two steps. The first step involved school selection. Four general education schools were selected in three municipalities of Lithuania with low-SES contexts. The second step included the selection of a grade in every school. The research sample was composed of 202 7th-10th grade students (112 girls and 90 boys). The sample distribution according to gender and grade is shown in Table 1.

Table 1. Research sample

	Girls		Boys		Total	
	n	%	n	%	n	%
7th grade	31	27.7	18	20	49	24.3
8th grade	30	26.8	26	28.9	56	27.7
9th grade	20	17.8	21	23.3	41	20.3
10th grade	31	27.7	25	27.8	56	27.7
Total	112	100	90	100	202	100

Study organization

The research was conducted in accordance with the ethical rules of the Helsinki Declaration. Oral consent from each school's principal was sought prior to the distribution of questionnaires. Informed consent was obtained from all the students and their parents or guardians. All students were informed that their responses would be treated in strictest confidence and that responses were entirely anonymous. The data collection was performed in May 2021. The research participants completed the anonymous questionnaire on the online platform https://apklausa.lt/. The anonymous self-report questionnaire was divided into three parts. Part I of the questionnaire collected students' basic information (gender, grade). Part II contained the Physical Activity Questionnaire for Adolescents (PAQ-A; Kowalski et al., 2004). This questionnaire was developed to assess general levels of physical activity. Each of the 9 questionnaire items

Table 2. Descriptive statistics of physical activity scores

	Girls		Boys		Total	
	Mean	SD	Mean	SD	Mean	SD
Spare-time activity: sports	1.83	0.52	2.09	0.69	1.94	0.62
Activity during physical education classes	3.40	1.07	3.91	1.00	3.59	1.05
Lunchtime activity	1.33	0.68	1.43	0.78	1.38	0.73
After-school activity	2.74	1.28	3.08	1.28	2.90	1.29
Evening activity	2.95	1.25	2.95	1.29	2.95	1.27
Weekend activity	2.99	1.15	2.98	1.23	2.98	1.18
Activity frequency over the last 7 days	2.64	1.20	2.99	1.26	2.80	1.23
Activity frequency during each day of the last week	2.90	0.96	2.82	1.05	2.86	1.00
PAQ-A total	2.40	0.62	2.54	0.69	2.46	0.66

was scored on a 5-point scale (the lowest activity response being 1 and the highest activity response being 5). The total score of the PAQ-A was calculated by adding all the average scores of the questions. Part III contained two subscales of the Student Engagement Scale (Lam et al., 2014), namely Affective Engagement and Behavioural Engagement. Each item of the subscales was rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In this study, the internal consistency of the PAQ-A, the Affective Engagement subscale, and the Behavioural Engagement subscale was checked with Cronbach's alpha test. The Cronbach's alpha of 0.70 or higher for a set of items is considered acceptable (Cohen et al., 2018). Cronbach's alpha test showed the PAQ-A reached acceptable reliability, $\alpha = 0.891$. The findings of Cronbach's alpha suggested that the two subscales ($\alpha = 0.892$ for Affective Engagement and $\alpha = 0.831$ for Behavioural Engagement) also had an acceptable internal consistency.

Statistical analysis

The data analysis was made using IBM SPSS Statistics 26. Frequency, percentage, mean, and standard deviation were used in the descriptive procedures. Between-gender differences were assessed by Student t-tests. The difference between the 7th-10th grade students was determined by ANOVA. Statistical significance level was $p < 0.05$. Cohen's d for a Student t-test was calculated, and the effect size was examined. For Cohen's d, a value of 0.20 is interpreted as a small effect, 0.50 is a medium effect, and 0.80 is a large effect. Partial Eta squared η^2 is an effect size measured for ANOVA. Basic rules of thumb are that $\eta^2 = 0.01$ indicates a small effect; $\eta^2 = 0.06$ indicates a medium effect; $\eta^2 = 0.14$ indicates a large effect. Multiple linear regression analyses were used to examine the association of gender, 7th-10th grade, and physical activity with student affective and behavioural engagement. In regression analysis, the effect size of the predictor variables is given by the beta loadings. In interpreting the effect size gives the following guidance: 0-0.1 weak effect, 0.1-0.3 modest effect, 0.3-0.5 moderate effect, and > 0.5 strong effect (Cohen et al., 2018).

Results

Physical activity

The research findings (Table 2) showed that students' physical activity depended on the time they participated in physical activities. The highest level of physical activity was during physical education classes. The least active periods were during the breaks between lessons. The boys' and girls' physical activity total scores were 2.54 (SD = 0.69) and 2.40 (SD = 0.62), respectively. The total score was not high either, and did not reveal a statistically significant difference ($t = 1.405$, $p = 0.162$).

The ANOVA test (Table 3) revealed that there was no statistically significant difference in the physical activity of students in different grades ($F = 2,457$, $p = 0.064$), although general levels of physical activity of the 7th-8th grade students were slightly higher than the 9th-10th grade students.

Table 3. Differences of physical activity between the 7th-10th grade students

	Mean	SD	Mean Square	ANOVA test		Partial Eta squared η^2
				F	p	
7th grade	2.58	0.77	1.039	2.457	0.064	0.040
8th grade	2.59	0.64				
9th grade	2.32	0.64				
10th grade	2.33	0.53				

Affective and behavioural engagement

Student t-tests (Table 4) reported a significant difference between lower affective engagement mean for the boys ($M = 3.15$, $SD = 0.79$) compared with the girls ($M = 3.41$, $SD = 0.73$; $t = -2.447$, $p = 0.015$). Moreover, a statistically significant difference was determined in the boys' and girls' behavioural engagement. The mean for the girls ($M = 3.56$, $SD = 0.60$) was higher than the mean for the boys ($M = 3.22$, $SD = 0.56$; $t = -4.217$, $p = 0.0001$). Finally, the Cohen's d was small for affective engagement ($d = 0.34$) and medium for behavioural engagement ($d = 0.59$).

Table 4. Student t-test findings for differences of variables in terms of gender

		Mean	SD	t-test		Cohen's d
				t	p	
Affective engagement	Boys	3.15	0.79	-2.447	0.015	0.34
	Girls	3.41	0.73			
Behavioural engagement	Boys	3.22	0.56	-4.217	0.0001	0.59
	Girls	3.56	0.60			

Comparing the affective engagement of the 7th-10th grade students, no statistically significant difference was found (Table 5). However, a statistically significant difference was

Table 5. ANOVA test findings for differences of variables in terms of 7th-10th grades

		Mean	SD	Mean Square	ANOVA test		Partial Eta squared η^2
					F	p	
Affective engagement	7th grade	3.31	0.89	1.383	2.419	0.067	0.035
	8th grade	3.19	0.62				
	9th grade	3.59	0.76				
	10th grade	3.15	0.75				
Behavioural engagement	7th grade	3.48	0.63	1.265	3.586	0.015	0.052
	8th grade	3.43	0.53				
	9th grade	3.63	0.61				
	10th grade	3.23	0.63				

Table 6. Predictions of student behavioural engagement

Predictors	Unstandardized Coefficients B	Std. Error	Standardized Coefficients β	t	p
Constant	2.473	0.170		14.566	0.0001
Physical activity	0.300	0.063	0.323	4.799	0.0001
Gender	0.407	0.082	0.332	4.936	0.0001

determined in their behavioural engagement. ANOVA with post-hoc Tukey HSD test showed a statistically significant difference in the behavioural engagement of the 9th and 10th grade students: 9th grade students (M = 3.63, SD = 0.61) were more engaged than the 10th grade students (M = 3.23, SD = 0.63; F = 3.589, p = 0.015). Nevertheless, partial Eta squared $\eta^2 = 0.052$ indicated a small effect.

The multiple linear regression analysis was implemented to determine the influence of physical activity, gender and grade on affective and behavioural engagement. It was determined that the grade was not a predictor of any engagement dimension. Having eliminated the grade and repeatedly performed a multiple linear regression analysis, it appeared that physical activity and gender were the predictors of only the students' behavioural engagement. The obtained statistically significant regression model had $R^2 = 0.20$; $F = 21.471$, $p < 0.0001$. The findings demonstrated that gender ($\beta = 0.332$, $p < 0.0001$) and physical activity ($\beta = 0.323$, $p < 0.0001$) as predictors had a significant moderate effect on behavioural engagement (Table 6).

Discussion

The findings of the study examining students' physical activity and engagement in learning during the COVID-19 pandemic enable us to highlight several important points.

Firstly, it was determined that during the COVID-19 pandemic period, the students' physical activity was low and did not depend on gender. The first trend (low physical activity) is confirmed by studies performed by other scientists in Lithuania and other countries. For example, the research by López-Sánchez et al. (2018) showed that every third child in Lithuania was physically active, whereas the decreased physical activity during the pandemic was determined by Moore et al. (2020). According to the researchers, only 2.6 percent of adolescents met the recommended guidelines of achieving 60 minutes of moderate-vigorous physical activity per day. Moreover, the study completed by Chambonniere et al. (2021) revealed that even initially active children and adolescents decreased their physical activity more than those initially inactive and increased their sitting time during lockdowns. However, the second trend that physical activity was not dependent on gender was unexpected, as the data from the afore-mentioned study (López-Sánchez et al., 2018) showed that boys of any age group were more physically active than girls. The determined difference could probably be explained by the fundamentally changed conditions: during the COVID-19 pandemic, a lot of sports clubs / activities have closed, as well as social communication and at the same time spontaneous physical activity has been limited (e.g., skating, skateboarding, playing football, basketball, etc.). According to Hayes (2020), social communication supported by social media could have a significant effect on adolescents' physical activity; hence, it could have significantly reduced this type of activity for boys.

Secondly, the findings of the study demonstrated that during the COVID-19 pandemic, the highest levels of students' physical activity depended greatly on obligatory school physical education lessons. During the lessons, both boys' and girls' physical activity reached a higher level, and the students' physical activity became of medium or high intensity. The literature review shows that benefits associated with physical activity and fitness are not unilateral but instead are specific to the type, timing, and intensity of the physical activity. In order to ensure health and developmental benefits, it is recommended that youth should participate in a variety of enjoyable, developmentally appropriate moderate-to-vigorous physical activities for at least 60 minutes per day (Piercy et al., 2018). According to researchers (Sallis et al., 2012), obligatory school physical education is probably the most effective way to enhance engagement in physical activity for adolescents. It is suggested that positive affective experiences in physical education lessons are crucial to evoke students' intention to be physically active later

in their lives. Therefore, it is also important to pay attention to the organisation of physical activity. Physical education lessons and extracurricular activities should be organised ensuring a motivational climate, goal-oriented tasks, and evoking enjoyment. Improperly organised lessons can provoke students' anger and amotivation to be physically active (Jaakkola et al., 2019). Thus, bearing in mind that physical education lessons were one of the main and most physical activity-enhancing measures during the COVID-19 pandemic, we would like to emphasise the importance of these lessons and their proper organisation.

Thirdly, our study data suggested that the levels of students' physical activity after school, in spare time, or at weekends were low; the lowest activity level was estimated during the breaks between lessons. This means that even after spending all day sitting at a computer during distance learning, the students were not inclined to become more physically active on their own during the breaks. This identified trend is confirmed by the data collected by other scientists. For instance, Tassitano et al. (2020) argue that schools, where students spend hours each day, offer too little physical activity, especially moderate-to-vigorous physical activity. In this regard, it is justified to recommend that schools offer opportunities to be physically active before, during, and after the school day.

Finally, the fact that physical activity was important and significant for students' learning during the COVID-19 pandemic period was also demonstrated by the regression analysis of the data collected in our study. Physical activity proved to be one of the predictors for behavioural engagement. This is a very important finding of the study, which again demonstrates the role of physical activity in student learning and encourages further research into physical activity and its links to the learning process. On the other hand, we would like to draw special attention to students who are from low-SES backgrounds, as their achievements may be significantly more negatively affected by COVID-19 pandemic learning conditions compared with other students (Renaissance Learning & Education Policy Institute, 2021). The data of our study suggest that physical activity for these students (both boys and girls) would help to improve their behavioural engagement and learning outcomes. According to other studies, physical activity and academic outcomes are positively correlated in children from poorer backgrounds (Efrat, 2011). Physically active students are more engaged with their classroom lessons (Zan, 2013) and this increased engagement is a possible mechanism by which students' physical activity could have a positive influence on their academic achievement.

Conclusions

Due to the changed learning conditions during the COVID-19 pandemic, it is critical to explore the factors that have influenced student learning processes and outcomes. The findings of our study demonstrated that during this period physical activity was a predictor with a significant moderate effect on behavioural engagement. It was also determined that during the pandemic, the physical activity of students was low, and its highest levels depended mostly on obligatory physical education classes at school. We dare to claim that these are significant research findings that emphasise the benefits of physical education lessons and the importance of physical activity to the learning process.

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Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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ЗНАЧЕННЯ ФІЗИЧНОЇ АКТИВНОСТІ УЧНІВ ДЛЯ ЇХНЬОЇ ЗАЛУЧЕНОСТІ ДО НАВЧАЛЬНОЇ ДІЯЛЬНОСТІ ПІД ЧАС ПАНДЕМІЇ COVID-19

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

Реферат. Стаття: 8 с., 6 табл., 40 джерел.

Мета дослідження. Це дослідження має на меті з'ясувати, наскільки фізична активність учнів є важливою для їхньої залученості до навчального процесу.

Матеріали та методи. Вибірку дослідження склали 202 учні 7-10 класів. Збір даних проводили в травні 2021 року. Учасники дослідження заповнили анонімну анкету на онлайн-платформі. Стандартизований Опитувальник із фізичної активності для підлітків і стандартизовану Шкалу залученості учнів використовували для оцінки рівнів фізичної активності й емоційної та поведінкової залученості.

Результати. Результати дослідження показали, що фізична активність учнів залежить від часу, який вони займалися фізичними вправами. Найвищий рівень фізичної активності був на заняттях із фізичного виховання. Визначено статистично значущу різницю в афективній та поведінковій залученості хлопців і дівчат. Середнє значення для дівчат було вищим, ніж середнє значення для хлопців. Також виявлено статистично значущу різницю в поведінковій залученості учнів 9-х і 10-х класів: учні 9-х класів були більш залученими, ніж учні 10-х класів. Множинний лінійний регресійний аналіз продемонстрував, що стать ($\beta = 0{,}332$, $p < 0{,}0001$) і фізична активність ($\beta = 0{,}323$, $p < 0{,}0001$) як предиктори мали значущий помірний вплив на поведінкову залученість.

Висновки. Результати дослідження показують, що хоча фізична активність студентів була низькою протягом періоду пандемії COVID-19, це явище (фізична активність) все ще залишається предиктором, який має значущий помірний вплив на поведінкову залученість. Також установлено, що під час пандемії найвищий рівень фізичної активності учнів залежав

здебільшого від обов'язкових уроків фізичного виховання. Таким чином, з огляду на те, що уроки фізичного виховання були основними заходами підвищення фізичної активності, хочемо підкреслити важливість цих уроків і їх правильну організацію.

Ключові слова: афективна залученість, поведінкова залученість, фізична активність, уроки фізичного виховання.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTS OF TAI CHI AND RESISTANCE BAND TRAINING ON ELDERLY'S BALANCE AND STRENGTH

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Abstract

Study purpose. The research aimed to study the effects of tai chi and resistance band training on elderly's balance and strength.

Materials and methods. The participants were 40 elderly females aged 62 to 76. They were selected by systematic random sampling, using balance score as the criterion. They were divided into two equal groups of 20 people each, namely, the Tai Chi and resistance band training (TCR) experimental group was trained for 8 weeks, 3 days a week for 60 minutes each day, and the control group (C) was not trained. The participants volunteered to sign the consent forms to participate in this research. Quantitative data was collected by measuring balance, hand muscle strength, and leg muscle strength. Qualitative data was collected via interviews and participant observation.

Results. The research found that (1) balance, hand muscle strength, and leg muscle strength were no different before the training. Post-training of Tai Chi and resistance band trainings (TCR) of the 4th and the 8th weeks, the experimental group had the mean of balance, hand muscle strength, and leg muscle strength better than the pre-training and the differences between the experimental group and the control group were statistically significant ($p<0.05$). (2) The experimental group had balance, strength, good flexibility, relaxed body and good mental health.

Conclusions. As regards the benefits to the physical fitness, tai chi and resistance band training (TCR) and combination exercise improve balance, hand muscle strength and leg muscle strength. This makes the elderly have good health and physical fitness.

Keywords: tai chi, resistance band training, balance, strength, elderly.

Introduction

Globally, the old people population continues to increase, and their health problems become a big issue as a result (Choi et al., 2011; Sun-Young & Yun-Hee, 2021). The ole people gradually wenken their muscle strength and muscle tone due to aging, and their muscle mass and basal metabolic rate decrease (Bechshoft et al., 2016; Brown et al., 2000). May reduce their ability to perform daily activities, resulting in health problems (Scott et al., 2015). Whereas the habit of exercising on a regular basis prevents aging and increases physical strength, thus reducing the incidence of disease (Ngandu et al., 2015). It also has a positive effect on the physical and mental health of the old people, such as preventing chronic diseases, improving physical function, increasing muscle strength, reducing depression, and relieving stress (Graham & Reid, 2000; Hicks et al., 2003; Sang-Wan & Ji-Youn, 2020). Therefore exercise is necessary for the health and physical fitness of the elderly.

Exercise is essential for active healthy aging without functional impairment (Van Roie et al., 2010; Sun-Young & Yun-Hee, 2021) and contributes to improving quality of life (Acree et al., 2006; Atlantis et al., 2004; Daskapan et al., 2005). Tai Chi Chuan is a valuable exercise for the older adults (Lida et al., 2018). This type of exercise is a traditional Chinese exercise, consisting of isometric, aerobic, isotonic, and meditative movements (Larkey et al., 2009; Tsang et al., 2003). It may result in improved trunk strength and movement abilities in the elderly (Wolf et al., 1996; Klarod et al., 2020). Tai Chi Chuan is effective in preventing falls and improving balance, muscle strength, proprioception, and endurance in older adults (Hu et al., 2016; Lan et al., 2013;

Logghe et al., 2010) help in the development of proper body posture control (Vikas et al., 2022; Nontakhod et al., 2022).

Resistance training is an effective exercise modality for increasing muscle strength and mass, which are important components of fitness and health (Bird et al., 2005; Winett & Carpinelli, 2001; Daniel, 2020). Incorporating resistance training as part of a preventive exercise program can improve flexibility, balance (Lopes et al., 2019), muscle strength (Kim et al., 2021), and functional capacity in older adults (de Oliveira et al., 2017; Minjoon et al., 2022).

However, in Southeast Asia little is known about the combination of Tai Chi and resistance training. This is because balance and strength play an important role in daily activities of the elderly. Therefore it is necessary to summarize current knowledge on this topic. As a guideline for maintaining the health and physical fitness of the elderly to have a good quality of life.

Materials and methods

Study participants

The participant were 40 elderly females, aged between 62-76 years old. They were selected by systematic random sampling, using balance score as the criterion. It was divided into two equal groups of 20 people each, the Tai Chi and resistance band training experimental group was trained for 8 weeks, 3 days a week for 60 minutes each day, and the control group was not trained. Quantitative data was collected by balance measure, hands muscle strength, and legs muscle strength. Qualitative data was collected via interviews and participant observation. The eligible criteria of research participations (1) The elderly aged between 62-76 years or over, be eligible to participate throughout the data collection. (2) There were no underlying or chronic diseases that hindered Tai Chi and resistance band training. The eligible criteria of research participations were not selected (1) The samples got injured and ill, they couldn't participate in the training/absence more than 3 times. (2) The samples requested to withdraw and didn't want to join in the training for a specified time.

Study organization

Researchers collected data by defining the samples to Tai Chi and resistance band training (TCR), 3 days a week, 60 minutes a day for 8 weeks to perform a balance testing (Osness Test), hands muscle strength (Arm Curl Test), and legs muscle strength (30-Second Chair Stand) of pre-training, post-training of the 4th and the 8th week. Qualitative data were collected via semi-structured interviews and participant observation.

Statistical analysis

Quantitative data analysis was performed by testing the difference of the mean balance, hands muscle strength, and legs muscle strength. Data were analysed by the different tests of the pre-training, post-training for the 4th and 8th weeks of the samples, it was analysed by one-way repeated measures ANOVA, comparison of differences in pairs of the mean of each repeated measures. Qualitative data were collected via semi-structured interviews and participant observation.

Results

The research found that following, (1) Balnace, hand muscle strength, leg muscle strength before the training was no different. Post-training of Tai Chi and resistance band trainings of the 4th and the 8th weeks, the experimental group had the mean of balance, hands muscle strength, legs muscle strength better than the pre-training and the control group were the statistically significant $p < 0.05$. difference at 0.05. (2) The experimental group had balance, strength, good flexibility, relax body and good mental health.

Table 1, it could be summarized that the participant were named pseudonym TY.1 (means the sample 1) aged between 62-76 years, mean age was 68.2 years, weight was 54.5 kg, height was 151.7 cm., body mass index (BMI) was 23.66, health problems were joint pain and body aches.

Table 1. Characteristics of the participant

Given name	Age	Weight	Height	BMI	Health Problems
T.Y.1	71	40	150	17.77	Backache
T.Y.2	68	43	144	20.73	Shoulder pain
T.Y.3	72	45	145	21.40	Frozen shoulder
T.Y.4	64	51	160	19.92	Leg pain
T.Y.5	63	55	149	24.77	Leg pain
T.Y.6	75	57	159	22.54	Frozen shoulder
T.Y.7	65	71	160	27.73	Backache
T.Y.8	65	49	147	22.67	Backache
T.Y.9	63	51	156	20.95	Waist pain
T.Y.10	75	49	146	22.98	Knee pain
T.Y.11	72	60	156	25.96	Knee pain
T.Y.12	68	55	152	23.80	Frozen shoulder
T.Y.13	60	71	163	26.73	Knee pain
T.Y.14	68	61	155	23.39	Leg pain
T.Y.15	65	66	153	27.76	Hip pain
T.Y.16	70	59	151	25.87	Shoulder pain
T.Y.17	74	44	143	21.51	Shoulder pain
T.Y.18	63	64	146	29.55	Leg pain
T.Y.19	69	52	149	23.41	Leg pain
T.Y. 20	74	49	151	22.71	Leg pain
X	68.2	54.5	151.7	23.66	

Table 2. Summary of findings

The benefits of tai chi and resistance band training
1. Improved strength and balance
2. Good flexibility

Table 2, could be summarized as follows; 1) More balance and strength 2) Good flexibility.

The interview and observation could be described as following.

More good balance and strength

Tai Chi and resistance band training are the movement of the exercises of the core muscles that take a long time to move and must maintain balance while stillness or movement. When training Tai Chi and resistance band will affect more balance and strength, as the sample TY.2 said that "In the past, there was no much strength, easily tried, after training, I was strong" in accordance with TY.9 said that "In the past, I couldn't walk for a long time, hands pain, legs pain, maybe there was a stagger. But it's okay now, I don't feel tired, get stronger, whenever I walk it balances". Likewise, TY.11 stated that "When I trained Tai Chi and resistance band, it was comfortable to walk like stronger muscles. I don't feel tired like the past". TY.12 supported that "In the past, each work was easy to get tired, not much energy, but when I often get training, I don't feel tired. Maybe my children have to tell me to take a break". TY.15 summarized that "In the past, I went to buy my stuff, I had to stop several times, sometimes I staggered, arms and legs are powerless, it was difficult to walk. After I trained Tai Chi and the resistance band I could walk comfortably, no stagger anymore. I don't even know where to walk without concentration".

Good flexibility

Tai Chi training is a continuous movement of the body. This makes muscles and joints moves in more angles and directions, whereas resistance band training improves muscles and joints stronger. As the sample TY.7 said that "First, the muscles and bones didn't stretch, didn't lift it up, later the post-training made me better". TY.8 supported that "Firstly, I couldn't stand up, but when I often trained Tai Chi and resistance band, I could lift it up the hands and legs easily". TY.16 summarized that Tai Chi and resistance band training, firstly, have not been done by me before, hands and leg couldn't lift it up, the post-training later could be done by me easily, it was very comfortable to stand up". It was consistent with the observation that was found that the samples trained Tai Chi and the resistance band improved more flexibility such as both hands put down in the land, and the resistance band training improved the upper arms and lower muscles groups.

Quantitative data analysis was performed by testing the difference of the mean balance, hands muscle strength, and legs muscle strength. Data were analysed by the different tests of the pre-training, post-training for the 4th and 8th weeks of the samples, it was analysed by one-way repeated measures ANOVA, comparison of differences in pairs of the mean of each repeated measures.

Figure 1 shows the comparison results of the mean age, weight of the control and experimental group. Mean ± Standard Deviation. The mean difference was ststistically significant between the groups, $p < 0.05$*. The mean was statistically different within the group, $p < 0.05$*

Figure 2 shows the comparative results of the average balance before training. After the 4th week of training and after the 8th week of the control group and the experimental group. Mean ± Standard Deviation. The mean difference was statistically significant between the groups, $p < 0.05$*. The mean was statistically different within the group, $p < 0.05$*.

Figure 3 show the comparative of the average arm muscle strength before training. After the 4th week of training and after the 8th week of the control group and the experimental group. Mean ± Standard Deviation. The mean difference was statistically significant between the groups, $p < 0.05$*. The mean was statistically different within the group, $p < 0.05$*.

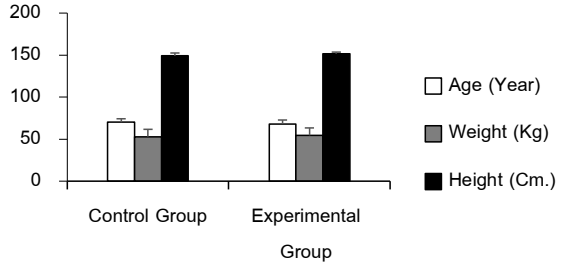

Fig. 1. Comparison results of the mean age, weight of the control and experimental group.

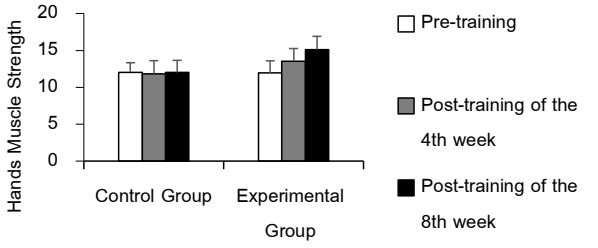

Fig. 2. Comparison of the averge balance before training. After the 4th week of training and after the 8th week of the control and experimental groups ($p < 0.05$*).

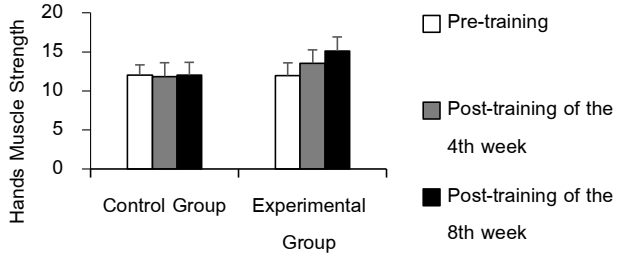

Fig. 3. Comparative of the average arm muscle strength before training. After the 4th week of training and after the 8th week of the control group and the experimental group ($p < 0.05$*).

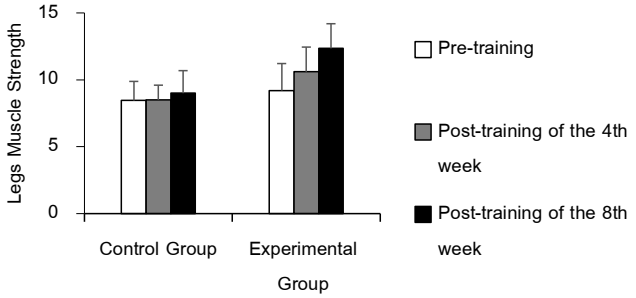

Fig. 4. Comparative results of the averge leg muscle strength before training. After the 4th week of training and after the 8th week of the control group and the experimental group ($p < 0.05$*).

Figure 4 show the comparative results of the averge leg muscle strength before training. After the 4th week of training and after the 8th week of the control group and the experimental group. Mean ± Standard Deviation. The mean difference was statistically significant between the groups, $p < 0.05$*. The mean was statistically different within the group, $p < 0.05$*.

Discussion

This study demonstrated that the balance, hand muscle strength, leg muscle strength before training was no different. After the 4th and 8th weeks of training, participants in the TCR group showed balance, hand muscle strength, and strength. and leg muscle strength was significantly improved compared to the control group. Which could be attributed to the Tai Chi and resistance band training (TCR). In this study, including helping to relax and good mental health. This is consistent with the study by Nontakhod et al. (2022) the training of physical activity with Qi Gong and Ruesi Dadton (RSD) in conjunction with massage can increase balance. Arm and leg muscle strength. It was consistent with Nontakhod et al. (2021) who found that the physical activities such as Qigong, Yoga and stretching could have a positive impact on health. That is the person would have 1) good health including good balance, flexibility, improved breath, reduced arches; 2) good health; 3) more socialization and 4) better concentration. It was consistent with Chen et al. (2012) stated about the study of Tai Chi training in elderly with visual impairment. It was found that the elderly were able to stabilize more. Make the elderly not fall easily It can help improve balance in older people. Another study on physical activities to elderly that found qigong training combined with yoga had a positive effect on the health of the elderly. Improve the overall physical, mental, social and intellectual health of the elderly. and reduce the fear of falling due to strong legs and good balance (Saetae et al., 2018) Consistent with Thaiprasert et al., (2019) said that Yoga training and nine square tables made the elderly healthy, physically, mentally. Socially, and memory, the fear was reduced due to having a good balance. The favorable effects of Qigong training on strengths are consistent with previous studies demonstrating significant improvements of knee extension strength after Tai chi training in elderly subjects (Christou et al., 2003; Lan et al., 2000; Song et al., 2014; Wolfson et al., 1996; Klarod et al., 2020). In terms of muscle strength, participants in the TCR group Meanwhile tai chi and resistance band training (TCR) from this training. The use of elastic bands to provide resistance during exercise for older adults, is considered safe and pratical (Hofmann et al., 2016; Rahim et al., 2021). The effectiveness of elastic bands in resistance training was proven to lead to a significant improvement in lower limb function, especially leg strength (Motalebi et al., 2018). This is consistent with the study by Minjoon et al., (2022) sais that an elongation band (EB) is used to improve the physical strength of older adults. In conclusion, EB exercises increased upper limb muscle strength, shoulder joint range of motion, and grip strength in older adults. It was consistent with Krabuanrat and Supaporn (2014) said that the exercise with the resistance band with nine square and stretching activities (RMS) improved good health. In addition, physical activities from tai chi, chiqong and yoga can help seniors gain strength and balance. can adjust the balance and reduce the fear of falling (Kim et al., 2014; Saetae & Supaporn. 2016). Including sensation of physical and psychological relaxtion (Miller & Taylor-Piliac, 2014; Zhao et al., 2017; Lida et al., 2018).

Conclusions

Tai Chi and resistance band training (TCR) application and combination forms of physical activity, to development balance hands muscle strength and legs muscle strength, this makes the elderly have better health than Tai Chi Training alone. Tai Chi and resistance band training is considerd as an alternative activity suitable for physical conditions for the elderly to have good health and physical fitness.

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Human research ethics

The research had been approved by the committee for the research ethics of Buriram Rajabhat University. The certificate issued was BRU: -rdi002-002/2564.

Conflict of interest

The author declares that there is no conflict of interest.

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ВПЛИВ ЗАНЯТЬ ТАЙЦЗИ ТА ТРЕНУВАНЬ З ЕСПАНДЕРОМ НА РІВНОВАГУ ТА СИЛУ ЛЮДЕЙ ПОХИЛОГО 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., 2 табл., 4 рис., 51 джерело.

Мета дослідження. Дослідження мало на меті вивчити вплив занять тайцзи та тренувань з еспандером на рівновагу та силу літніх людей.

Матеріали та методи. Учасницями дослідження були 40 літніх жінок віком від 62 до 76 років. Вони були відібрані шляхом систематичної випадкової вибірки за критерієм оцінки рівноваги. Їх розділили на дві рівні групи по 20 осіб у кожній, а саме: експериментальну групу з тайцзи та тренуваннями з еспандером (TCR) тренували протягом 8 тижнів, 3 дні на тиждень по 60 хвилин кожного дня, а контрольну групу (C) не тренували. Учасниці зголосилися підписати форми згоди на участь у цьому дослідженні. Кількісні дані збирали шляхом вимірювання рівноваги, сили м'язів рук і м'язів ніг. Якісні дані збирали шляхом інтерв'ю та спостереження за учасницями.

Результати. Дослідження показало, що (1) рівновага, сила м'язів рук і м'язів ніг не відрізнялися до тренування. Після тренування тайцзи та тренування з еспандером (TCR) на 4-му та 8-му тижнях експериментальна група мала середнє значення рівноваги, сили м'язів рук та сили м'язів ніг краще, ніж перед тренуванням, і відмінності між експериментальною та контрольною групами були статистично значущими ($p<0,05$). (2) Експериментальна група мала рівновагу, силу, гарну гнучкість, розслаблене тіло та гарне психічне здоров'я.

Висновки. Що стосується користі для фізичної форми, заняття тайцзи та тренування з еспандером (TCR) і комбіновані вправи покращують рівновагу, силу м'язів рук і м'язів ніг. Завдяки цьому люди похилого віку мають міцне здоров'я та гарну фізичну форму.

Ключові слова: тайцзи, тренування з еспандером, рівновага, сила, люди похилого віку.

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ORIGINAL SCIENTIFIC ARTICLE

BASIC LOCOMOTOR LEARNING MODEL: NEW APPROACH USING SMALL GAMES COMPETITION IN ELEMENTARY SCHOOL

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Abstract

Study purpose. Physical education, sports and health for elementary school students are oriented to learning locomotor movements, so learning these skills requires fun activities, such as games. This research aims to develop a basic locomotor learning model based on a small game competition for elementary school students.

Materials and methods. This study used a research and development approach using ADDIE model. This research was carried out in three elementary schools, namely: Elementary school 22 Gelumbang, Elementary school 11 Gelumbang and Elementary school 2 Lembak. Data were collected using observation, interview, questionnaire, and test. The questionnaire instrument used in this study was the Guttman scale questionnaire because of using the Guttman scale. Expert judgments were used to analyze the product.

Results. The model can be applied in all elementary schools in the territory of Indonesia because product development has referred to competencies and learning outcomes in the 2013 curriculum. There are four types of games that have been developed for learning locomotor skills, namely 1) jump rope game, 2) watch out for crocodiles, 3) continuous running game, and 4) box jump game. Each game has different locomotor skill movements, including walk, run, slide, leap, gallop, skip, jump, and hop. Based on the effectiveness aspect, the results of the product trial show that the 'wary crocodile game' is a game that is in great demand and favored by students.

Conclusions. The locomotor skills learning model for elementary school students based on small game competitions has been feasible and effective for use in sports and health physical education classes. This model can also be applied in all elementary schools in the territory of Indonesia because product development has referred to competencies and learning outcomes in the 2013 curriculum.

Keywords: basic locomotor, elementary school, learning model, small games.

Introduction

Physical education is an important part of the overall education system. Physical education is a medium to encourage the development of motor skills (basic movements), physical abilities, knowledge, reasoning, appreciation of values (attitude, mental, emotional, and social), and habituation of healthy lifestyles that lead to increased balanced growth. and development (Young et al., 2021; Carson Sackett & Edwards, 2019). In developing concepts with various teaching methods, the material is given during physical education learning (Hartati et al., 2019). Physical education is the occurrence of learning through physical activity by designing so that physical fitness, knowledge, healthy living behaviour, being active, sportsmanship, emotional intelligence, development skills and motor skills can be improved (Silva et al., 2019). Physical education learning at the education level is found in elementary schools, junior high schools, and high schools (Montero-Carretero & Cervelló, 2020).

Physical education material contained in elementary schools is about learning basic movements. Regulation of the Minister of Education and Number 67 of 2013 concerning the Basic Framework and Curriculum Structure of Elementary Schools/Madrasah Ibtidaiyah states that one of the characteristics of the curriculum is designed to develop attitudes

(affective), knowledge (cognitive) and skills (psychomotor) and their application in various situations in schools and schools. school. Public. The structure and curriculum of physical education in sports and health in existing primary schools have the characteristics of basic technical skills from various sports.

The 2013 curriculum at the elementary school level is used thematically integratively for learning physical education subjects (Hartati et al., 2018). The basic technical skills of this sport will be mastered by students if they have mastered the basic movement skills first. Motor skills are a process of developing a person's ability to move which is controlled by the brain through the interaction of various parts and systems in the body (Ayubi & Komaini, 2021) Basic movements are skills that involve the brain, muscle strength involving the arms and legs that are used to achieve an exercise or movement, such as throwing a ball, visiting, or jumping through air movements, or maintaining balance (Komaini et al., 2021). Motor skills are divided into two, namely fine motor skills and gross motor skills. Through various activities including motor skills, physical education learning in elementary schools will train children to learn various movement skills in the form of games, athletics, and gymnastics (Dapp et al., 2021).

Elementary school 22 Gelumbang has implemented the 2013 curriculum, therefore researchers analyzed core competencies and basic competencies. After that, analyze student needs, student characteristics, and facilities to support the learning process in Physical Education subjects. The results of the preliminary analysis are the observations of researchers in the field during the physical education learning process, learning basic locomotor movements in fifth-grade students still uses the teacher method (theory) and demonstration (practice). After that, the researcher conducted an interview with one of the physical education subject teachers at Elementary school 22 Gelumbang, the information on learning problems obtained by the researcher included: (1) the teacher's inability to explain basic movement material, especially locomotor basic movements (2) the inability of students to accept learning material basic locomotor movements (3) students prefer to play rather than pay attention to the teacher's explanation. Most students do not like the basic locomotor movement material, because the characteristics of elementary school children prefer to play and move actively.

Reviana et al., (2021) in their journal has the same problem, namely, students do not like learning basic movements because they feel bored with the applied learning model. In line with research by Hernawan et al. (2019) in his research to overcome this problem, the researcher used the development of a locomotor basic movement learning model for elementary school students using PACEF (Productive, Active, Creative, Effective and Fun). For elementary school students, mastery of locomotor skills can also be done through throwing and catching activities (Jaakkola et al., 2019). In addition, physical activity such as aerobic fitness exercise can be used as a medium to improve the basic motor skills of elementary school students (de Bruijn et al., 2019; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Logan, Kipling Webster, Getchell, Pfeiffer, & Robinson, 2015).

Various studies have shown that basic movement skills competence and moderate to vigorous physical activity are opportunities for locomotor movement skills (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014; Han, Fu, Cobley, & Sanders, 2018; Webster, Martin, & Staiano, 2019). Because children who cannot master FMS are more likely to experience failure in the motor domain movement in games and sports is also impaired (Hardy, King, Farrell, Macniven, & Howlett, 2010; Bryant, Duncan, & Birch, 2014; Shams, Hardy, Vameghi, Loovis, & Shamsipour Dehkordi, 2021). In addition, FMS is the basis of early motor markers, especially for autism spectrum disorders (Gandotra et al., 2020)

From previous research, it is illustrated that locomotor skills can be trained with various physical activities. One of the activities that can provide fun stimulation for children to practice their locomotor skills is games. This is the gap to be presented in this game. Games (small games competitions) for the development of learning models for students' basic locomotor skills in elementary schools. The design of this learning model was developed by the 2013 Curriculum Basic Competencies in sports and health physical education lessons for elementary school students. The design of this model is also a new approach to locomotor skills activities. While the basic reason for implementing this research is the need for the development of learning models for basic locomotor skills by the use of the curriculum, student backgrounds, and learning needs by current scientific developments in the field of physical education and sports.

Thus, the purpose of this study was to develop a basic locomotor learning model based on small game competitions for elementary school students. The development of this learning model is expected to be a good, effective, fun learning, and make students more active in the teaching and learning process of basic movements to achieve physical education learning objectives. In addition, this model also allows students to receive basic locomotor movement learning with a new model and by student characteristics, namely, students love to move and play. This means that playing activities become physical learning. Teachers and students are expected to be motivated to learn the basic locomotor movements taught by the teacher which can have an impact on improving motor skills.

Materials and methods

This study used a research and development approach. It is used to produce certain products and tests their effectiveness these products (Creswell, 2012; Gall et al., 2010). It is used to create a new model for locomotor skills learning using small games competition. This research was carried out in three elementary schools, namely: Elementary school 22 Gelumbang, Elementary school 11 Gelumbang and Elementary school 2 Lembak. This study used the ADDIE model (Branch, 2010). The stages of the ADDIE model to develop a small game competition-based locomotor skills learning model are described as follows.

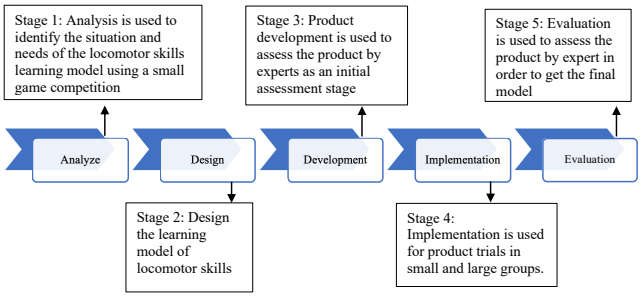

Fig. 1. The Steps of research adapted from the ADDIE model

Table 1. Dimension Movement for Basic Locomotor Skill Instrument

Locomotor Skills	Indicators
Walk	The eyes view are straight forward, the hands are swinging back and forth, the body position is upright, and the feet move forward alternately
Run	Straight forward view, relaxed body position and leaning forward, hands swing back and forth alternately, knee position raised with both feet moved quickly and flying towards the front.
Slide	The body moves sideways, the eyes look horizontally, the arms move following the movement of the body, and the legs are not crossed
Leap	Both legs are raised, moving forward alternately for several steps and then jumping and preceded landing on one leg, swinging hands following body movements, and straight eyesight.
Gallop	In a straightforward view, the position of the foot is lifted alternately and moves forward, relaxing the body, the position of the hand follows body movements
Skip	The feet jump alternately (up and down), the position of the body upright moves to float, a straightforward view, and the hand swings following the body movements.
Jump	The position of the body is lifted and moves from one place to another place, hands are swinging forward following body movements, feet are raised forward (down and up) quickly, and knees are bent when landing.
Hop	One of the legs is lifted alternately and moves forward, one hand straight up opposite the leg raised, body position is upright, and when landing begins with one leg as a pedestal

Participants

The participants were students from three elementary schools was around 50 students and 10 teachers. Besides, the expert was learning media experts, curriculum experts, and locomotor and sports learning experts.

Measures

The data used in the study are 1) observation used for problem identification and to determine the effectiveness of product trials in the field. 2) Interviews were used to analyze students' perceptions of the practicality of using a game-based locomotor motion learning model. 3) Questionnaires are used to obtain an analysis of the needs of the basic locomotor movement model from students and teachers. Questionnaires were distributed to students (N=100) and teachers (N=10). The questionnaire was designed using a closed questionnaire type and participants had to choose the answers that had been provided related to the questions. The questionnaire instrument used in this study was the Guttman scale questionnaire because by using the Guttman scale the researchers got clear answers from students and teachers. Questionnaires were also used for product assessment by teachers. The model validation uses expert judgment consisting of learning media experts, curriculum experts, and locomotor and sports learning experts. 4) The test is used to determine the increase in student locomotor skills learning activities before and after using a small game competition. Researchers use correlation tests to see the relationship between pretest and posttest during product testing. The questionnaire used to analyze the need for locomotor skills was distributed to 100 students and 10 physical education and sports teachers. The results of the needs analysis are presented in percentages. The following is the questionnaire of needs analysis of the locomotor skills model (Sari, 2019);

Results

Needs Analysis and Design

In this initial product development stage, the researcher first analyzed the goals and practice of the product in the form of a small game aimed at training elementary school students' basic movements. Then the researchers analyzed the character of the students, the target students were elementary school children. In the analysis, elementary school-aged children are very happy to play, love to move, enjoy group activities, and enjoy hands-on practice. The main purpose of physical and health education is to increase life-long physical activity and encourage the physical, psychological and social development of students. The initial product developed by the researcher was a game to watch out for crocodiles, a continuous running game, a box jump game and a jump rope game.

The result of locomotor skills learning needs for elementary school students is explained in the following table 2.

Table 2 shows that the small game competitions that students want and need in order are 1) jump rope game, 2) watch out for crocodiles, 3) continuous running game, and 4) box jump game. Of the four games, there are eight basic locomotor skills required. Meanwhile, each small game competition has a different orientation of locomotor skills.

Table 2. The Result of Needs Analysis

Types of Competition Small Games	Types of Locomotor Skill	Students	Teacher
		%	%
Watch out for crocodiles	Walk, Run, Slide, Leap	77	90
Continuous running game	Walk, Run	65	70
Box jump game	Gallop, Skip, Jump, Hop	60	70
Jump rope game	Walk, Run, Slide, Leap, Gallop, Skip, Jump, Hop	90	90

Development, Implementation, and Evaluation of Product

Researchers used a validation sheet that was used to assess whether the design of the locomotor basic movement learning model would be more effective than before or not. The results of the small game product assessment have an average of 80% with a "good" rating category. Based on this assessment, it can be concluded that the small game product is feasible and ready to be used in further research. In ad-

dition to the assessment, the validator also provides suggestions and comments regarding the small game product developed by the researcher. Suggestions and comments that are corrected by the validator will then be used as the basis for researchers to improve the product, to produce a product that is worthy of being tested at a later stage. The validator suggests that each game is equipped with media or facilities that can be obtained easily so that this game can also be played by students at home.

Based on the results of the small group effectiveness test conducted on the fifth-grade students of Elementary school 22 Gelumbang, Elementary school 11 Gelumbang and Elementary school 2 Lembak, totalling 20 people, it can be seen that the small game product that the researcher developed is quite effective for use in the physical education learning process in elementary schools. In the watch game, there is a crocodile, there is a 50% increase in the results of the pretest and post-test differences, then in the continuous running game there is a 70% increase in the results of the pretest and post-test differences, then in the box jump game there is a 30% increase in the results of the pretest and post-test differences, and finally, in the jump rope game, an 80% increase was seen from the difference between pretest and posttest. After conducting a small group effectiveness test, the researchers then conducted a large group test.

Based on the results of the large group effectiveness test conducted on the fifth-grade students of Elementary school 22 Gelumbang, Elementary school 11 Gelumbang and Elementary school 2 Lembak, totalling 50 people, it can be seen that the small game product that the researcher developed is considered effective for use in the physical education learning process in elementary schools. In the watch game, there are crocodiles, there is a 60% increase in the results of the pretest and post-test differences, then in the continuous running game there is a 60% increase in the results of the pretest and post-test differences, then in the box jump game there is a 42.4% increase in the results of the pretest and posttest differences, and finally, in the jump rope game, there was a 35% increase from the difference between pretest and posttest.

The following is the final learning model of locomotor skills using competition small games.

Discussion

The locomotor basic movement learning model is based on small game competition in small and large group trials,

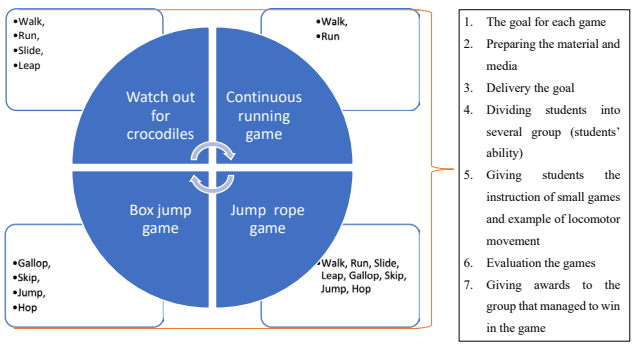

Fig. 2. Syntax of Small Games Competition for Locomotor Skills Learning Model

and peer assessment and the experts show the valid model. The results of the assessment of game product drafts in small group trials and expert validators obtained an average percentage of 86%. The validation results that have been assessed by the validator (learning media experts, curriculum experts, and locomotor and sports learning experts) and small game-based locomotor basic movement learning are included in the good or valid category and can be continued for small group trials. Validation is considered fulfilled if the instrument has been designed well, and the validation is tested by experts (Faizah et al., 2019).

Based on the results of the small group effectiveness test, it can be seen that the small game product that the researcher developed is considered effective for use in the physical education learning process in elementary schools. In the watch out for crocodiles game, there is a 50% increase in the results of the pretest and post-test, then in the continuous running game there is a 70% increase in the results of the pretest and post-test differences, then in the box jump game there is a 30% increase in the results of the pretest and posttest differences, and finally in the jump rope game showed an 80% increase from the difference between pretest and posttest.

The results of the research conducted are in line with previous research conducted by Reviana et al. (2021), this research has problems in following the learning process because they admit to being bored with physical education lessons so that students have difficulty in improving basic movement skills. The purpose of holding this research is to solve the problem by applying an interesting learning method for students, namely using the play method. This research provides a solution to the problem of boredom in the learning process and improves the quality of learning to achieve learning objectives. This research is in line with research conducted by Harvey et al. (2021) in his research, who tried to develop a game-based skill learning model for elementary school children. Research from Hanief (2021) forms the basic movements of elementary school students in the form of clogs, Sodor carts, and forts that have a close relationship with the intellectual, social, and character development of children.

The results of the assessment of the product draft of developing a small game-based locomotor basic motion learning model for large group trials from the validation of experts obtained an average percentage score of 88%. It means the accuracy of a test tool or scale in carrying out its measurement function (Rodríguez Mantilla & Fernández Díaz, 2015). The product draft of the locomotor basic movement learning model based on small games has been validated and revised by an expert validator, so a large group trial is carried out in elementary schools. Based on the results of the large group effectiveness test, it can be seen that the product is considered effective for use in the physical education learning process in elementary schools. In the watch game for crocodiles, there is a 65% increase in the results of the pretest and post-test differences, then in the continuous running game there is a 60% increase in the results of the pretest and post-test differences, then in the box jump game there is a 42.5% increase in the results of the pretest and posttest differences, and finally, in the jump rope game, there was a 35% increase from the difference between pretest and posttest.

This research has a mission to develop a basic locomotor learning model for elementary school students in Class

VI that supports productive, active, creative, effective and fun learning in the learning system of Physical Education, Sports and Health in school. In addition to increasing student activity, small games in the form of "watch out for crocodiles", continued running, box jumping, and rope jumping can increase students' motivation to learn (Irfandi & Rahmat, 2016'; Palmizal et al., 2020). Researchers tried learning through play for the development of creativity and cognitive early childhood (Nurjanah & Wahyuseptiana, 2018).

The interesting thing that researchers found was that students liked small game-based learning in the form of "watch out for crocodiles" and continued running, box jumping and rope jumping seen from the enthusiasm shown by students and students focused on learning basic locomotor movements seen from the focus of students listening to instructions teacher or researcher and from the activeness of students because they are excited when playing. Each instruction given in this learning model has been adapted to the learning outcomes of the 2013 curriculum. This means that the development of this small game-based locomotor skills learning model has a context that is in line with the 2013 curriculum so that it can be used by all regions in Indonesia. Every movement of the game also shows the traditional games that are often played by children in Indonesia.

Thus, learning basic locomotor movements that appear in traditional games provides a comfortable learning environment for elementary school children and is easy to socialize (Awalludin Nugraha et al., 2018). In addition, the games used in learning locomotor skills also simultaneously build students' motor creativity (Roslan & Abdullah, 2020). There is an interactive diversity made by students in every movement made during game activities, so this condition can have a positive impact on their physical, emotional and cognitive development (Oboeuf et al., 2020). The physical and motor development of each child during the product trial showed a level of difference, but overall this small game-based locomotor skills learning model had a significant effect on improving locomotor skills.

Conclusions

The results of the research and development data analysis that have been carried out conclude that the locomotor skills learning model for elementary school students based on small game competitions has been feasible and effective for use in sports and health physical education classes. This model can also be applied in all elementary schools in the territory of Indonesia because product development has referred to competencies and learning outcomes in the 2013 curriculum. There are four types of games that have been developed for learning locomotor skills, namely 1) jump rope game, 2) watch out for crocodiles, 3) continuous running game, and 4) box jump game. Each game has different locomotor skill movements, including walk, run, slide, leap, gallop, skip, jump, and hop. This means that each game can have one or more or even all the moves that have been identified during the needs analysis activity. This small game-based locomotor basic movement learning model can motivate students to carry out basic locomotor movement learning activities. Based on the effectiveness aspect, the results of the product trial show that the "wary crocodile game" is a game that is in great demand and favoured by students. The results of the tests conducted, also show that the type of game that watches out for costs has the highest percentage.

These findings also have advantages and disadvantages. The advantages of small games in learning locomotor skills are 1) the types of movements that are carried out are movements that are carried out every day by students in their playing activities, and 2) four types of small games are designed to have the same concept as various traditional games such as hide and seek, jump rope, sack racing, crankshaft, jump rope, and so on. 3) Learning instructions are made simple and easy to understand by students. However, the drawbacks of this game are the trials carried out in only one area and the less diverse types of small games. Therefore, this research can still be developed by further researchers such as developing more diverse types of games, such as traditional and modern games or multimedia technology that can complement games for locomotor skill movements. The results of this study also have an impact on the diversity of physical education and sports learning models in schools, especially for learning locomotor skills.

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Conflict of interest

There are no conflicts of interest to declare.

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БАЗОВА ЛОКОМОТОРНА МОДЕЛЬ НАВЧАННЯ: НОВИЙ ПІДХІД ДО ВИКОРИСТАННЯ ЗМАГАНЬ У МАЛИХ ІГРАХ У ПОЧАТКОВІЙ ШКОЛІ

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

Реферат. Стаття: 7 с., 1 табл., 2 рис., 35 джерел.

Мета дослідження. Фізичне виховання, спорт і здоров'я для учнів початкових класів спрямовані на вивчення локомоторних рухів, тому навчання цих навичок вимагає цікавих занять, наприклад ігор. Це дослідження має на меті розробити базову локомоторну модель навчання на основі невеликих ігрових змагань для учнів початкової школи.

Матеріали та методи. У цьому дослідженні використовували підхід дослідження та розробки з використанням моделі ADDIE. Це дослідження було проведено в трьох початкових школах, а саме: початкова школа №22 міста Гелумбанг, початкова школа №11 міста Гелумбанг і початкова школа №2 міста Лембак (Індонезія). Дані збирали за допомогою спостереження, інтерв'ю, анкетування та тестування. Інструментом анкетування, який використовували в цьому дослідженні, був опитувальник за шкалою Гутмана через використання шкали Гутмана. Для аналізу продукту використовували експертні оцінки.

Результати. Цю модель можна застосовувати в усіх початкових школах на території Індонезії, оскільки розробка продукту стосується компетенцій і результатів навчання в навчальній програмі 2013 року. Існує чотири типи ігор, які були розроблені для вивчення локомоторних навичок, а саме: 1) гра в стрибки через скакалку, 2) гра в стеження за крокодилами, 3) гра в безперервний біг і 4) гра в стрибки з коробки. Кожна гра передбачає різні рухові навички, зокрема ходьбу, біг, обережний плавний рух, перестрибування, галоп, перескакування, стрибки, підскакування. З огляду на аспект ефективності, результати випробування продукту показують, що «гра в обережного крокодила» — це гра, яка користується великим попитом і прихильністю учнів.

Висновки. Модель навчання локомоторних навичок для учнів початкової школи на основі невеликих ігрових змагань виявилася практично здійсненною та ефективною для використання на уроках спортивно-оздоровчого фізичного виховання. Цю модель також можна застосовувати в усіх початкових школах на території Індонезії, оскільки розробка продукту стосується компетенцій і результатів навчання в навчальній програмі 2013 року.

Ключові слова: базовий локомоторний, початкова школа, модель навчання, малі ігри.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTIVENESS OF MOBILITY AND STABILITY EXERCISES IN RESISTANCE-TRAINED MALES WITH SHOULDER IMMOBILITY IN DIFFERENT AGE GROUPS

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Abstract

Background. Resistance-trained males aim to increase their overall health, strength and fitness level. Many resistance-trained males aiming to increase their strength neglect the muscles that stabilize the scapular and glenohumeral joints. The shoulder joint is among the most frequently injured areas in resistance-trained males. In addition, strength training displays different effects in young and old individuals.

The study purpose was to investigate the effects of stability and mobility exercises on range of motion, posture and body awareness in resistance-trained males with shoulder immobility.

Materials and methods. Thirty-two resistance-trained males diagnosed with shoulder immobility were divided into two groups according to their age ranges (G1: Adult, G2: Young Adult). The program consisting of mobility and stability exercises was applied 3 days a week for 8 weeks. The participants were evaluated with a universal goniometer, the New York Posture Rating, and the Body Awareness Questionnaire before and after the treatment lasting 8 weeks.

Results. Following the 8-week treatment, improvements in body awareness and range of motion were observed in all participants ($p \leq 0.05$). There were improvements in the scores of the New York Posture Rating and Body Awareness Questionnaire in both groups, but they were not statistically significant ($p \geq 0.05$).

Conclusions. An exercise program combining stability and mobility exercises was applied to resistance-trained males with shoulder immobility and it was observed to have positive effects on the range of motion of the joint, body awareness and posture. We are of the opinion that various types of exercise should be implemented when planning exercise programs.

Keywords: awareness, body builders, exercise, resistance-trained, posture, shoulder.

Introduction

Skeletal muscles display a high degree of plasticity in response to different mechanical stimuli. Out of these stimuli, overloading, with a combination of quantitative changes in muscle mass and fiber size, is one of the most effective ways to increase hypertrophy both at the whole muscle and at the single fiber level. The increase in fiber, and thus in muscle size, is the result of a positive balance between protein synthesis and degradation. Since mechanical loading is one of the most important methods to increase protein synthesis, the method used to maximize the mechanical stress applied to skeletal muscle is resistance training (Monti et al., 2021). Both strength and endurance are required during a sporting activity (Degens et al., 2019). Resistance exercise and strength training are significant methods for athletes to improve their athletic performance. Intense resistance training should be performed to achieve high-level performance in strength and power-based sports. Generally, weight-training exercises put the shoulder in a bad position, such as external rotation, at the end of the joint range of motion while under heavy load. This results in joint and muscle imbalances and makes the shoulder prone to injury. Training routines aimed at specific muscle groups or exercises often neglect the balance of strength and mobility, which is necessary for unimpaired shoulder function (Kolber et al., 2009).

The shoulder joint is one of the joints with the greatest range of motion. However, mobility and stability are inversely proportional. The stability balance of the shoulder joint, which has a large physiological range of motion, is sensitive. Some activities require mobility (e.g. swimming), while

others require stability (e.g. weight lifting, assistant referee) (Best & Tanaka, 2018).

Bodybuilders aim to increase their overall health, strength and fitness level. Many bodybuilders aiming to increase their strength neglect the muscles that stabilize the scapular and glenohumeral joints while concentrating on strength training for the pectoralis, deltoid, and abdominal groups. Bodybuilders have been observed to experience a loss of muscle strength in the scapular stabilizers and rotator cuff muscles. Such strength imbalances may lead to a poor scapulohumeral rhythm during shoulder elevation (Kolber et al., 2009; Grandou et al., 2020).

Strength and endurance training displays different effects in young and old individuals (Stunes et al., 2022). Resistance training is a good stimulant to increase strength in both young and old adults, however, muscle hypertrophy that occurs consistently in young males declines with age. This suggests that strength gains in older adults mostly result from adaptations of non-muscle tissues (Petrella et al., 2007; Kosek et al., 2006).

While being educated on appropriate exercise selection and injury prevention strategies, strength athletes should be trained on changes in shoulder laxity, capsular restriction, or shoulder muscle balance that may develop secondary to weight training (Kolber et al., 2009).

Exercise practices show different effects on individuals depending on age. There are studies indicating the different effects of exercise practices in young and middle-aged individuals in the literature. However, these studies have mostly investigated the effects of strengthening exercises (Rader et al., 2016; Pesta et al., 2014). Our aim in this study is to examine the effectiveness of stability and mobility exercises in bodybuilders with shoulder immobility.

Materials and methods

Study participants

Thirty-two bodybuilders who had been diagnosed with shoulder immobility by a physician were included in our study. A total of 30 participants completed the eight-week exercise treatment. The participants were divided into two groups based on their age ranges. While the first group included those aged 18-30, those aged 30-60 were included in the second group. Inclusion criteria for the study were: having been diagnosed with shoulder immobility by a physician and being a male bodybuilder over the age of 18. Exclusion criteria were: being a female bodybuilder, having scapular dyskinesis, having undergone a surgery within the last six months, and having an orthopedic or neurological disease.

Study organization

The athletes included in the study were given a program including stability and mobility exercises after the initial measurements and evaluations were performed by a blind evaluator. The partipicants were evaluated for the second time eight weeks later and the effects of the exercise program on them were examined.

The sample size was calculated to be 28 with 0.05 error in the %80 confidence interval. After calculating the drop-out rate as 20%, 32 individuals were included in the study. Thirty two individuals were included in the study in case they might drop out for various reasons (Grgic et al., 2018).

All athletes included in the study were given the "Informed Voluntary Consent Form" and their consent was obtained. Demographic data such as the athletes' age, weight, height, sports age, status of drug use and operation history were collected. Necessary approvals were obtained from the Non-Interventional Clinical Research Ethics Committee of Istanbul Medipol University before conducting the study (E-10840098-772.02-3687, date: 24/06/2022). The study was conducted with the individuals who accepted the informed consent form approved by the Ethics Committee of Istanbul Medipol University

Assesment Parameters

Assesment of Joint Range of Motion. Goniometric measurements were repeated bilaterally with a universal goniometer. Measurements of upper extremity, shoulder flexion, internal and external rotation were made. They were repeated three times for each evaluation. The mean of the measurements was recorded as the score.

Assesment of Posture. Posture assessment was done using the New York Posture Rating, which consists of 13 items. Posture analysis is performed while standing upright. A score of five was given if the participant's posture was correct, three if moderately impaired, and one if severely impaired. The total score to be obtained from the test is a maximum of 65 and a minimum of 13. The higher the score, the better posture the participant has (McRoberts et al., 2013).

Assesment of Body Awareness. Body awareness was evaluated using the Body Awareness Questionnaire. This questionnaire includes physical, emotional and social elements that question the sensitivity of the participant to physical reactions in normal or abnormal body conditions. Conducted to determine the normal or abnormal sensitivity level of body components, the Body Awareness Questionnaire consists of 18 items under 4 subscales (changes in body process, sleep-wake cycle, prediction at the onset of the disease, prediction of body responses). The participant is asked to score each item on a scale of 1-7. Evaluation is performed based on the total score. A higher score indicates a better body sensitivity (Karaca & Bayar, 2021).

Exercise Program

Before the athletes started their exercise program, in order to raise their awareness, they were trained on the importance of shoulder mobilization and stabilization and how to contract the right muscle groups. Following the evaluations, in addition to the usual training programs, the athletes performed an exercise program 3 days a week for 8 weeks, accompanied by the same physiotherapist.

The number and frequency of repetitions of the exercises were updated every two weeks. They would perform Prone I, T, W, Y's, Wall Angels and Anterior Shoulder Stretch, Shoulder Circle Rotation, Prone Shoulder CARs and Shoulder Side Stretch, and stretching exercises for pectoral muscles.

Statistical analysis

SPSS 26.0 (Statistical Package for Social Sciences, Chicago, Illinois, United States) software was used for statistical analysis in the study. Statistical analysis methods including

descriptives, comparators, and correlations were used. Mean, standard deviation, and percentage distribution values were calculated using descriptive statistical methods. Conformity to the normal distribution was evaluated using the Shapiro-Wilk test. Parametric tests were used if the data conformed to the normal distribution, and nonparametric tests were used if they did not. Independent samples t-test was used for the parametric data, and Mann Whitney-U test for nonparametric data. Paired samples t-test was used for the comparison of in-group values before and after the eight-week treatment, Wilcoxon paired two-sample test was used for nonparametric ones, and Chi-square test was used to compare the categorical data. A p value lower than 0.05 was considered statistically significant.

Results

Thirty-five resistance-trained males with shoulder immobility were evaluated in the study. Three of them were excluded from the study because two had scapular dyskinesia and one had undergone shoulder surgery. A total of 32 individuals were included in the study. One participant from each group could not complete the study for various reasons, and the scores of 30 participants were recorded in the end.

Table 1. Demographic Data

	Group 1	Group 2	p
Age	21.36 ± 2.95	41.29 ± 8.67	0.00
Height	178.14 ± 5.96	175.65 ± 5.99	0.279
Weight	75.29 ± 8.08	83.07 ± 9.51	0.028
BMI	23.72 ± 2.30	26.98 ± 3.28	0.05

The values are shown as mean ± SD. p<0.05 was considered statistically significant. Age: years, BMI: Body Mass Index (kg/m^2)

Since the participants were divided into groups based on age, there was a statistical difference in their age, weight and BMI before the treatment (p≤0.05).

Table 2. General conditions of the groups before treatment

	Group 1	Group 2	p
How many days a week does the athlete train?	4.50 ± 1.01	3.71 ± 1.54	0.124
Does the athlete experience stiffness in their shoulder?	3.36 ± 1.99	3.21 ± 1.42	0.828
Does the athlete experience difficulty or pain when they raise their arms above their head?	3.50 ± 2.28	1.64 ± 1.64	0.020
Happiness after exercise	8.64 ± 1.65	9.71 ± 0.726	0.035

The values are shown as mean ± SD. p< 0.05 was considered statistically significant.

There was no statistically significant difference in the number of weekly training sessions and stiffness in the shoulder region in both groups (p≥0.05). However, the feeling of pain when raising the arms was observed to be higher in Group 1 (p=0.020). The feeling of happiness after exercise was observed to be higher in Group 2 (p=0.035).

After the exercise programs were completed, a statistically significant increase was observed in all evaluation parameters in both groups (p≤0.05). There was a statistical difference between the groups in the measurements of right and left shoulder flexion, external rotation of the left shoulder, internal rotation of the left and right shoulder (p ≤ 0.05)

When the pre-treatment scores of both groups were examined, no statistical difference was found between the two groups, but the NYPR lateral and posterior scores of the adult group were lower (p=0.071).

Discussion

Our study investigated the effectiveness of exercises in resistance-trained males with shoulder immobility. To the best of our knowledge, there has been no study examining the effectiveness of combined exercises in resistance-trained males with shoulder immobility. In resistance-trained males with shoulder immobility in different age groups, to whom we implemented stability and mobility and stretching exercises, improvements were observed in all the evaluation parameters in both adult and young adult groups as a result of the exercise program, except for the results of lateral posture analysis in the young adult group.

Martel et al. investigated the effects of gender and age on muscle fiber adaptation in individuals performing high-intensity resistance training. The effects of the exercises applied three times a week for 9 weeks on the lower extremity extensor muscles were evaluated. It was concluded that there were differences in muscle fibers between males and females (Martel et al., 2006). Unlike this study, we examined the upper extremity muscles. In addition, we included only male participants in our study, as we predicted that there would be differences between males and females.

Staron et al. compared the gender-related cross-sectional areas of various muscle fiber types during the transition from childhood to adulthood. Gender-specific patterns of muscle fiber types were found to develop during this transition (Staron et al., 2000). Bougea et al., on the other hand, examined the relationship between aging and muscle fibers in their autopsy study on individuals aged 24-82 who died due to sudden death. As a result, they observed that the number and volume of muscle fibers decreased with aging (Bougea et al., 2016). Considering the relationship of muscle fibers and structure with age, the participants were divided into two groups as those aged 18-30 and those aged 30-60.

Previous studies investigated injury sites of recreational resistance-trained athletes. Shoulder, upper extremities and spine were found to be the most frequently injured areas. The reason why upper extremity injuries are so common is the mistakes made in exercise programs. The biggest one is that recreational resistance-trained athletes usually do exercises for the upper extremity muscles and neglect the ones for the core region and lower extremity muscles. As a result, biomechanical problems occur. The resistance-trained athletes in our study also developed shoulder immobility problem (Siewe et al., 2014). Moezy et al. investigated the effectiveness of scapular stabilization exercises in individuals with shoulder impingement syndrome. Their study reported that the exercise applications provided improvements in the

Table 3. Evaluation results of the groups before and after treatment

	Group 1			Group 2			p
	Before Treatment	After Treatment	Group p	Before Treatment	After Treatment	Group p	
Shoulder flex left	125.14 ± 12.93	142.29 ± 11.06	0.00	123.29 ± 6.91	134.29 ± 7.52	0.00	0.002
Shoulder flex right	123.14 ± 11.31	141.43 ± 11.49	0.00	118.86 ± 4.94	131.29 ± 4.81	0.001	0.018
Shoulder ext rot left	78.79 ± 7.97	85.21 ± 6.34	0.00	79.21 ± 5.59	83.14 ± 4.96	0.00	0.037
Shoulder ext rot right	81.21 ± 6.40	86.64 ± 4.80	0.002	78.50 ± 6.60	82.86 ± 5.38	0.00	0.417
Shoulder int rot left	62.57 ± 5.65	71.14 ±5.53	0.00	61.64 ± 3.46	67.14 ± 3.76	0.001	0.018
Shoulder int rot right	61.57 ± 5.65	70.71 ± 5.74	0.002	59.43 ± 2.47	65.64 ± 2.41	0.00	0.002
Body awareness questionnaire	86.29 ± 13.84	98.29 ± 10.63	0.00	89.29 ± 12.44	96.21 ± 11.91	0.00	0.098
NYPR lateral	27.86 ± 3.18	32.29 ± 2.30	0.109	25.14 ± 4.35	29.29 ± 3.50	0.001	0.792
NYPR posterior	27.50 ± 3.30	27.86 ± 3.18	0.00	24.93 ± 3.89	25.14 ± 4.35	0.00	0.667

The values are shown as mean ± SD. $p<0.05$ was considered statistically significant. NYPR: New York Posture Rating. Flex: Flexion, Ext: External, Int: Internal, Rot, Rotation.

range of abduction and external rotation and posture in the participants (Moezy et al., 2014). Improvements in shoulder flexion, internal and external rotation were noted in both groups as a result of shoulder joint range of motion measurements. However, more differences were observed in the range of motion in the young adult group. Gharisia et al. concluded that stretching exercises increase joint range of motion in athletes with internal deficits in the glenohumeral joint (Gharisia et al., 2021). Goto et al. examined the effects of range of motion exercises performed at different angles in their study on young trained men. Similarly to our study, the participants performed the exercises three days a week for eight weeks. They concluded that range of motion exercises facilitate muscle hypertrophy positively (Goto et al., 2019). Moradi et al. implemented an eight-week exercise program in their study examining male volleyball players with internal rotation deficit in the shoulder. They found that the exercise program they implemented, in which the participants performed stretching exercises for five days and strengthening exercises for three days a week, was an effective treatment method for shoulder internal rotation deficit (Moradi et al., 2020). In accordance with the literature, we planned the exercise program to be performed three days a week for eight weeks. We included stabilization, stretching and strengthening exercises in our exercise program. Similarly to these studies, we recorded improvements in joint range of motion.It is known that bodybuilding training causes muscle damage in the upper extremity in resistance-trained males (Ferreira et al., 2017). It is thought that problems in the alignment of the head and shoulder also affect the muscles around the shoulder (Thigpen et al., 2010). In a study examining the effectiveness of stabilization exercises in individuals with round-shoulder posture, they performed stabilization and stretching exercises. The study indicated that the exercise application was effective in improving posture in individuals (Kim et al., 2018). Similarly, stretching and stabilization exercises were given to bodybuilding athletes with shoulder immobility. When we compared the pre- and post-treatment scores, we observed that the scores of the adult group were lower than the young adult group. This could be because the posture of the individuals in the adult group may have been affected more negatively than the younger group as a result of the longer-term application of inappropriate exercise prescriptions in the adult group. Another reason could be that postural problems become more common with age. However, on the contrary, improvements were observed in posture analysis in the adult group, while improvements were observed in posture evaluations except for the lateral posture analysis in the young adult group. Lee et al. found that stretching exercises for the pectoralis minor muscle improved the posture of individuals by improving scapular stabilization and alignment (Lee et al., 2015). Ruivo et al. applied strengthening and stretching exercises to individuals with forward head and protracted shoulder posture in their study. As a result, improvement was observed in posture (Ruivo et al., 2017). Similarly, Shiravi et al. reported that scapular stabilization exercises had a positive effect on posture in individuals with forward head and round shoulder problems. In our study, in addition to stabilization exercises, stretching exercises for pectoralis major and minor muscles were given. As a result, improvements were recorded in posture (Shiravi et al., 2019).

Postural awareness is the subjective conscious awareness of body posture based primarily on proprioceptive feedback from the body environment to the central nervous system. Erden and Emirzeoğlu examined body awareness in different sports branches in their study. They concluded that body awareness is similar between different sports branches and different age groups. We observed an increase in body awareness after the exercise applications, but no statistically significant difference was found between the groups (Erden & Emirzeoğlu, 2020).

Tıkaç et al. investigated the effects of regular exercise practices on body awareness in young adults. They found that the exercise practices had a positive effect on self-efficacy, self-esteem and body awareness parameters. As a result of the exercise applications in our study, an increase in body awareness score was observed in both groups, but the young adult group achieved better results (Tikac et al., 2022). The effect of physical activity level on life satisfaction and happiness in different age groups was investigated. The age groups were divided into three as young adults, middle-aged adults

and older adults. As a result of the study, it was found that as the age increases, the increasing exercise level increases the happiness level in individuals (An et al., 2020). We observed in our study that the post-exercise happiness level of the adult group was higher than the young adult group.

Conclusions

The study found that the combined exercise program applied to resistance-trained males with shoulder immobility had positive effects. We are of the opinion that various types of exercises should be included while planning the exercise program.

Our study has several limitations. A total of 32 trained males were included in our study. The number of participants could have been higher. In addition, the duration of doing sports was not homogeneously assigned to the participants. We are aiming to design studies by considering these limitations in the future.

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Clinical trials registration number: NCT05450666

Conflict of interest

The authors declare no conflict of interest.

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ЕФЕКТИВНІСТЬ ВПРАВ НА РУХЛИВІСТЬ І СТАБІЛЬНІСТЬ У ЧОЛОВІКІВ, ЯКІ ТРЕНУЮТЬСЯ З ОПОРОМ, З НЕРУХОМІСТЮ ПЛЕЧЕЙ У РІЗНИХ ВІКОВИХ ГРУПАХ

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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., 30 джерел.

Історія питання. Чоловіки, які тренуються з опором, прагнуть покращити свій загальний рівень здоров'я, сили та фізичної форми. Багато чоловіків, які тренуються з опором, прагнучи збільшити свою силу, нехтують м'язами, які стабілізують лопатковий та гленохумеральний суглоби. Плечовий суглоб є однією з найбільш часто травмованих ділянок у чоловіків, які тренуються з опором. Крім того, силові тренування по-різному впливають на молодих і літніх людей.

Мета дослідження полягала в тому, щоб вивчити вплив вправ на стабільність і рухливість на діапазон рухів, поставу та усвідомлення тіла у чоловіків, які тренуються з опором, з нерухомістю плечей.

Матеріали та методи. Тридцять два чоловіки, які тренуються з опором, у яких була діагностована нерухомість плечей, були розділені на дві групи відповідно до їхніх вікових діапазонів (G1: дорослі, G2: молодь). Програму, що складається із вправ на рухливість і стабільність, застосовували 3 дні на тиждень протягом 8 тижнів. Учасників оцінювали за допомогою універсального гоніометра, тесту «Нью-Йоркський рейтинг постави» та шкали «Опитувальник з усвідомлення тіла» до та після проходження курсу вправ, який тривав 8 тижнів.

Результати. Після 8-тижневого курсу вправ в усіх учасників спостерігалося покращення усвідомлення тіла та діапазону рухів ($p \leq 0,05$). В обох групах спостерігалися покращення в балах тесту «Нью-Йоркський рейтинг постави» та шкали «Опитувальник з усвідомлення тіла», але вони не були статистично значущими ($p \geq 0,05$).

Висновки. До чоловіків, які тренуються з опором, у яких була діагностована нерухомість плечей, застосовували програму вправ, що поєднує вправи на стабільність і рухливість, і було помічено, що вона мала позитивний вплив на діапазон рухів суглоба, усвідомлення тіла та поставу. Ми вважаємо, що під час планування програм вправ слід застосовувати різні види вправ.

Ключові слова: усвідомлення, культуристи, вправа, які тренуються з опором, постава, плече.

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ORIGINAL SCIENTIFIC ARTICLE

PERFORMANCE OF HAND MOVEMENTS BY 3-5-YEAR-OLD GIRLS WITH DIFFERENT HANDEDNESS

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Abstract

The purpose of the study was to determine the state of performance of motor actions by girls with different handedness, which establishes a valid program for each age period of 3–5 years.

Materials and methods. Sixty girls took part in the study (compared with the right-, left-hand preference, and ambidexterity), each attended a preschool, and at the time of the study, the age of each was within the range of 3 years 5 months 2 days to 3 years 5 months and 29 days. To obtain the necessary data, motor actions determined by the current child development program in the preschool period were used. The quality of the girls' performance of each defined motor action was assessed, and the procedure took place in January of each new school year, that is, when the girls were first 3 years old, then 4 and 5 years old.

Results. Each age of the period of 3-5 years is marked by handedness-related features of development and manifestation of the motor function of girls when performing motor actions with their hands. At the same time, the majority of motor actions were performed by the girls of each sample with a score lower than the maximum score. This does not contribute to the intensive development of the motor function of girls, which differs from the task defined by the current program for preschool education institutions. Comparing the results of girls with different handedness, it was found that in most motor actions, the scores obtained for performance differ by a statistically significant amount, and at each age of the studied period.

Conclusions. Establishing features in the quality of performance of motor actions by girls with different handedness at each age period of 3-5 years is an important task. To increase the effectiveness of the educational process, the teacher needs to pay more attention to the study of those motor actions that were evaluated with low scores in girls with a certain preferred hand.

Keywords: girls, preschool age, hand asymmetry, motor function, development.

Introduction

In the preschool period, one of the main functions of a child is movement (Katzmarzyk & Silva, 2013). Therefore, educators pay considerable attention to the development of this function, especially during physical education, which is implemented in various forms of classes (Altavilla & Di Tore, 2016; Di Tore et al., 2016). At the same time, the basis of such classes is the content of the current program on child development in the preschool period (Bayer et al., 2014). This content provides motor actions that a child at a certain age of 3-6 years should master at the level of exploration of degrees of freedom, and preferably at the highest level, that is, at the level of capitalization of degrees of freedom (Bernstein, 1991; Schmidt & Lee, 2013).

However, at the current stage, the issue of the state of formation of children's abilities and skills in motor actions, which are determined by the specified current program, has not been sufficiently studied (Turvey & Fonseca, 2009).

The need for such information does not raise doubts, because it allows establishing the effectiveness of physical education in the formation of abilities, and skills in basic motor actions, as well as shortcomings and discrepancies between the required and real results.

On the other hand, the achievement of the goal of physical development of children in the preschool period is greatly facilitated by the implementation in practice of the provision on taking into account their characteristics (Malina et al., 2004; Kalinková, 2007). One of the effective criteria for individualization is the child's handedness (Iedynak et al., 2017; De Kovel et al., 2019; Güntürkün et al., 2020). This is due to the discrepancy in the development of motor function (Reiss, 2000), physical qualities (Galamanzhuk & Iedynak, 2016), psychosocial (Fisher, 2006; Iedynak & Galamanzhuk, 2010), physiological (Galamanzhuk et al., 2019) and some other performance abilities (Scharoun & Bryden, 2014; Ratini, 2021) of children in the preschool period.

At the same time, there are separated studies (Galamanzhuk, 2015) aimed at establishing peculiarities in the formation of motor skills and skills of children with different handedness in actions determined by the current program of their development in the preschool period as basic motor actions. In this regard, research on solving such a problem is relevant.

The purpose of the study was to determine the state of performance of motor actions by girls with different handedness determined by the current program for each age period of 3-5 years.

Materials and methods

Study participants

60 girls took part in the study: 20 each with the right (R), left (L) hand preference, and ambidexterity (A), each attending a preschool; the base of the study was a total of 15 preschool education institutions located in various cities of the western region of Ukraine. At the time of the beginning of the study, the age of all the girls ranged from 3 years 5 months 2 days to 3 years 5 months and 29 days. The main attention was focused on evaluating the girls' performance of each defined motor action. The results were recorded in January of each new academic year, that is, when the same girls were first 3 years old, then 4 and 5 years old.

Study organization

To obtain the necessary data, girls' performance of motor actions determined by the current program for each age period of 3-5 years was evaluated (Bayer et al., 2014). In particular, at the age of 3, such actions were: collecting balls, carrying them and putting them in a certain place (basket, box); rolling the ball on an inclined surface; rolling the ball with one or two hands to the teacher; rolling the ball with one or two hands under the arc; rolling the ball with one or two hands to each other, moving behind it during its roll; throwing the ball forward with both hands from below; throwing the ball forward from the chest; throwing the ball from behind the head; throwing the ball with both hands to the teacher; trying to catch the ball thrown by the teacher (distance 80-100 cm); throwing the ball over the rope stretched at the level of the child's chest (distance 1-1.5 m); throwing a ball (weight 100 g) at a horizontal target (basket, box) with the right and left hands from a distance of 1.3-1.5 m; throwing objects with the right and left hands at a distance; throwing a ball (weight 100 g) at a vertical target from a distance of 1-1.5 m. At the age of 4, girls performed the following motor actions: rolling the ball from the teacher to the child and back from a half-squat position (distance 1.5-2 m); rolling the ball between objects into the goal (width 50-60 cm, distance 1.5-2 m); throw the ball to the teacher with both hands from below and from the chest; catching the ball thrown by the teacher (distance – 1.5 m); throwing a ball (weight 100 g) at a horizontal target (basket, box) from a distance of 1.5-2.0 m; throwing the ball with both hands from the chest and from below into a basket (box) standing on the floor at a distance of 2 m; after throwing the ball on the floor, trying to catch it two or three times in a row; throwing a ball (weight 100 g) with the right and left hands at a vertical target (the height of the center of the target is 1.2 m above the floor, the distance to the target is 1.5-2.0 m); throwing a ball (weight 100 g) with the right and left hands at a distance (distance 3-5 m). At the age of 5, the girls' performance of the following motor actions was assessed: throwing a ball from one hand to another at a different pace; while standing still, hitting the ball on the floor (12 repetitions); throwing the ball to another child with two hands from the chest; throwing the ball from behind the head while standing or moving forward; catching the ball from different starting positions; catching the ball after bouncing off the floor; throwing and catch the ball with both hands (up to 20 times in a row); hitting the wall with a ball; throwing a stuffed ball (weight 1 kg) to another child; catching a stuffed ball; throwing a small ball into the ring at a height of 2.2 m from the floor; throwing objects (bag, ball) with the right and left hands for 3-5 m; throwing a ball (weight 100 g) at a moving target.

Recommendations (Grime & Wright, 2016) regarding the use of the Delphi Method were taken into account when evaluating the correct performance of motor actions by girls. Thus, 5 experts (2 Candidates of Science and 3 Doctors of Science) took part in the assessment, all of them specialists in physical education of children, and each of them has at least 10 years of experience. The girls were given 2 attempts to perform each motor action, and the best one was evaluated. But the girls did not know that their performance was being evaluated; this made it possible to minimize the excitement of the girls because it could affect the correct performance of the motor action (Thomas et al., 2011). The evaluation took place in two rounds: first, each expert evaluated the performance of all the girls' proposed motor actions, after that he studied the results of the questionnaires of his colleagues, video recordings of the girls' performance of the motor actions, and corrected (if he changed his mind) his evaluation results. After that, each expert received a final score, which was used to assess the girls' performance of a certain motor action; all five scores were taken into account when finding the average score for the performance of each motor action.

Experts took into account the recommendations for the assessment of motor development and function in preschool children (Tieman et al., 2005; Timmons et al., Pfeiffer, 2007). A system was chosen to provide the evaluation with one of the following points: "3" – the highest point, which indicates the achievement of the set goal due to the technically correct

performance of all movements in the action, which is evidenced by the absence of errors; "2" – the set goal is achieved because the motor action is performed correctly in general, except for one or two movements (parameters – movement trajectory, pace, etc.) that are reproduced with minor errors, that is, that do not affect the result; "1" – the set goal was not achieved due to difficulties in performing the motor action, although individual movements (parameters) were reproduced correctly.

The girls' hand preference was determined at the beginning of the study, taking into account the recommendations (Edlin et al., 2015) using the Short Form of Edinburgh Handedness Scale (Veale, 2014). The organization of the study took into account the provisions of the Helsinki Declaration of the World Medical Association (WMA-2013) on the ethical principles of medical research with human participants. The research protocol was approved by the ethics commission of Kamianets-Podilskyi National University.

Statistical analysis

All statistical analyzes were performed using SPSS Version 21. For each assessment, the following calculations were performed: arithmetic mean (M), standard deviation (SD), and Kolmogorov-Smirnov Test (KS). The last one made it possible to establish a difference from the normal distribution of individual values in each sample of girls (Vincent, 2005). In this regard, when comparing two averages, non-parametric tests were used, namely Mann-Whitney (U, Z values), and Wilcoxon (W values); the 0.05, 0.01, 0.001 levels of probability were used to indicate statistical significance (Khalafian, 2007).

Results

Before starting the analysis of the data obtained in experimental groups of girls in each age period of 3-5 years, the correspondence of the individual values distribution of each indicator to the normal distribution was established. It was found that in 3-year-old girls with different hand preferences, the distribution of individual results differed from the normal one (Table 1).

In addition, the obtained data indicated that girls from A and R performed for the highest score of "3" for one movement out of all 14 offered. Moreover, it was the same motor action, namely "to collect balls, carry them, and put them in a certain place." The same result was noted for girls from L, but they additionally scored a score of "3" for the performance of "rolling a ball with one or two hands to the teacher" and "throwing objects with the right and left hands at a distance." But the former also had the least number of motor actions, the performance of which was evaluated with the lowest score "1". There were 6 such actions, while the girls from A – 9, from R – 10.

Comparing the scores of these 3-year-old girls with different hand preferences for performing the specified 14 motor actions, the following was found. In girls from A and L, as well as from L and R, 8 grades differed by a statistically significant value, while in girls from A and R – 6 (Table 2).

In all cases, such a feature was noted for the score for performing the motor action "rolling the ball with one or two hands to the teacher", because it was the highest in girls with L (3 points), while it was significantly lower in R, namely 2.45±0.6 points ($p = 0.001$), in A the smallest, – 1.9±0.85 (respectively, $p = 0.013$ and $p = 0.001$).

At four years old, the distribution of the obtained data differed from the normal one (Table 3).

The following was also noted: according to the obtained data, out of all 9 motor actions, the highest score of "3" was evaluated for the performance of only one action and only by girls from A, namely "throw a ball weighing 100 g with the right and left hands at a distance (a distance of at least

Table 1. Results of performance of motor actions by 3-year-old girls with different handedness

N	Motor action	girls with A (n=20)			girls with A (n=20)			girls with R (n=20)		
		M	SD	K-S, p	M	SD	K-S, p	M	SD	K-S, p
1	Collect balls, carry them and put them in a certain place (basket, box)	3.00	0	<0.01	3.00	0	<0.01	3.00	0	<0.01
2	Roll the ball on an inclined surface	1.85	0.37	<0.01	1.75	0.44	<0.01	1.25	0.64	<0.01
3	Roll the ball with one or two hands towards the teacher	1.90	0.85	<0.01	3.00	0	<0.01	2.45	0.60	<0.01
4	Roll the ball with one or two hands under the arc	1.00	0	<0.01	0.75	0.44	<0.01	0.8	0.52	<0.01
5	Roll the ball with one or two hands to each other, moving behind it during its roll	1.55	1.10	<0.01	1.00	0	<0.01	0.9	0.79	<0.01
6	Throw the ball forward with both hands from below	2.25	0.91	<0.01	2.25	0.85	<0.01	1.35	0.93	<0.01
7	Throw the ball forward from the chest	2.10	0.64	<0.01	2.50	0.51	<0.01	1.65	0.88	<0.01
8	Throw the ball from behind the head	2.05	0.94	<0.01	2.25	1.33	<0.01	1.55	0.94	<0.01
9	Throw the ball with both hands to the teacher	1.85	0.87	<0.01	2.25	0.85	<0.01	2.5	0.60	<0.01
10	Try to catch the ball thrown by the teacher (distance 80-100 cm)	1.20	1.00	<0.01	1.50	1.15	<0.01	1.65	0.49	<0.01
11	Throw the ball over the rope stretched at the level of the child's chest (distance 1-1.5 m)	1.00	0.56	<0.01	1.50	0.89	<0.01	0.8	0.89	<0.01
12	Throw the ball (weight 100 g) at a horizontal target with the right and left hands (distance - 1.3-1.5 m)	1.80	0.83	<0.01	1.25	0.44	<0.01	0.95	0.89	<0.01
13	Throw objects with the right and left hands at a distance	2.70	0.47	<0.01	3.00	0	<0.01	2.65	0.59	<0.01
14	Throw a ball (weight 100 g) at a vertical target from a distance of 1-1.5 m	1.80	0.83	<0.01	2.50	0.51	<0.01	1.8	0.95	<0.01

Table 2. Comparison of the results of performance by 3-year-old girls motor actions with different handedness

Motor action (N)	Mean Rank		Sum of Rank		U	W	Z	Asymp.Sig (2-talled)
	A (n=20)	L (n=20)	A (n=20)	L (n=20)				
1	20.50	20.50	410.0	410.0	200.0	410.0	.000	1.000
2	21.50	19.50	430.0	390.0	180.0	390.0	-.781	0.435
3	13.50	27.50	270.0	550.0	60.0	270.0	-4.480	0.000
4	23.00	18.00	460.0	360.0	150.0	360.0	-2.360	0.018
5	27.50	13.50	550.0	270.0	60.0	270.0	-4.512	0.000
6	20.63	20.38	412.5	407.5	197.5	407.5	-.074	0.941
7	17.25	23.75	345.0	475.0	135.0	345.0	-1.190	0.047
8	18.88	22.13	377.5	442.5	167.5	377.5	-.999	0.318
9	18.00	23.00	360.0	460.0	150.0	360.0	-1.443	0.149
10	19.00	22.00	380.0	440.0	170.0	380.0	-.840	0.401
11	16.25	24.75	325.0	495.0	115.0	325.0	-2.481	0.013
12	24.13	16.88	482.5	337.5	127.5	337.5	-2.247	0.025
13	17.50	23.50	350.0	470.0	140.0	350.0	-2.623	0.009
14	15.75	25.25	315.0	505.0	105.0	315.0	-2.751	0.006
	A (n=20)	R (n=20)	A (n=20)	R (n=20)				
1	20.50	20.50	410.0	410.0	200.0	410.0	.000	1.000
2	21.50	19.50	430.0	390.0	180.0	390.0	-.781	0.435
3	13.50	27.50	270.0	550.0	60.0	270.0	-4.480	0.000
4	23.00	18.00	460.0	360.0	150.0	360.0	-2.360	0.018
5	27.50	13.50	550.0	270.0	60.0	270.0	-4.512	0.000
6	20.63	20.38	412.5	407.5	197.5	407.5	-.074	0.941
7	17.25	23.75	345.0	475.0	135.0	345.0	-1.190	0.047
8	18.88	22.13	377.5	442.5	167.5	377.5	-.999	0.318
9	18.00	23.00	360.0	460.0	150.0	360.0	-1.443	0.149
10	19.00	22.00	380.0	440.0	170.0	380.0	-.840	0.401
11	16.25	24.75	325.0	495.0	115.0	325.0	-2.481	0.013
12	24.13	16.88	482.5	337.5	127.5	337.5	-2.247	0.025
13	17.50	23.50	350.0	470.0	140.0	350.0	-2.623	0.009
14	15.75	25.25	315.0	505.0	105.0	315.0	-2.751	0.006
	L (n=20)	R (n=20)	L (n=20)	R (n=20)				
1	20.50	20.50	410.0	410.0	200.0	410.0	.000	1.000
2	25.25	15.75	505.0	315.0	105.0	315.0	-2.898	0.004
3	25.50	15.50	510.0	310.0	100.0	310.0	-3.592	0.000
4	20.13	20.88	402.5	417.5	192.5	402.5	-.261	0.794
5	22.00	19.00	440.0	380.0	170.0	380.0	-1.113	0.266
6	25.50	15.50	510.0	310.0	100.0	310.0	-2.849	0.004
7	26.00	15.00	520.0	300.0	90.0	300.0	-3.168	0.002
8	24.25	16.75	485.0	335.0	125.0	335.0	-2.169	0.030
9	19.13	21.88	382.5	437.5	172.5	382.5	-.822	0.411
10	19.75	21.25	395.0	425.0	185.0	395.0	-.433	0.655
11	24.75	16.25	495.0	325.0	115.0	325.0	-2.478	0.013
12	23.00	18.00	460.0	360.0	150.0	360.0	-1.518	0.129
13	23.50	17.50	470.0	350.0	140.0	350.0	-2.619	0.009
14	24.75	16.25	495.0	325.0	115.0	325.0	-2.487	0.013

Note: Mann-Whitney U, Wilcoxon W; a reliably significant difference between the two means is highlighted in color

3-5 m)". As for the lowest score, it was used to evaluate the performance of 5 motor actions by girls with A, and L and the performance of 6 actions by girls with R.

Other data related to the comparison of scores obtained for the performance of each of the 9 specified motor actions (Table 4).

At 5 years, the distribution of most of the obtained data differed from normal, and exceptions were characteristic of each group of girls (Table 5).

We received data that indicated the following: out of all 13 motor actions, the performance of only one action by girls from A and R was rated the highest.

Table 3. Results of performance of motor actions by 4-year-old girls with different handedness

N	Motor action	girls with A (n=20)			girls with L (n=20)			girls with R (n=20)		
		M	SD	K-S, p	M	SD	K-S, p	M	SD	K-S, p
1	Roll the ball from the teacher to the child and back from a half-squat position (1.5-2 m)	2.05	0.51	<0.01	1.50	0.89	<0.01	2.15	0.67	<0.10
2	Roll the ball between objects into the goal (width 60-50 cm, distance 1.5-2 m)	2.10	0.85	<0.15	1.75	0.85	<0.05	1.85	0.99	<0.15
3	Throw the ball to the teacher with both hands from below and from the chest	2.10	1.02	<0.05	2.50	0.51	<0.05	2.40	0.68	<0.05
4	Catch the ball thrown by the teacher (distance - 1.5 m)	1.85	0.88	<0.10	1.75	0.85	<0.05	1.65	1.09	>0.20
5	Throw the ball (weight 100 g) at a horizontal target from a distance of 1.5-2.0 m	0.85	067	<0.10	2.25	0.85	<0.05	1.85	0.99	>0.20
6	Throw the ball with both hands from the chest and from below into a basket standing on the floor (distance - 2 m)	1.45	0.76	<0.01	2.00	1.03	<0.05	1.80	0.89	>0.20
7	After throwing the ball on the floor, try to catch it two or three times in a row	1.00	0.79	>.20	0.50	0.51	<0.05	0.75	1.02	<0.05
8	Throw the ball (weight 100 g) with the right and left hands at a vertical target (the height of the center of the target is 1.2 m above the floor, the distance to the target is 1.5 -2.0 m	1.00	0.79	>.20	1.25	0.44	<0.01	1.30	0.86	<0.10
9	Throw a ball (weight 100 g) with the right and left hands at a distance (a distance of at least 3-5 m)	3.00	0	<0.01	2.25	0.44	<0.01	2.50	0.61	<0.05

Table 4. Comparison of the results of performance by 4-year-old girls motor actions with different handedness

Motor action (N)	Mean Rank		Sum of Rank		U	W	Z	Asymp. Sig (2-talled)
	A (n=20)	L (n=20)	A (n=20)	L (n=20)				
1	25.13	15.88	502.5	317.5	107.5	317.5	-2.693	0.007
2	22.75	18.25	455.0	365.0	155.0	365.0	-1.297	0.195
3	18.75	22.25	375.0	445.0	165.0	375.0	-1.057	0.290
4	21.13	19.88	422.5	397.5	187.5	397.5	-0.365	0.715
5	13.00	28.00	260.0	560.0	50.00	260.0	-4.254	0.000
6	17.75	23.25	355.0	465.0	145.0	355.0	-1.718	0.046
7	24.00	17.00	480.0	340.0	130.0	340.0	-2.063	0.039
8	18.75	22.25	375.0	445.0	165.0	375.0	-1.068	0.286
9	28.00	13.00	560.0	260.0	50.00	260.0	-4.837	0.000
	A (n=20)	R (n=20)	A (n=20)	R (n=20)				
1	19.58	21.43	391.5	428.5	181.5	391.5	-0.593	0.553
2	21.90	19.10	438.0	382.0	172.0	382.0	-0.803	0.422
3	19.20	21.80	384.0	436.0	174.0	384.0	-0.771	0.441
4	21.33	19.68	426.5	393.5	183.5	393.5	-0.466	0.641
5	14.85	26.15	297.0	523.0	87.0	297.0	-3.205	0.000
6	18.00	23.00	360.0	460.0	150.0	360.0	-1.483	0.138
7	22.65	18.35	453.0	367.0	157.0	367.0	-1.239	0.215
8	18.80	22.20	376.0	444.0	166.0	376.0	-0.982	0.326
9	25.00	16.00	500.0	320.0	110.0	320.0	-3.354	0.000
	L (n=20)	R (n=20)	L (n=20)	R (n=20)				
1	15.88	25.13	317.5	502.5	107.5	317.5	-2.686	0.007
2	19.88	21.13	397.5	422.5	187.5	397.5	-0.362	0.717
3	21.00	20.00	420.0	400.0	190.0	400.0	-0.305	0.760
4	20.75	20.25	415.0	405.0	195.0	405.0	-0.141	0.888
5	22.75	18.25	455.0	365.0	155.0	365.0	-1.288	0.198
6	21.50	19.50	430.0	390.0	180.0	390.0	-0.581	0.561
7	20.00	21.00	400.0	420.0	190.0	400.0	-0.302	0.763
8	20.38	20.63	407.5	412.5	197.5	407.5	-0.079	0.937
9	17.88	23.13	357.5	462.5	147.5	357.5	-1.644	0.100

Note: Mann-Whitney U, Wilcoxon W; a reliably significant difference between the two means is highlighted in color

Table 5. Results of performance of motor actions by 5-year-old girls with different handedness

N	Motor action	girls with A (n=20)			girls with L (n=20)			girls with R (n=20)		
		M	SD	K-S, p	M	SD	K-S, p	M	SD	K-S, p
1	Throw the ball from one hand to the other at different paces	2.00	0.56	<0.05	2.00	1.03	<0.05	2.10	0.72	<0.15
2	Hit the ball on the floor while standing still (12 repetitions),	1.95	1.10	>0.20	1.50	0.89	<0.01	1.35	0.81	<0.05
3	Throw the ball with the other to the child with two hands from the chest,	2.15	0.67	<0.10	2.25	0.85	<0.05	2.05	0.76	>0.20
4	Throw the ball from behind the head while standing or moving forward	1.75	1.07	>0.20	2.50	0.89	<0.01	2.25	0.85	<0.05
5	Catch the ball from different starting positions	1.70	0.73	<0.10	1.00	0.73	<0.15	1.15	0.49	<0.01
6	Catch the ball after bouncing off the floor	1.80	1.01	<0.10	1.75	0.85	<0.05	2.10	0.79	>0.20
7	Throw and catch the ball with both hands (up to 20 times in a row	1.30	0.73	<0.10	2.25	0.85	<0.05	2.05	0.89	<0.15
8	Hit the wall with the ball	1.85	0.67	<0.10	2.75	0.44	<0.01	2.20	0.77	<0.15
9	Throw the stuffed ball (weight 1 kg) to another child	1.70	0.47	<0.01	2.50	0.51	<0.05	1.85	0.88	>0.20
10	Catch a stuffed ball	2.15	0.37	<0.01	2.00	0.73	<0.15	1.80	1.01	>0.20
11	Throw a small ball into a ring at a height of 2.2 m from the floor	2.10	1.02	<0.01	1.50	1.15	>0.20	1.45	0.69	<0.01
12	Throw objects (bag, ball) with the right and left hands at 3-5 m	3.00	0	<0.01	2.75	0.44	<0.01	3.00	0	<0.01
13	Throw a ball (weight 100 g) at a moving target	1.80	0.83	<0.01	1.00	0	<0.01	1.45	0.94	<0.10

When comparing grades, it was found that 7 grades differed by a statistically significant amount for girls from A and L, 4 grades for girls from A and R, and 4 for girls with L and R – 3 (Table 6).

Discussion

During the preschool period, the formation and further development of the child's motor function take place (Wilmore et al., 2012; Katzmarzyk & Silva, 2013). Therefore, in this period, one of the defining tasks for teachers, pediatricians, and psychologists is to ensure a targeted impact on the child's motor function (Herasymchuk et al., 2014; Iedynak & Galamanzhuk, 2017). For this, physical exercises are used, which, as well as motor actions used in everyday life, is necessary to teach the child (Altavilla & Di Tore, 2016; Galamanzhuk & Iedynak, 2016). Therefore, considerable attention is paid to this issue in the preschool period and the search for effective criteria for the individualization of education and child development is carried out (Galamanzhuk et al., 2019). One of the promising criteria is the handedness of each child (Güntürkün et al., 2020; Ratini, 2021).

The data obtained at each age testified to the existence of peculiarities in the quality of performance of motor actions by girls with different handedness. So, at 3 years old, the result was as follows: for the highest score of "3", girls from A and R performed one motor action each, girls from L – three, for the lowest score of "1" – respectively 9, 10 and 6 actions out of all 14 offered. When comparing the grades, their discrepancy was found (at the level of $p = 0.05 \div 0.0001$), namely: the girls from L had 8 of these when compared with the grades of girls from A and R, as well as 6 – when comparing the grades in the last two samples.

At the age of 4, the comparison of grades showed that girls with A significantly (at the level of $p = 0.05 \div 0.001$) differed by 5 and 2 grades from those obtained by girls with L and R; in the latter, the assessment for the performance of one motor action differed.

At the age of 5, by comparison, the following was established: in girls with A, 7 and 4 grades differed (at the level of $p = 0.05 \div 0.001$) from those obtained by girls with L and R; in the latter, the score for performing 3 motor actions differed.

One of the reasons for this result is the connection of handedness in the human motor cortex, which is quite strong because $r = -0.76$ ($p = 0.01$) (Volkmann et al, 1998). At the same time, the expansion of the hand motor cortex in the dominant hemisphere may provide extra space for the cortical encoding of a greater motor skill repertoire of the preferred hand. As noted by (Gainotti, 2015), manual experience acquired during tool manipulation can influence the hemispheric representation of tools and other artifacts.

The data of our study confirm that the performance of motor actions, which children learned during the school year, contributed to an increase in the level of motor function development. But the results of girls with different handedness were not the same, which was associated with a complex of characteristics. Some of the main ones were satisfactorily explained as follows: with an increase in the complexity of the motor action, the volume of brain areas that are sequentially involved in its implementation increases, and contralateral and ipsilateral activations also increase; it provides intensive development of motor function (Gut et al., 2007). Important to the above is also the data that, regardless of handedness, when performing a motor action with the non-leading hand, both hemispheres are involved in this activity (Scharoun & Bryden, 2014; De Kovel et al., 2019).

In addition, the obtained data were associated with differences in the development of the physical condition of children with different handedness (Galamanzhuk, 2015).

In a practical aspect, the obtained data will contribute to increasing the results of teaching children new motor actions. Also, these data are important, because they complement the idea of the manifestation of different degrees of freedom in the functioning of cortical structures of children with different handedness.

We see the prospect of further research in obtaining information related to the selection of flexible, diverse,

Table 6. Comparison of the results of performance by 5-year-old girls motor actions with different handedness

Motor action (N)	Mean Rank		Sum of Rank		U	W	Z	Asymp. Sig (2-talled)
	A (n=20)	L (n=20)	A (n=20)	L (n=20)				
1	20.50	20.50	410.0	410.0	200.0	410.0	0.000	1.000
2	23.13	17.88	462.5	357.5	147.5	357.5	-1.521	0.128
3	19.50	21.50	390.0	430.0	180.0	390.0	-0.582	0.561
4	16.38	24.63	327.5	492.5	117.5	327.5	-2.440	0.015
5	25.00	16.00	500.0	320.0	110.0	320.0	-2.630	0.009
6	21.25	19.75	425.0	395.0	185.0	395.0	-0.426	0.670
7	14.88	26.13	297.5	522.5	87.5	297.5	-3.195	0.000
8	13.75	27.25	275.0	545.0	65.0	275.0	-3.980	0.000
9	14.00	27.00	280.0	540.0	70.0	280.0	-4.019	0.000
10	21.63	19.38	432.5	387.5	117.5	387.5	-0.736	0.461
11	23.5	17.5	470.0	350.0	140.0	350.0	-1.721	0.095
12	23.0	18.00	460.0	360.0	150.0	360.0	-2.360	0.018
13	26.00	15.00	520.0	300.0	90.0	300.0	-3.797	0.000
	A(n=20)	R(n=20)	A(n=20)	R(n=20)				
1	20.30	20.70	406.0	414.0	196.0	406.0	-0.115	0.909
2	24.03	16.98	480.5	339.5	129.5	339.5	-1.989	0.047
3	21.20	19.80	424.0	396.0	186.0	396.0	-0.413	0.680
4	17.88	23.13	357.5	462.5	147.5	357.5	-1.497	0.134
5	24.53	16.48	490.5	329.5	119.5	329.5	-2.503	0.012
6	19.05	21.95	381.0	439.0	171.0	381.0	-0.832	0.405
7	16.18	24.83	323.5	496.5	113.5	323.5	-2.471	0.013
8	17.90	23.10	358.0	462.0	148.0	358.0	-1.519	0.129
9	19.40	21.60	388.0	432.0	178.0	388.0	-0.663	0.507
10	22.40	18.60	448.0	372.0	162.0	448.0	-1.152	0.249
11	23.88	17.13	477.0	342.5	132.5	477.0	-2.044	0.041
12	20.50	20.50	410.0	410.0	200.0	410.0	0.000	1.000
13	22.23	18.78	444.5	375.5	165.5	375.5	-0.984	0.325
	L(n=20)	R(n=20)	L(n=20)	R(n=20)				
1	20.00	21.00	400.0	420.0	190.0	400.0	-0.289	0.773
2	20.88	20.13	417.5	402.5	192.5	402.5	-0.239	0.811
3	22.00	19.00	440.0	380.0	170.0	380.0	-0.866	0.386
4	22.38	18.63	447.5	372.5	162.5	372.5	-1.180	0.238
5	19.38	21.63	387.5	432.5	177.5	387.5	-0.707	0.480
6	18.13	22.88	362.5	457.5	152.5	362.5	-1.365	0.172
7	21.75	19.25	435.0	385.0	175.0	385.0	-0.726	0.468
8	24.50	16.50	490.0	330.0	120.0	330.0	-2.458	0.014
9	21.38	19.63	427.5	392.5	182.5	392.5	-0.507	0.612
10	21.50	19.50	430.0	390.0	180.0	390.0	-0.572	0.567
11	20.75	20.25	415.0	405.0	195.0	405.0	-0.144	0.886
12	18.00	23.00	360.0	460.0	150.0	360.0	-2.360	0.018
13	17.00	24.00	340.0	480.0	130.0	340.0	-2.196	0.028

Note: Mann-Whitney U, Wilcoxon W, the particularly significant difference between the two means is highlighted in color

non-programmed strategy options for the implementation of various activities (Kuhl & Kazen, 2008; Porac, 2016).

Conclusions

At each age of 3-5 years, the development and manifestation of the motor function of girls when performing motor actions with their hands is marked by features due to handedness. At the age of 3, girls with A and R had the highest score for performing one motor action, girls with L had three, and the lowest score was 9, 10, and 6 of all 14 actions, respectively. At the age of 4, for the highest score, girls from A performed only one motor action, girls from L and R – none, for the lowest score – 5, 5, and 6 motor actions out of all 9 offered. At the age of 5, girls from A and R performed one motor action each for the highest score, girls from L –none, for the lowest score – 8, 6, and 5 motor actions out of all 13 offered.

When comparing the scores obtained by girls with different handedness, in most cases a statistically significant (at the level of $p < 0.05 \div 0.0001$) discrepancy was found in each age period of 3-5 years.

To increase the effectiveness of the educational process, the teacher needs to pay more attention to the study of motor

actions, the performance of which was evaluated by girls with a certain preferred hand with low scores.

Conflict of interest

The authors state no conflict of interest.

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СТАН ВИКОНАННЯ РУХІВ ДІВЧАТКАМИ 3-5 РОКІВ ІЗ РІЗНОЮ МАНУАЛЬНОЮ АСИМЕТРІЄЮ РУХОВИХ ДІЙ РУКАМИ

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Реферат. Стаття: 10 с., 6 табл., 36 джерел.

Мета дослідження полягала у визначенні стану виконання дівчатками з різною мануальною асметрією рухових дій руками, що встановлює чинна програма для кожного віку періоду 3-5 років.

Матеріали та методи. У дослідженні взяло участь 60 дівчаток (порівно з правою, лівою домінуючою рукою та амбідекстрією), кожна відвідувала заклад дошкільної освіти, а на момент початку дослідження вік кожної знаходився в межах 3 років 5 місяців 2 днів до 3 років 5 місяців і 29 днів. Для одержання необхідних даних було використано рухові дії, що визначені чинною програмою розвитку дитини у дошкільний період. Оцінювали якість виконання дівчатками кожної визначеної рухової дії, процедура відбувалася у січні кожного нового навчального року, тобто коли дівчаткам було спочатку 3 роки, потім 4 та 5 років.

Результати. Кожний вік періоду 3-5 років відзначається зумовленими мануальною асметрією особливостями розвитку і вияву моторної функції дівчаток при виконанні рухових дій руками. При цьому, більшість рухових дій виконувалася дівчатками кожної вибірки на нижчий від максимального бал. Це не сприяє інтенсивному розвитку моторної функції дівчаток, що відрізняється від завдання, яке визначено чинною програмою для закладів дошкільної освіти. Порівнюючи результати дівчаток із різною мануальною асметрією виявили, що у більшості рухових дій одержані за виконання оцінки відрізняються на статистично значущу величину, причому в кожному віці досліджуваного періоду.

Висновки. Встановлення особливостей у якості виконання дівчатками з різною мануальною асиметрією рухових дій руками в кожному віці періоду 3-5 років є важливим завданням. Для збільшення дієвості освітнього процесу педагогу необхідно підвищити увагу до вивчення тих рухових дій, які в дівчаток із певною мануальною асметрією були оцінені низькими балами.

Ключові слова: дівчатка, дошкільники, мануальна асиметрія, моторна функція, розвиток.

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RELATION BETWEEN PHYSICAL ABILITIES AND FUNDAMENTAL MOTOR SKILLS IN PRESCHOOLERS

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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

The aim of this study was to determine the interconnection between physical abilities and fundamental motor skills in preschool children. The aim was also to determine the differences in the observed variables in relation to gender.

Materials and methods. The testing successfully included 52 preschool children, 30 boys and 22 girls. Five tests of physical ability (modified agility "T" (MAT) test, broad jump test, standing balance test, squat test and sit up test) were used, and fundamental motor skills were assessed with the Test of Gross Motor Development, 3rd edition (TGMD-3). One-way ANOVA was used to determine the effects of gender on results in physical abilities and fundamental motor skills. The Pearson product-moment correlation coefficient was used to determine the relation between physical abilities and fundamental motor skills.

The results of this work indicated, in most cases, a moderate and significant correlation of fundamental motor skills and parameters of physical abilities both in the total sample and also individually in boys and girls ($p \leq 0.05$). A significant difference in almost all variables of physical abilities and fundamental motor skills was noted in favor of boys ($p \leq 0.05$ and $p \leq 0.01$), except for the Standing balance test which indicated that there were not considerable differences between the sexes ($p > 0.05$).

Conclusions. So it can be concluded that the information obtained can lead physical education educators to better understanding of the relations between motor status variables, which further enables them to work effectively with children who will, by virtue of a proper physical development and education, become and remain physically active throughout their life.

Keywords: gross motor development, children, agility, strength, balance.

Introduction

Motor development can be defined as the gradual acquisition of control and/or the use of more and less muscle mass. Due to the interaction of the nervous and muscular systems, which enables the child to skillfully navigate in space, manipulate objects and explore the world around him, it is often called "perceptual-motor development", as well as "physical or motor coordination" (Williams & Monsma, 2006). Gross motor development in early childhood is important for achieving greater interaction with the environment (Kit et al., 2017) and is recognized as a means of assessing the overall level of child development during the earliest months and years of their life (Dewey et al., 2002). In addition to acquiring and improving the level of physical abilities, motor development is also characterized by mastering motor skills, which begins from the earliest childhood and lasts until adulthood (Milenković, 2021).

Even O'Brien & Hayes (1994) and Williams (1983) considered the period from 2 to 6 years of one's life to be the "golden age" of motor development, and modern research recognizes it as being a valid assertion (Figueroa & An, 2017; Goodway, Ozmun & Gallahue, 2021; Pedersen & Hansen, 2022). In the course of the aforementioned period, children create a basis for the functioning of the body for the later stage of development through the acquisition of a large number of fundamental locomotor and manipulative skills, because the early years are the basis for neuromuscular coordination that each individual uses throughout life to engage in many mental, social, emotional and recreational dimensions of life (Williams & Monsma, 2006). Locomotor skills are the movement of the body through space and include walking, running, jumping, galloping,

climbing, descending, sliding, while manipulative are the skills of controlling objects and include throwing, catching, hitting, kicking, shooting, etc. (Haywood & Getchell, 2020).

Motor skills improve in the established order from the most fundamental to the most complex voluntary movements that keep improving by constant exercise (Milenković, 2021). The learning process and the basis for the development of motor skills are closely connected with play and physical activity in which different motor skills are used (Cech & Martin, 2012; Riethmuller, Jones & Okely, 2009). Children have a natural tendency to study their body and the world around them, while developing their motor skills (Williams & Monsma, 2006). Most developmental changes in motor performance over time are considered a product of maturity and general interaction with the environment and occur linearly (Haubenstricker & Seefeldt, 1986), however, it has been shown that children can learn motor skills if appropriate training programs are implemented and if sufficient exercise time is provided (Zipp & Gentile, 2010; Brown, 2010; Palmer et al., 2020), because motor skills are significantly correlated with cognitive development factor (Iivonen & Sääkslahti, 2014; Van der Fels et al., 2015; Gandotra et al., 2022).

The factors which motor skills depend on concern the growth and development of the body, physical and cardiorespiratory abilities required to perform motor skills (Haapala, 2013), then the maturation of the central nervous system (Pecuch et al., 2021), talent (Faber et al., 2020) and at the end on constant physical activity (Iivonen et al., 2013), ie. practicing and improving motor skills (Milenković, 2021). The dynamics of changes in motor skills is not the same in every child of the same age, often due to the amount of time the child has spent practicing a certain skill, which affects the lower or higher level of motor competence and ability to participate in physical activity (Hands, 2008). In terms of overcoming these differences, physical education as an organized physical exercise offers a variety of contents that allow children to try on different activities, meeting their needs for movement and expanding the range of their motor skills and quality of their performance, which makes them ready for everyday life (Mostafavi et al., 2013; Lorås, 2020).

The proven reliable and valid Test of Gross Motor Development (TGMD) by D.A Ulrich is often used for the research purposes to assess motor development in children. After the first edition of the test (Ulrich & Sanford, 1985) which had the task of dealing with shortcomings in instruments for assessing motor behavior (lack of standardization, difficulties in identifying specific aspects of movement, impossibility of mutual comparison), a second edition appeared (Ulrich, 2000) as an improvement of the tests from the first edition with the criterion and normative standardization (Kit et al., 2017). An even newer third edition of this test (Ulrich, 2016) also allows a successful assessment of motor development intended for children from 3 to 10 years of age, both in healthy children (Maeng, Webster & Ulrich, 2016; Rintala, Sääkslahti & Iivonen, 2017; Mohammadi et al., 2017), and in children with certain developmental disabilities (Allen et al., 2017). Editions of this test provide an effective tool for assessing fundamental motor skills. There is a relatively acceptable matching between TGMD-2 and TGMD-3 in the obtained raw scores and somewhat less strength for percentile scores, which indicates similarity, but not interchangeability of these editions (Palmer et al., 2021).

This research aims to determine the relationship between physical abilities and fundamental motor skills in preschool children. It is also necessary to determine the differences in the observed variables in relation to gender.

Materials and methods

Participants

60 preschool children took the test. The testing was successfully completed by 52 children, 30 boys and 22 girls (Table 1). The written permission of the parents of all children to participate in this research was obtained, as well as the consent of the children themselves. The research was organized in accordance with the recommendations for clinical research given by the World Health Organization (WHO) within the Helsinki Declaration (2013).

Measuring instruments

Physical Fitness. Five tests were used in the testing, which have so far been found to be reliable and valid for assessing physical abilities (tests of agility, explosive and repetitive strength and balance). A closer look at the procedures and the scoring systems can be found on the Topend Sports website (Wood, 2008):

- Modified agility „T“ (MAT) test (Sassi, et al., 2009);
- Broad jump test (Castro-Piñero et al., 2010);
- Standing balance test (Šarabon & Omejec, 2007);
- Squat test (30sec) (Blazevich, Gill & Newton, 2002);
- Sit up test (30sec) (Ojeda, Maliqueo & Barahona-Fuentes, 2020).

The Witty Timing System (Microgate, Bolzano, Italy) was used to measure the time when performing the Agility T test. A digital stopwatch was used to measure time when performing other physical fitness tests. A measuring tape was used for the Broad jump test.

Fundamental Motor Skills. The Test of Gross Motor Development – 3rd edition (TGMD-3) (according to Ulrich, 2016) was used in the testing. TGMD-3 is a criterion-based and normatively standardized test that assesses the fundamental motor skills of children aged 3 to 10. The TGMD-3 consists of a locomotor and ball skills subtest. The Locomotor subtest measures fundamental motor skills that require fluent and coordinated movement of the child, while the Ball Skills subtest measures fundamental motor skills that demonstrate the movements of efficient throwing, catching and striking. Each motor skill is assessed through three to five criteria based on whether the criterion is met (1 point) or not (0 points). For each motor skill, two attempts are evaluated, after which the points obtained for each criterion within the performed motor skill are added up. The maximum score that a respondent can achieve on the TGMD-3 is a total of 100 points, 46 points on the locomotor subtest and 54 points on the ball skills subtest. The usual duration of TGMD-3 is 15-20 minutes per the testee.

Testing procedure

Testing of physical abilities and fundamental motor skills was performed by trained investigators in the gym of the preschool institution. Two days earlier, a trial test was organized to prepare the children for the complete

procedure they would undergo during the experimental testing. A warm-up of 15 minutes was performed before each test. Each of the tests of physical abilities was repeated three times, so the best result was taken for further analysis. After completing each test and before moving on to the next, there was a 5–8 minutes break in order to avoid negative effects on testing caused by fatigue. TGMD-3 was performed according to the description presented earlier.

When it comes to assessing fundamental motor skills, before the implementation of TGMD-3, investigators were specially trained to administer the test. In order to ensure the interrater-reliability of TGMD-3, two investigators that underwent a standardized measurement procedure, independently assessed the performance of the subjects. After completing the testing of physical abilities and fundamental motor skills, data processing began.

Statistical analysis

In addition to the descriptive parameters (Mean ± St.Dev) for all variables, the one-way ANOVA was used to determine the effect of gender on scores in physical abilities and fundamental motor skills. The Pearson product-moment correlation coefficient was used as well to determine the relation between physical abilities and fundamental motor skills. The Pearson product-moment correlation coefficient can be interpreted as the effect size and it indicates the strength of the relation between the two variables. According to Cohen's (1988), the correlation coefficient of .10 and above is considered a weak or small correlation, of .30 and over represents a moderate correlation, and of .50 or over represents a strong or large correlation. Statistical significance was established at the levels of $p \leq 0.05$ and $p \leq 0.01$.

Results

The following chapter presents the obtained research results in change of direction speed, explosive strength and running speed (Tables 1 and 2), as well as their interpretation.

Table 1. Descriptives (Mean±St.Dev) and difference between genders

Indicator	Total (n=52)	Boys (n=30)	Girls (n=22)
Age (y)	5.74 ± 0.9	5.46 ±0.5	5.83 ±0.9
TGDM-3 (raw score)	65.50 ± 10	69.93 ±8.4[b]	59.45 ±8.7
Locomotor skills subtest (raw score)	29.31 ± 5.8	32.03 ±4.6[b]	25.59 ±5.3
Ball skills subtest (raw score)	36.29 ± 4.9	38.07 ±4.5[b]	33.86 ±4.3
MAT test	9.61 ± 0.3	9.41 ±0.3[b]	9.88 ±0.2
Broad jump test	113.06 ± 8.79	117.10 ±7.4[a]	107.55 ±7.6
Standing balance test	41.04 ± 4.3	40.19 ±5.3	42.18 ±1.8
Squat test	21.15 ± 1.7	21.63 ±1.8[a]	20.50 ±1.4
Sit up test	10.08 ±2.4	11.17 ±2.3[b]	8.59 ±1.9

[a]Significance between boys and girls $p \leq 0.05$;
[b]Significance between boys and girls $p \leq 0.01$; TGDM-3 – Test of Gross Motor Development – 3rd edition

Table 1 contains descriptive data of all variables of this study presented in total and by gender. Variables include total TGMD-3 score, locomotor subtest score, ball skills subtest score, and physical ability tests (MAT test, Broad jump test, Standing balance test, Squat test and Sit up test). If the difference between boys and girls is observed, significantly better results of boys in relation to girls can be determined for almost all variables: TGMD-3 ($F = 19.03$, $p < 0.001$), locomotor subtest ($F = 22.05$, $p < 0.001$), ball skills subtest ($F = 11.43$, $p < 0.001$), MAT test ($F = 45.73$, $p < 0.001$), Broad jump test ($F = 20.81$, $p < 0.001$), Squat test ($F = 5.89$, $p = 0.019$) and Sit up test ($F = 18.19$, $p < 0.001$). Significant differences between boys and girls were not observed in the Standing balance test ($F = 2.86$, $p = 0.097$).

Table 2. Pearson correlation coefficient between TGDM-3 scores (total and by subtests) and physical fitness by gender

Indicator	MAT test		
	Total	Boys	Girls
TGDM-3	-0.759[b]	-0.628[b]	-0.797[b]
Locomotor skills subtest	-0.767[b]	-0.606[b]	-0.724[b]
Ball skills subtest	-0.666[b]	-0.613[b]	-0.646[b]
Broad jump test			
TGDM-3	0.767[b]	0.637[b]	0.784[b]
Locomotor skills subtest	0.744[b]	0.615[b]	0.636[b]
Ball skills subtest	0.697[b]	0.566[b]	0.803[b]
Standing balance test			
TGDM-3	0.391[b]	0.590[b]	0.605[b]
Locomotor skills subtest	0.279[a]	0.468[b]	0.584[b]
Ball skills subtest	0.431[b]	0.596[b]	0.520[a]
Squat test			
TGDM-3	0.788[b]	0.702[b]	0.691[b]
Locomotor skills subtest	0.810[b]	0.819[b]	0.628[b]
Ball skills subtest	0.658[b]	0.549[b]	0.588[b]
Sit up test			
TGDM-3	0.728[b]	0.696[b]	0.565[b]
Locomotor skills subtest	0.720[b]	0.650[b]	0.522[b]
Ball skills subtest	0.623[b]	0.634[b]	0.432[a]

[a]Significant correlation is $p \leq 0.05$;
[b]Significant correlation is $p \leq 0.01$; TGDM-3 – Test of Gross Motor Development – 3rd edition

The relation between physical abilities and fundamental motor skills (shown as the total score of TGMD-3, locomotor subtest and ball skills subtest) are given in Table 2.

When analyzing the total sample a significant correlation is perceived which is mostly of strong effect size between almost all tests of physical abilities and the total result of TGMD-3 (MAT test -0.759; Broad jump test 0.767; Squat test 0.788; Sit up test 0.728), except Standing balance test 0.391 with moderate effect size. It is similar in the case of the connection of physical abilities with subtests: locomotor subtest (strong effect size: MAT test -0.767; Broad jump test 0.744; Squat test 0.810; Sit up test 0.720; small but significant correlation: Standing balance test 0.279) and balls skills

subtest (strong effect size: MAT test -0.666; Broad jump test 0.697; Squat test 0.658; Sit up test 0.623; moderate effect size: Standing balance test 0.431).

When the sample is observed from the gender point of view, a significant correlation between the variables of physical abilities and fundamental motor skills is noticed in both boys and girls. In boys, there is a strong and significant correlation of all tests of physical abilities with the overall result of TGMD-3. Results are the same both in locomotor and ball skills subtests. In girls, most coefficients between physical abilities and subtests are significant and strongly correlated, except moderate effect size between ball skills subtest and Sit up test (0.432).

Discussion

The aim of this study was to determine the connexion between physical abilities and fundamental motor skills in preschool children. It was also necessary to determine the differences in the observed variables in relation to gender.

Observing the connection between physical abilities and fundamental motor skills, the results of this paper indicate in most cases a moderate and significant correlation of fundamental motor skills and physical ability parameters in the total sample and also individually in boys and girls ($p \leq 0.05$). Similar results can be found in other researches dealing with the physical performances of preschool children. Burns, Brusseau & Hannon (2017) found a significant correlation between ball skills subtest and physical performances, but on the other hand, there was no significant interconnection between locomotor subtest TGMD-3 and physical performances. However, the relation between the parameters of fundamental motor skills and physical abilities is dynamic and can change during the childhood, so the development of object management skills in childhood can be important for the development and maintenance of physical abilities during childhood and adolescence (Stodden et al., 2014). This dynamic relation between motor competence and physical ability keeps strengthening with age (Utesch et al., 2019), which has been fully accepted by Stodden et al. (2008), indicating that physical ability plays the role of mediator in the emergent relationship between motor competencies and physical activities and that as a child is growing from early to middle childhood, the relationship of these elements from the initial weak connection is becoming stronger.

It is considered that the cause of low levels of physical activity in children is an insufficient level of physical abilities, as well as a lack of motor competence, ie. low level of fundamental motor skills (Erwin & Castelli, 2008). The research shows that the relation between physical parameters and fundamental motor skills is significantly related to the general level of physical activity in children (Castelli & Valley, 2007; Logan et al., 2015; Webster, Martin & Staiano, 2019; Hu, Wu & Kong, 2022), which also affects later age, as active children become active adults (Janz, Dawson & Mahoney, 2000). Any movement in the form of free activity has a positive effect on fundamental motor skills (Kracht, Webster & Staiano, 2020; Li, Yin, Sun & Gao, 2022), which is also true for the impact of organized programs on physical performances through cardiorespiratory endurance and fundamental motor skills as well (Brusseau et al., 2018).

When it comes to the differences in the observed variables of physical abilities and fundamental motor skills in relation to gender, the results of this study showed a significant difference in almost all variables of physical abilities and fundamental motor skills in favor of boys ($p \leq 0.05$ and $p \leq 0.01$), except for the Standing balance test in which there are not significant differences ($p > 0.05$). These results are consistent with previous research that suggests similar conclusions (Robinson, 2011; Bonvin et al., 2012; Vameghi, Shams & Dehkordi, 2013; Mnejja et al., 2022). Barnett et al. (2010) concluded that boys control objects better than girls, and Goodway, Robinson & Crowe (2010) who dealt with determining the difference between boys and girls in object control and locomotor skills, agree upon that matter. The reason for such differences between boys and girls can be found in the various leisure activities and games which children participate in. It is common for boys and girls to play in different ways during their childhood and some of these activities are in a greater extent in favor of the development of physical abilities and motor skills in boys, and to a lesser extent in girls. In addition to the different ways of playing, the cultural and social factors of the environment in which children grow up also make a certain contribution, so dolls are intended for girls, and balls and other sports equipment for boys. Boys are directed to ball games, climbing, skipping, dragging and other more "dangerous" activities, while safer games with less physical engagement are intended for girls. In this regard, children's development should not only rely on free activities, but, already confirmed by numerous other studies (Roth et al., 2015; Salaj, Krmpotić & Stamenković, 2016; Johnson et al., 2019; Hudson, Ballou & Willoughby, 2021), it is also necessary to conduct programmed exercise within institutionalized physical education, initially in preschool and then later in school institutions (Milenković, 2022). All the mentioned researches indicate a positive effect of organized and planned exercise on the development of physical abilities and fundamental motor skills in preschool children. In addition to the positive impact of free activities and play on motor development, working with children requires professional and organized physical exercise in appropriate educational institutions. In that way, the difference in motor development between boys and girls can be reduced.

The limitations of this research are in the small sample of respondents and the fact that the sample was taken from two preschool institutions. Capturing a wider population and a larger number of respondents would undoubtedly provide much more precise and reliable results. Besides, a number of physical performance parameters can be taken into account that would more fully cover all segments of motor skills. Nevertheless, this research provides sufficient information that can indicate the importance of motor development of preschool children and serve for some new research based on the previous ones, can result in more complete picture of this problem.

Conclusion

Due to the different levels of physical activity to which they are exposed, children may have a rich and varied movement experience versus children whose motor manifestations are poor. This is why it is necessary to expose preschoolers to an appropriate level of physical activity that will cause adaptive changes in motor skills and enable the development of those skills. Institutionalized physical exercise in

the form of preschool physical education plays an important role in this process. In order to improve the motor status and proper development of the organism, the work program requires professional planning, diverse and interesting content, adequate feedback, instructions and encouragement of educators as a contribution to raising self-confidence, especially for children with poor motor skills. When it comes to the results of this research, the information obtained can help the physical education educators to achieve better understanding of the relationship between variables of motor status, which further allows them to work effectively with children who will become physically active throughout physical development and education throughout their life.

Conflict of interest

The author did not receive support from any organization for the submitted work. The author has no relevant financial or non-financial interests to disclose.

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ЗВ'ЯЗОК МІЖ ФІЗИЧНИМИ ЗДІБНОСТЯМИ Й ОСНОВНИМИ РУХОВИМИ НАВИЧКАМИ ДІТЕЙ ДОШКІЛЬНОГО ВІКУ

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

Реферат. Стаття: 8 с., 2 табл., 66 джерел.

Метою цього дослідження було визначити взаємозв'язок між фізичними здібностями та основними руховими навичками дітей дошкільного віку. Метою також було визначити відмінності спостережуваних змінних у зв'язку зі статтю.

Матеріали та методи. Учасниками тестування успішно стали 52 дитини дошкільного віку: 30 хлопчиків і 22 дівчинки. Використовували п'ять тестів на фізичні здібності (модифікований тест на спритність «Т» (MAT), тест на стрибки в довжину, тест на збереження рівноваги в положенні стоячи, тест на присід і тест на підйом тулуба в сід із положення лежачи), а основні рухові навички оцінювали за допомогою Тесту розвитку великої моторики, 3-тє видання (TGMD-3). Для визначення впливу статі на результати фізичних здібностей та основних рухових навичок використовували однофакторний дисперсійний аналіз. Для визначення зв'язку між фізичними здібностями та основними руховими навичками використовували коефіцієнт кореляції Пірсона.

Результати цієї роботи показали в більшості випадків помірну та значущу кореляцію основних рухових навичок і параметрів фізичних здібностей як у загальній вибірці, так й індивідуально у хлопчиків і дівчинок ($p \leq 0,05$). Майже в усіх змінних фізичних здібностей і фундаментальних рухових навичок відзначена значуща різниця на користь хлопчиків ($p \leq 0,05$ та $p \leq 0,01$), за винятком тесту на збереження рівноваги в положенні стоячи, який показав, що значних відмінностей між статями немає ($p > 0,05$).

Висновки. Таким чином, можна дійти висновку, що одержана інформація може привести вчителів фізичного виховання до кращого розуміння зв'язків між змінними рухового статусу, що надалі дозволить їм ефективно працювати з дітьми, які завдяки правильному фізичному розвитку та вихованню стануть і залишаться фізично активними протягом усього життя.

Ключові слова: розвиток великої моторики, діти, спритність, сила, рівновага.

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ORIGINAL SCIENTIFIC ARTICLE

RELATIONSHIP BETWEEN QUALITY OF LIFE AND LEVEL OF PHYSICAL ACTIVITY AND FAMILY WELL-BEING

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Abstract

Study purpose. The objective of the study was to assess the relationship between quality of life and physical activity level and family well-being.

Materials and Methods. The International Physical Activity Questionnaire (IPAQ) was used to assess parental physical activity. The quality of life was assessed with the Short Form (SF-36) Health Survey Questionnaire. The data obtained were processed using cluster and correlation analysis, and descriptive statistics. The study involved 106 young adults (married couples), who were parents of preschool and primary school-aged children.

Results. An assessment of parental physical activity showed that 62.3% of the respondents had a low level of physical activity and 37.7% had a moderate level, whereas no individuals with a high level of physical activity were found. Families with children were divided into clusters with the k-means method according to the level of physical activity: Cluster 1 included families with a low level of physical activity; and Cluster 2 included the families with a moderate level of physical activity. The results of the study confirmed the relationship between the quality of life and the level of physical activity and family well-being. It was found that all the quality of life components of the study participants with a moderate level of physical activity are significantly higher ($p<0.05$) than those of the participants with a low level of physical activity. Correlation analysis of family well-being and quality of life indicators revealed significant relationships ($p<0.05$) between physical functioning, physical role functioning, vitality, and mental health.

Conclusions. The direct statistically significant relationship between family well-being score and quality of life components of the respondents was demonstrated.

Keywords: health-enhancing physical activity, quality of life, family well-being, active leisure, parents, children.

Introduction

The issue of population health promotion and maintenance is the main economic, social, and political challenge for the state. According to sociological surveys, only 15% of Ukrainians consider themselves healthy (Andreieva et al., 2020; Yelizarova et al., 2020). Every year, the percentage of sedentary people who do not meet the recommended level of regular physical activity is increasing (Guthold et al., 2020). As noted by the WHO, physical inactivity ranks fourth among the factors that are responsible for premature mortality of people on a global scale (Bull et al., 2020). Due to a significant number of the population that is not involved in health-enhancing and recreational physical activity in conjunction with ignoring other components of a healthy lifestyle, Ukraine has one of the worst indicators of the average duration and quality of life of people in Europe (Andreieva et al., 2020). Therefore, it is necessary to implement various programs aimed at overcoming this social challenge. It is worth noting that the development and implementation of measures to improve the quality of life are fully consistent with the European and global trends of population involvement in physical activity. In Ukraine, over the past 20 years, the measures have been taken to increase the number of the population involved in physical activity during leisure time (Andreieva et al., 2022). The researchers are currently in an

active search for a solution to the challenges of introducing health-enhancing physical activity during the organization of family leisure (Maltsev et al., 2022; Rodríguez-Sánchez et al., 2011; Taylor et al., 2012). At the same time, insufficient attention has been paid to the relationship between the quality of life and the level of physical activity and family well-being in scientific studies. Thus, despite close attention to family leisure research, the main studies have been focused on issues of quality of family life (for example, family satisfaction and family cohesion) and the organization of family leisure (for example, the influence of socioeconomic status on family well-being, barriers to family leisure activities, etc.), as well as assessing the relationship between family leisure patterns and family functioning (Zabriskie, 2001). A systemic analysis of the specialized literature gave us an understanding of the breadth and depth of research in the field of family leisure, but no attempts were made to quantitatively synthesize and interpret the relationships between quality of life and physical activity level and family well-being. The generalization of such results will increase the possibility of finding previously unrecognized statistically significant relationships between the studied variables and will allow them to be used as a factor of population's involvement in health-enhancing and recreational physical activity.

The objective of the study was to assess the relationship between the level of quality of life and physical activity and family well-being.

Material and methods

Participants

The research involved 106 families (the average age of parents was 35.1±4.2 years). The family structure of 95.3% participants included four people: two adults (mother and father) and two children. All the participants (parents) were asked to carefully read and sign the informed consent form, which described all stages and procedures of the study.

Procedure

The first stage of the study included an assessment of the level of parental physical activity. Assessment was based on responses to the International Physical Activity Questionnaire (IPAQ). A version consisting of 27 items divided into five parts was used. Each part covers a specific type of activity: job-related physical activity (part 1); transportation physical activity (part 2); housework, house maintenance, and caring for family (part 3); recreation, sport and leisure-time physical activity (part 4, when answering the questions of this part of the questionnaire, those types of physical activity that the respondents already mentioned, i.e. physical activity related to job, transportation, housework, and caring for family, were not taken into account); time spent sitting or lying down (part 5, the time spent in transport was not taken into account). The IPAQ provided an opportunity to describe and analyze in detail general PA and its particular types such as leisure-time PA, home and outdoor PA, job-related PA, transportation-related PA. The structure of the IPAQ make possible to differentiate various types of activities by intensity as follows: low-intensity, moderate-intensity, and vigorous-intensity activities. An analysis of the survey results included several stages. At the first step, energy expenditures were calculated for each type of activity taking into account the intensity of activity (low, moderate, and vigorous). At the second step, the level of total physical activity was estimated in MET-minutes per week. The total level of PA in MET-minutes per week is equal to the sum of the total amounts of each type of physical activity (job-related, transportation-related, home and outdoor PA, and leisure-time PA).

The second stage included quality of life assessment. Quality of life was assessed using the Short Form 36 (SF-36) Health Survey Questionnaire (Hagstromer et al., 2006; Lins & Carvalho, 2016). The questionnaire made it possible to assess all the components of quality of life including those related to general health status. SF-36 consists of 36 questions, which are combined into 8 scales and two summary components, and was designed to evaluate general health perceptions; limitations in physical activities because of health problems; limitations in usual role activities because of physical health problems; limitations in usual role activities because of emotional problems; limitations in social activities because of physical or emotional problems; bodily pain; vitality (energy and fatigue); and general mental health (psychological distress and well-being). The scales are constructed to measure physical and mental components of health. The answers for each item are scored on a 0 to 100 range so that a high score defines a more favorable health state. Then the items in the same scale are averaged together to create the 8 scale scores.

Statistical analysis

Clustering by means of Data Mining was used in the study. Families with children were divided into clusters with the k-means method according to the level of physical activity (Cluster 1 included families with a low level of physical activity; and Cluster 2 included the families with a moderate level of physical activity). A normality test of the raw data using the Shapiro-Wilk test showed that they did not comply with the normal distribution. Therefore, the median (Me), 25 and 75 percentiles were used to represent the data, and Spearman's rank correlation coefficient was used for correlation analysis.

The significance level was set to $\alpha=0.05$. The exact p-values are given in the test, and when the p-value was less than 0.0001, it was indicated that $p < 0.01$. Mathematical and statistical processing of the raw data was performed using the statistical software Statistica 10.0.

Results

According to the questionnaire results, the respondents were placed using the Categorical Score into one of the three categories: low or inactive, moderate, and high. No individuals with a high level of physical activity were identified in this study. Depending on the level of physical activity, the participants were divided into two clusters: with a low (Cluster 1) and moderate (Cluster 2) levels of physical activity. The first cluster included 66 people, and the second cluster consisted of 40 people.

To analyze the relationship between the components of the quality of life and physical activity, the respondents were assigned to two clusters on the basis of their physical activity (Table 1).

Table 1. Assessment of quality of life indicators in parents with different levels of physical activity (n=106)

Quality of life components	Average values, points				Normality test results			
	Cluster 1 (n=66)		Cluster 2 (n=40)		W_1	p_1	W_2	p_2
	Me	25%, 75%	Me	25%, 75%				
Physical functioning	70.0	65.0; 75.0	85.0	85.0; 90.0	0.941	0.004	0.796	<0.05
Role limitations due to physical health problems	50.0	25.0; 50.0	75.0	75.0; 100.0	0.829	<0.05	0.797	<0.05
Bodily pain	52.0	31.0; 52.0	94.0	87.0; 100.0	0.820	<0.05	0.776	<0.05
General health perceptions	35.0	30.0; 42.0	59.5	45.0; 80.0	0.959	0.028	0.934	0.021
Vitality (energy and fatigue)	35.0	20.0; 35.0	75.0	60.0; 85.0	0.912	<0.05	0.937	0.027
Social functioning	37.5	25.0; 50.0	62.5	62.5; 87.5	0.869	<0.05	0.849	<0.05
Role limitations due to personal or emotional problems	33.3	33.3; 33.3	66.7	66.7; 66.7	0.466	<0.05	0.774	<0.05
General mental health (psychological distress and well-being)	32.0	32.0; 36.0	76.0	70.0; 80.0	0.774	<0.05	0.912	0.004

Note: Me – Median; 25%, 75% – percentiles; W_1, W_2 – Shapiro–Wilk test values for Clusters 1 and 2, respectively; p_1, p_2 – the achieved significance levels.

Table 2. Comparative analysis of quality of life indicators of the families with children who had different levels of physical activity (n=106)

Quality of life components	Calculated data				p
	Σr_1	Σr_2	U	Z	
Physical functioning	2408.0	3263.0	197.0	7.316	<0.05
Role limitations due to physical health problems	2614.0	3057.0	403.0	5.974	<0.05
Bodily pain	2308.0	3363.0	97.0	7.968	<0.05
General health perceptions	2585.5	3085.5	374.5	6.159	<0.05
Vitality (energy and fatigue)	2224.0	3447.0	13.0	8.515	<0.05
Social functioning	2437.0	3234.0	226.0	7.127	<0.05
Role limitations due to personal or emotional problems	2634.5	3036.5	423.5	5.840	<0.05
General mental health (psychological distress and well-being)	2245.0	3426.0	34.0	8.379	<0.05

Note: Σr_1, Σr_2 – sum of ranks for the samples Cluster 1 and Cluster 2, respectively; U – Mann-Whitney U test; Z – Z-test; p – the achieved significance level.

A comparative analysis indicated that the group of respondents who formed Cluster 2 have significantly higher values of quality of life components then the participants from Cluster 1 ($p<0.05$) (Table 2). Obviously, families that had a higher level of health-enhancing recreational physical activity and, accordingly, a higher level of family well-being, are also demonstrated higher values of quality of life components.

The results of correlation analysis using Spearman's rank correlation coefficient ρ confirmed the presence of direct statistically significant ($p < 0.05$) relationships between family well-being and quality of life components excluding general health (Fig. 1).

The families from the Cluster 2 also had higher values of physical and mental components of quality of life. Furthermore, the differences between the values of the mental component were found to be significant at $p<0.05$ (Table 3).

No significant differences were observed between different clusters in the values of physical component of quality of life ($p > 0.05$), however the mean values of the members

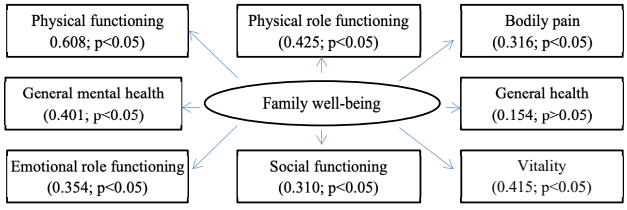

Fig. 1. Influence of family well-being on the quality of life of respondents (n=106)

of the Cluster 2 were higher compared to Cluster 1. Furthermore, the direct significant relationship between the family well-being score and quality of life components of the respondents was shown. The decreased scores of mental component in the survey participants compared to the published data, including the standardized values of the scales, can be explained by the unfavorable conditions of quarantine restrictions on the Ukrainian territories where the survey took place.

Table 3. Analysis of scores of quality of life components (n=106)

Results of comparative analysis		Quality of life components			
		Physical		Mental	
		Cluster 1	Cluster 2	Cluster 1	Cluster 2
Normality of distribution test	W	0.973	0.958	0.935	0.923
	p	0.164	0.144	0.002	0.010
	Normality of distribution	+	–	+	–
Descriptive statistics	Me	52.8	53.8	28.3	47.5
	25%	49.1	50.7	25.9	44.5
	75%	56.5	57.4	31.2	51.1
Comparative analysis	U	1119		43.0	
	Z	1.307		8.320	
	p	0.191		<0.05	
Correlation with the level of family well-being	ρ	0.270		0.317	
	t	2.853		3.404	
	P value	<0.05		<0.05	

Discussion

Many authors have devoted their research to assessing the relationship between the quality of life and physical activity level of different population groups (Grygus, 2017; Hakman et al., 2018; Kashuba et al., 2021; Krutsevich et al., 2021). In domestic and international science, the field of research is actively growing, which studied the quality of life as a complex medical and social phenomenon (Grygus et al., 2019; Karpukhina et al., 2020; Pavlova et al., 2016). Researchers offer theoretical models aimed at finding relationships between the functional state of an individual and his well-being (Andrieieva & Hakman, 2018; Drozdovska et al., 2020). Studies devoted to the use of health-enhancing recreational technologies to ensure the quality of human life have made it possible to solve some theoretical and practical issues of ensuring an appropriate quality of life for various population groups. Strong evidence (mainly from randomized controlled trials) has shown that, for adults aged 18–65 years, physical activity improves quality of life and well-being (Marquez et al., 2020). Nevertheless, scientific research on the relationship between physical activity and quality of life is narrowly focused, since the main object of study remains somatic health (Andrieieva & Hakman, 2018; Galan et al., 2019; Kashuba et al., 2019). A number of issues regarding the relationship between physical activity and individual components of quality of life, such as mental health, family well-being, life satisfaction, etc., remain insufficiently studied (Andrieieva et al., 2019; Hakman et al., 2020; Orikhovska et al., 2020).

The results obtained in our study expanded scientific knowledge regarding the importance of the optimal level of physical activity for ensuring recreational effect, quality of life, and improving physical and mental health of adult persons. We confirmed the data of researchers (Granero-Jiménez et al., 2022) regarding the close correlation between the physical activity level and psychological well-being of the study participants. Also, our research results complement the data reported by Sobkey (2014). A study involving 100 participants aged from 18 to 70 revealed a positive association between physical activity and health-related quality of life that was measured with the Short Form Health Survey (SF-36) in 4 domains, including physical functioning, role limitations due to physical health problems, vitality, and general health (Kokandi et al., 2019). Another study of 400 people aged 18-60 using the IPAQ and SF-36 showed that more than half of the studied population (57%) had a low level, 30% had a moderate level, and 13% had a high level of physical activity. In contrast, no individuals with a high level of physical activity were found in our study. Their health-related quality of life was highly correlated with their level of physical activity. The main domains related to physical activity were physical functioning, role limitations due to physical health problems, and general health (Moshibah et al., 2015). Pavlova and co-authors conclude that a low level of physical activity correlates with low indicators of quality of life, in particular with the predominance of passive forms of recreation, reduce quality of life values on the scales of general health, physical functioning, vitality, and mental health (Pavlova et al., 2016). In our study, similar results were obtained, in particular we confirmed the data regarding the relationship between the quality of life of adults and the health status and of physical activity level. Individuals with a moderate level and a low level of physical activity had statistically significant differences in all of the quality of life components.

There is a substantial body of research evidence regarding the relationship between the quality of life and family well-being of parents of children with disabilities (Bjornson et al., 2008; Park, 2021; Pratesi et al., 2021; Silva et al., 2020; Xu et al., 2018). Nevertheless, there is a lack of data on the improvement of quality of life of families due to organizing active leisure time. Researchers note that promoting family physical activity is important for encouraging healthy habits in children. The results obtained in the study (Paez et al., 2022) show that children of parents with a low level of physical activity often have excess body weight, disharmonious physical development, and low physical fitness. Therefore, it is important to encourage parents and children to participate in health-enhancing and recreational physical activities together.

The results of this study provide relevant information to professionals in health-enhancing and recreational physical activity regarding the arguments for increasing the level of participation of clients in regular physical exercise. Further study of the relationship between quality of life and physical exercise, in particular during leisure time, is promising for the development of effective health programs aimed at ensuring a high level of well-being in people of all ages in order to achieve adherence to physical exercise and improve psychological well-being.

The main limitations of this study are related to the sampling technique, since we used an on-line approach, as well as the lack of information on the nature of the parents' employment, which did not allow us to assess the relationship between physical activity level and quality of life depending on professional activity.

Conclusions

The results of the study confirmed the relationship between quality of life and physical activity level and family well-being. It was found that all the quality of life components in study participants with a moderate level of physical activity were significantly higher ($p<0.05$) than in the participants with a low level of physical activity. Correlation analysis of family well-being and quality of life indicators revealed significant relationships ($p<0.05$) between physical functioning, physical role functioning, vitality and mental health.

Conflicts of interest

The authors declare that they have no competing interests.

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ЗВ'ЯЗОК МІЖ ЯКІСТЮ ЖИТТЯ ТА РІВНЕМ РУХОВОЇ АКТИВНОСТІ ТА СІМЕЙНИМ БЛАГОПОЛУЧЧЯМ

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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., 36 джерел.

Метою дослідження було оцінити зв'язок між якістю життя та рівнем рухової активності та сімейним благополуччям.

Матеріали та методи. Для оцінки рухової активності батьків використовувався Міжнародний опитувальник фізичної активності (IPAQ). Якість життя оцінювали за допомогою Короткої форми (SF-36). Отримані дані обробляли за допомогою кластерного та кореляційного аналізу, описової статистики. У дослідженні взяли участь 106 дорослих людей (сімейних пар), які є батьками дітей дошкільного та молодшого шкільного віку.

Результати. Оцінка рухової активності батьків показала, що 62,3% респондентів мають низький рівень і 37,7% мають помірний рівень рухової активності, а осіб з високим рівнем рухової активності не виявлено. Сім'ї з дітьми були розподілені на кластери методом k-means за рівнем рухової активності: кластер 1 включав сім'ї з низьким рівнем рухової активності; а кластер 2 включав родини з помірним рівнем рухової активності. Результати дослідження підтвердили зв'язок між якістю життя, рівнем рухової активності та сімейним благополуччям. Виявлено, що всі компоненти якості життя учасників дослідження з помірним рівнем рухової активності вірогідно вищі ($p<0,05$), ніж в учасників з низьким рівнем рухової активності. Кореляційний аналіз показників сімейного благополуччя та якості життя виявив достовірний зв'язок ($p<0,05$) між фізичною активністю, роллю фізичних проблем в обмеженні життєдіяльності, життєздатністю та психічним здоров'ям.

Висновки. Доведено наявність прямого статистично значущого кореляційного зв'язку між оцінкою сімейного благополуччя й компонентами якості життя опитаних.

Ключові слова: оздоровчо-рекреаційна рухова активність, якість життя, сімейне благополуччя, активне дозвілля, батьки, діти.

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ORIGINAL SCIENTIFIC ARTICLE

JUSTIFICATION OF THE SELECTION TECHNIQUES IN MARTIAL ARTS USING WALD'S SEQUENTIAL ANALYSIS

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Abstract

The study purpose was to develop a selection technique in martial arts based on indices of physical development using Wald's sequential analysis.

Materials and methods. 12 anthropometric indicators were determined. 9 indexes of physical development were calculated on their basis. 16 elite athletes (candidates for masters and masters of sports) were divided into two groups. Group 1 included 7 athletes (judo, sambo, Greco-Roman and freestyle wrestling) aged 18.43±0.43. Group 2 included 9 kickboxing athletes aged 18.22±0.52.

Results. A prognostic table containing indices of physical development has been developed. The informativeness of the indicators varied within 296.15–1.73. The content of the prognosis consists of evaluating the results, determining the corresponding coefficients and summing these coefficients until one of the prognostic thresholds is reached. In accordance with generally accepted approaches, the value of the thresholds was set at the level of ±13, which corresponds to a probability of 95% ($p<0.05$). Exceeding the positive threshold improves an athlete's prospects in wrestling. Achieving a negative threshold corresponds to a perspective in kickboxing.

Conclusions. The conducted research made it possible to justify and develop a method for selecting martial arts athletes using indices of physical development. The proposed technique is based on Wald's sequential analysis and is a simple, informative and objective tool for the selection and prognosis of athletes' condition.

Keywords: martial arts, physical development, indices, selection, success.

Introduction

Effective selection is one of the leading tasks in sports science nowadays. The selection procedure involves the use of tests and functional tests (Ishihara, Kuroda, & Mizuno, 2019). The main requirement for the tests is to reflect the specifics of the sport. This significantly increases the efficiency of selection.

The use of various methods for sports selection and prognosis is analyzed in this study (Spann and Skiera, 2009). It is concluded that the combination of these methods significantly increases the efficiency of this procedure. A similar conclusion was made in the study (Ihsan et al., 2022) studied the technique of pencak-silat. The quality of technical elements is determined by both physical and psychological components.

The effectiveness of selection in handball was evaluated in the study (Schorer et al., 2017). The selection system included general and special tests, expert assessment of athletes' performance, analysis of their performance during games based on video analysis. Test results were the most effective components of the selection.

The analysis of physical, anthropometric and strength qualities of rugby players was carried out in the study (Pearce et al., 2018). Discriminant analysis was used to increase the efficiency of selection and prognosis. The high significance of the used indicators was determined.

Morphofunctional features of basketball players can be used as criteria for sports selection and orientation (Bezmylov et al., 2022). The informativeness of anthropometric

indicators (body length and mass) and indicators of functional capabilities (VO_2max) were confirmed. The authors proposed using these indicators for the athletes functional state monitoring.

It is proposed to use the ratio of the length of the limb segments to the body length and somatotype for selection and predict the success in basketball (Korkmaz, Cetin, & Bozduman, 2020). These ratios were significantly higher in basketball players than in the control group. The indexes used are specific to basketball. They can be used for selection and prognosis in this sport.

The possibilities of controlling the effectiveness and efficiency of selection in volleyball were studied in the study (Altavilla et al., 2022). Monitoring of physical qualities and jumping ability is recognized as an important aspect. Creating an anthropometric profile of athletes significantly increases the objectivity of the assessment.

A comparative analysis of tests for the selection, diagnosis of abilities and capabilities of athletes was carried out in the study (Kalina & Jagiełło, 2018). Hardware and simulation methods were considered the most effective.

Analysis of indicators of physical development is an informative and valid tool for sports selection. The anthropometric characteristics of athletes are an important component of selection and success (Burdukiewicz et al., 2018). The authors analyzed the biometric data of martial arts athletes and determined somatotype features characteristic of their specific types. The development of such a profile makes it possible to increase the effectiveness of selection and prognosis in these sports.

Similar results were obtained in the study (Konstantinova et al., 2019). The authors determined the characteristic features of freestyle wrestlers' somatotype. Athletes were most often characterized by a brachymorphic somatotype. It is recommended to use Rohrer's index to determine the level of physical development of wrestlers.

Functional preparedness standards for women 25-35 years old were developed on the basis of a complex of modes of muscle energy supply (Furman et al., 2022). The obtained results became the basis of models of functional preparedness of women aged 25-35 with different somatotypes. It was concluded that the somatotype should be considered in assessing indicators of functional preparedness.

Achievement of success in martial arts is ensured due to optimal body composition, the development of muscle strength, flexibility, anaerobic and aerobic potential (Mata-Ordonez et al., 2018). Effective selection and forecasting should include these qualities. The specificity of martial arts implies constant control of body weight as an integral indicator of physical development.

Indices of physical development are an informative tool for the analysis of physical fitness in sports and recreational physical culture. It is proposed to use anthropometric indicators and indices based on them for selection in sports games (Masanovic et al., 2019). The possibility of using anthropometric indices, body composition and functional indicators as criteria for the effectiveness of health training has been proven (Eroğlu Kolayiş & Arol, 2020). It is proposed to use the body mass index for the comparative assessment of young Swiss men (Wyss et al., 2019). The stability of this indicator is associated with maintaining sufficient physical fitness.

The available results confirm the effectiveness of the application of anthropometric indicators and indices for selection and prognosis in sports. This determined the relevance of the study.

The purpose of the research was the substantiation and development of the selection method in martial arts based on indices of physical development using Wald's sequential analysis.

Material and Methods

Participants

16 elite athletes (candidates for master and master of sports), who were divided into groups, took part in the study. The first group included 7 wrestlers (judo, sambo, Greco-Roman and freestyle wrestling), age (18.43±0.43) years. The second group included 9 kickboxing athletes, age (18.22±0.52) years. The average age and skill level of the groups did not differ significantly.

The research program and design were discussed and approved at the meeting of the commission on bioethics of the Kharkiv State Academy of Physical Culture (protocol No. 15 dated January 26, 2022).

The research design included the determination of 12 anthropometric indicators. Measurements were performed according to the requirements of the unified method of anthropometric studies (Marfell-Jones et al., 2001). Body length and weight, chest circumference, length and circumference of limb segments, wrist dynamometry of both hands were determined. A set of special indices based on the indicators under study was used.

Procedure

Body mass index (BMI) was defined as the ratio of body mass (kg) to body length (m2). Values of 20-25 are accepted as the norm.

The Erisman index was found as the difference between the chest circumference and half of the body length. Proportional physical development is characterized by a positive value of this indicator. Its value is not less than 5.8 cm in athletes.

The power index was defined as the ratio of wrist dynamometry to body mass, expressed in percentage. Values of 50%-75% are accepted as the norm.

The ratio of the limb segments was determined as follows: hands – as the ratio of the forearm length to the shoulder length.

The Vervek index was determined by the formula:

$$IV = BL / (2 \times BM + CC),$$

where BL – body length (cm), BM – body mass, (kg), CC – chest circumference at rest, (cm). With an IV value in the range of 0.75-0.85, the physique is estimated as hypersthenic, 0.85-1.25 – normosthenic, 1.25-1.35 – asthenic.

The Livi index was determined by the formula:

$$IL = CC/ BL,$$

where CC is the chest circumference at rest (cm), BL is the body length (cm). The value of IL in the range of 50-55% indicates harmonious physical development.

The indicators of the limb segments mass and the conditional moments of force of the limb segments were deter-

mined according to the formulas given in the study (Epyphanov, 1999). The massiveness indicators were determined by the formula:

$$SMI=CS\times100\% / LS,$$

where SMI is the segment massiveness indicator (c.u.), CS is the circumference of the segment (cm), LS is the length of the segment (cm).

The segment conditional moments of force were determined by the formula:

$$SCMF=CS\times LS,$$

where SCMF is the segment conditional moment of force (cm^2), CS is the circumference of the segment (cm), LS is the length of the segment (cm).

Average values for the entire sample were considered the norm in the indicated indices.

Statistical analysis

Statistical analysis of the obtained data was performed with the help of licensed MS Excel. Wald's sequential analisys was used as a tool for solving the prognostic problem (Antomonov, 2018; Gubler, 1990). The method is a prognostic table, which includes coefficients of indices and their informativeness. Prognostic coefficients were calculated according to the formula:

$$PC = 10 \cdot \log\frac{p1 \cdot \frac{D1}{S}}{p2 \cdot \frac{D2}{3}}$$

where,

PC is predictive coefficient;

S is the total number of people in the group;

D1 is the number of test persons who had a value more than the average value in group 1;

D2 is the number of test persons who had a value more than the average value in group 2;

p1 is the probability of exceeding the average value in group 1;

p2 is the probability of exceeding the average value in group 2.

The predictive coefficients in the case of the value lower than average were found similarly.

The informativeness is calculated by the formula:

$$I = PC \cdot 0.5 \cdot \left[\left(p1 \cdot \frac{D1}{S}\right) - \left(p2 \cdot \frac{D2}{S}\right)\right]$$

where, I is the informativeness; other designations are the same as in the previous formula.

Results

The developed selection method for various types of martial arts is given in Table 1.

The prognostic table includes the indices, the value of its prognostic coefficients, and the value of informativeness. The indicators in the table are placed in the order of decreasing informativeness. This minimizes the number of steps in the prognostic procedure and reduces the number of possible errors. An informativeness value below 1.0 was considered insignificant. Indicators with such or less informativeness were excluded from the table.

Selection in martial arts is carried out in several stages. The used indices of physical development are calculated, and their values are estimated. The prognostic coefficient of each index is determined and their sequential summation is carried out. When the indices specified in the table are fulfilled, the positive coefficient is summed, when they are unfulfilled, the negative coefficient is summed. The value of the permissible error is 5%, which corresponds to the value of the threshold of 13 points. When the threshold +13 is reached, a conclusion is made about the athlete's prospects in wrestling ($p<0.05$). When the -13 threshold is reached, a conclusion is made about the athlete's prospects in kickboxing ($p<0.05$). If, after completing the table, none of the thresholds are reached, a conclusion is made about an uncertain prognosis and the need for additional research.

Discussion

Physical development is an effective tool for assessing the athletes' condition. This determines the use of these indicators in sports selection, prognosing the sports skills growth and success. The main requirements for the criteria used are validity, informativeness and specificity for the sport (Klymovych et al., 2020). The validity of this approach was confirmed when analyzing the condition of female synchronized swimming athletes of different skill levels (Rovnaya et al., 2016), athletes of various types of martial arts (Romanenko et al., 2020). Non-observance of these requirements does not allow effective selection and prognosis. This is reported in the study (Giovanis et al., 2017). The authors applied tests specific for ski slalom to football players. This significantly distorted the existing results.

Wald's sequential analysis is quite widely used in medical and biological research (Antomonov, 2018; Gubler,

Table 1. Prognostic table of selection for different types of martial arts

Indice	Prognostic coefficients		Informativeness
	Wrestling n=7	Kickboxing n=9	
Shin massiveness index, not less than 93 c.u.	-7.94	8.87	296.15
Left hand power index, not less than 50%	8.08	-4.93	243.72
Thigh massiveness index, not less than 141 c.u.	-4.35	5.07	107.01
Right hand power index, not less than 50%	4.10	-2.59	71.62
Right hand index, more than 0.75 c.u.	-1.92	5.86	30.46
Shin conditional moment of force, not less than 1512 cm^2	2.06	-2.89	27.80
Livi index, over 50%	-1.34	2.85	13.81
Body mass index, within 20-25 kg/m^2	-1.13	1.09	7.16
Erisman index, more than 5 cm	-0.67	1.09	3.19
Vervek index, over 0.85	1.09	-0.16	1.73

1990). An important advantage of this method is the possibility of choosing the probability of the prognosis. It can vary between 80-99.9% depending on the selected threshold value (8-30 points). To obtain a reliable result, 7-10 indicators should be included in the table. The methodology developed by us includes 10 indicators. This makes it possible to consider it informative.

Sequential analysis was used to develop a technique for predicting success in artistic swimming (Podrihalo et al., 2021). The methodology uses indices of physical development and the results of functional tests specific to this type of sport.

The physical development index method evaluates the ratio between individual anthropometric indicators and the dependence between them. The wide use of indices in sports science and practice is due to their simplicity and availability of definition, the possibility of use in athletes' condition monitoring.

The used design is the analysis of the elite athletes condition allows to significantly increase the efficiency of the analysis. The dependence of training organization and metabolic parameters in elite taekwondo athletes has been confirmed (Sung et al., 2017). An important tool for condition monitoring was the determination of indices of physical development and somatotype components.

The informativeness of the results can be significantly increased because of the use of a set of indices. This approach was tested in the study (Podrigalo et al., 2019). Indexes were used to compare the athletes' physique in different types of martial arts. Certain features have been confirmed. A higher body mass index in wrestlers reflects the predominance of the muscle component of the somatotype. The Erisman and Pignet indexes, the shoulder width index illustrate better muscle development in wrestlers and kickboxing athletes compared to karate and taekwondo athletes. A high power index illustrates the importance of grip strength in wrestling. Indexes of the limb segment ratio reflect the peculiarities of martial arts techniques.

The results of Table 1 confirm that the most informative indices are the indicators of the shin and thigh massiveness. This reflects the specifics of martial arts. Kicking kicks in kickboxing are the most important element for victory. The kick power is directly dependent on the massiveness of the segment that does the kick.

The shin conditional moment of force can be explained in the selection from this perspective. This indicator ensures the athlete's stability. This is most important for effective fighting. Simultaneously, the shin power is not essential for kicking.

The limb segments massiveness indices and conditional moments of force were proposed in the study (Epyphanov, 1999) to evaluate the effectiveness of rehabilitation. They were used in the analysis of the armwrestling athletes' condition with different skill levels (Podrihalo et al., 2020). The determined excess of these indices in the group of experienced athletes confirms the assumption about the importance of limb muscle development for success in this type of sport. The use of longitudinal indicators in these indices reflects the importance of long levers for armwrestling. The inclusion of limb segment perimeters in the indices illustrates the importance of these groups in muscle development. Thus, limb segments massiveness indices and conditional moments of force reflect the main factors important for success and can be used for sports selection.

The power indices of the hands are also characterized by sufficiently high informativeness for selection. These indicators are especially important in the wrestling, which is confirmed by the available results (Podrigalo et al., 2019). Victory in the wrestling depends largely on the grip effectiveness. The power index characterizes the power of the muscles of the forearm and hand. These muscles provide an effective grip. Therefore, the power index of the hands should be evaluated as an important selection indicator in the wrestling. Simultaneously, to win in kickboxing, it is necessary to do a kick that does not depend on the power of the forearm and hand muscles. Thus, the power index should be recognized as a specific indicator for selection in wrestling. Similar results were obtained when analyzing the anthropometric characteristics of elite Japanese female wrestlers (Arakawa et al., 2015).

The hand index reflects the ratio of segments of the following upper limb – forearm and shoulder. The value of this indicator is 0.75 in a harmoniously developed person. An increase in this index illustrates the relative lengthening of the forearm. The given data confirm the available literary sources (Tumanian & Martirosov, 1976). In this study, the relevance of physique for sports selection was analyzed using the example of martial arts. According to the authors, the lengthening of the arm increases the shoulder lever of force in wrestlers. This, in turn, promotes the manifestation of additional efforts and makes it possible to perform strikes with less effort. The relative lengthening of kickboxers' arms reflects the ability to do kicks at a greater distance. This should also be evaluated as an essential factor for victory and considered during the selection.

Body mass is the main anthropometric indicator and integral criterion of physical development. It largely determines the physical preparedness of athletes (Osipov et al., 2016). This determines the high informative value of indexes that include this criterion. In this study, 3 indices were used, which include the body mass of athletes.

Body mass index monitoring is quite relevant in sports (Fernandez-Arguelles & Fernandez-Rio, 2018; Greier & Drenowatz, 2018). Its connection with the time engaged in sports and the level of motor skills development was confirmed. A model for athlete condition monitoring is proposed. The model is based on motor skills indicators and anthropometric criteria.

The body mass index and the Livy, Vervek, and Erisman indices allow us to assess the proportionality of the body composition, the correspondence of the main anthropometric indicators to each other, illustrate the development of muscles, and reflect the strength of the body composition. Their analysis allows us to conclude that the most optimal for both wrestling and kickboxing is the presence of harmonious development. This is evidenced by the closeness of the prognostic coefficients. The low informativeness of these indicators, in our opinion, indicates the small importance of the proportionality of physical development. This once again confirms the assumptions made.

Thus, the obtained results largely agree with the available literature sources and confirm the informativeness, validity, and effectiveness of the martial arts selection technique using indices of physical development.

Conclusions

The conducted research made it possible to develop a method of selection in different types of martial arts. The methodology is based on Wald's sequential analysis and includes indices of physical development. The proposed technique is a simple, informative and objective selection tool for wrestling or kickboxing. The specificity of massiveness indices and conditional moments of force of limb segments for selection in kickboxing is confirmed. Hand strength indices are specific for selection in the wrestling. The indicated indices illustrate the main factors important for success in these sports. Determining the used indicators is quite simple and accessible. This allows us to conclude about the availability, transparency and financial expediency of conducting the selection.

Conflict of interests

The authors declare no conflict of interest.

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ОБГРУНТУВАННЯ МЕТОДИКИ ВІДБОРУ В ЄДИНОБОРСТВАХ ІЗ ВИКОРИСТАННЯМ ПОСЛІДОВНОГО АНАЛІЗУ ЗА ВАЛЬДОМ

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Реферат. Стаття: 7 с., 1 табл., 33 джерела.

Метою дослідження була розробка методики відбору в єдиноборствах на підставі індексів фізичного розвитку із використанням послідовного аналізу за Вальдом.

Матеріали і методи. Визначали 12 антропометричних показників. Розраховували 8 індексів фізичного розвитку на їх підставі. 16 елітних атлетів (кандидати в майстри та майстри спорту) були розподілені на групи. 1 – 7 борців (дзюдо,

самбо, греко-римська та вільна боротьба), середній вік (18,43±0,43) років. 2 група – 9 атлетів кікбоксингу, середній вік (18,22±0,52) років.

Результати. Розроблена прогностична таблиця, що містить індекси фізичного розвитку. Інформативність показників вар'ювала в межах 296.15-1.73. Зміст відбору полягає у оцінці результатів, визначенні відповідного коефіцієнта і підсумовуванні цих коефіцієнтів до досягнення одного з прогностичних порогів. Відповідно до загальноприйнятих підходів, величина порогів була встановлена на рівні ± 13, що відповідає ймовірності 95% ($p<0.05$). Перевищення позитивного порогу означає перспективність атлета боротьби. Досягнення негативного порога відповідає перспективності у кікбоксингу.

Висновки. Проведені дослідження дозволили обґрунтувати та розробити методику відбору атлетів єдиноборств з використанням індексів фізичного розвитку. Запропонована методика базується на послідовному аналізі Вальда і є простим, інформативним та об›єктивним інструментом відбору та прогнозу стану атлетів.

Ключові слова: єдиноборства, фізичний розвиток, індекси, відбір, успішність.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF DIFFERENT JAB TECHNIQUES ON PEAK ACTIVATION OF UPPER-BODY MUSCLES IN YOUTH BOXERS

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Abstract

The study purpose was to analyse the peak EMG at five upper-body muscles during four different jab techniques in youth boxers.

Materials and methods. Male youth national-level boxers (n=7) were assessed for peak electromyography (EMG) of anterior deltoid (AD), biceps brachii (BB), triceps brachii (TB), flexor carpi radialis (FCR), and upper trapezius (UT) while performing four jab techniques: long-range targeting head (LRH), long-range targeting body (LRB), medium-range targeting head (MRH), and medium-range targeting body (MRB).

Results. The LRH induced the highest EMG for AD (2092.9±411.9) and BB (1392.0±687.3). The MRB induced the highest EMG for the FCR (1337.16±538.28), TB (1589.3±600.3), and UT (1221.2±507.5). However, between jab techniques, only the AD showed a significant ($p<0.001$) different EMG. Specifically, the LRH induced greater AD EMG compared to LRB (157.5 [$p<0.001$]), MRH (411.0 [$p=0.003$]), and MRB (398.3 [$p=0.010$]). Further, the LRB induced greater AD EMG compared to MRH (253.5 [$p=0.024$]) and MRB (240.8 [$p=0.049$]). The MRH and MRB (-12.7 [$p=0.911$]) induced similar AD EMG.

Conclusions. Peak EMG at five upper-body muscles varies between jab techniques. However, the differences seem relatively small, except for the AD muscle, with a descending pattern of peak EMG for the LRH > LRB > MRH and MRB jab techniques.

Keywords: Boxing, Youth sports, Muscles, Electromyography, Musculoskeletal and neural physiological phenomena, Human physical conditioning.

Introduction

Boxing (also known as pugilism) is one of the oldest combat sports in the history of mankind (Chaabène et al., 2015). Interconnected factors like motor and psychological ability, sound technique, and tactics may impact the outcome of a boxing match (Buśko et al., 2014), as well as the selection and accurate execution of a punch above the belt, to the head or chest (Dinu & Louis, (2020). Among punching techniques, the jab is the longest-range punch used in boxing (Wigle et al., 2014). A jab is performed with several aims, such as establishing dominance or initiating further punching combinations (Gilbert, 2018; Wigle et al., 2014). Attacking an opponent with a jab is effective and energy-saving (Werner & Lachica, 2000). The jab can be executed using different techniques, such as the long-range (i.e., with step) and the medium-range (i.e., without step) jab (Wigle et al., 2014), aimed at different target areas: long-range jab targeting head, long-range jab targeting body, medium-range jab targeting head and medium-range jab targeting body. However, it is not clear which jab technique recruits which muscle in terms of peak muscle activation (Chen et al., 2021; Stanley, 2020; Walilko et al., 2005).

Electromyography activity (EMG) is useful to identify muscle recruitment and sequence of involvement during

specific movements (Carrier et al., 2015; Reaz et al., 2006; Roberts & Gabaldón, 2008). Such information may help to design better training drills and physical fitness test batteries (Oliva-Lozano & Muyor, 2020; Türker & Sözen, 2013). Putra et al. (2021), used surface EMG on dominant upper limb muscles of healthy male adult (31.9 ± 3.1 years) during punch performance (in a virtual reality environment) in standing and sitting positions, revealing no difference in the percentage of maximum EMG of upper trapezius, anterior deltoid, biceps and triceps muscles of dominant side. Shigeki et al. (2018) examined the three-dimensional trunk kinematics and surface EMG of lower back muscle activity among experienced and inexperienced male boxers (20.9 ± 1.6 years) during a straight punch with the dominant and non-dominant arms and noted greater EMG in the inexperienced group. In another study by Lockwood & Tant (1997), the authors examined the EMG of the gastrocnemius, biceps femoris, rectus femoris, external oblique, serratus anterior, pectoralis major-s ternal, anterior deltoid, and triceps brachii muscles in synchronisation with two-dimensional kinematics, while professional and amateur male boxers (24.2 ± 1.0 years) performed jabs, and noted higher wrist and elbow velocity in the professional group, although similar EMG was noted between the groups for all the assessed muscles.

Although previous studies (Lockwood & Tant, 1997; Shigeki et al., 2018) assessed EMG of muscles involved in boxing-related punching techniques, none investigated the upper body muscle EMG while performing different jab techniques. However, a study was conducted by Putra et al. (2021) investigated the EMG of upper body muscles while performing jab in standing and sitting variations indicated no significant differences. Since the study was confined to execution of jab in sitting variations and only on adults, it limits the implication of their results to young boxers. Therefore, the current study aimed at analysing the peak EMG at five upper-body muscles during four different jabs techniques in youth boxers.

Materials and methods

Study participants

To estimate the sample size of the participants, we used the G*Power software (Erdfelder et al., 1996). We had pre-set the effect size as 0.8 according to the benchmark suggested by Cohen (1988) for large effect size, α error probability as 0.05, power as 0.95, number of groups as 1, number of measurements as 4 (since a single group of boxers was repeatedly tested for four different techniques of jab), correlation among repeated measures as 0.5 and the non-sphericity correction € as 1 for repeated measures ANOVA (Lakens, 2013), the total sample size was n = 5. However, a sample of n = 8 was considered appropriate due to potential participants attrition. In addition, a greater number of participants may help to compensate for potential data death due to difficulties related to EMG recordings. For example, EMG recording is vulnerable to contamination from a variety of causes, including interference from the electrical supply, mechanical objects, stimulus objects, activity of other muscles, and fast movement (e.g., surface EMG electrodes can come off from the attached surface, or induce malfunction) (Türker, 1993). Indeed, after the completion of data collection, the equipment could not capture data for one subject. Therefore, we proceeded with a total of seven participants (n = 7, age = 17.3 ± 1.3 years, boxing experience = 5.9 ± 1.2 years) as the sample for the study. All the participants were members of a training centre and were practising to participate in an upcoming competition. The participants' height (175.3 ± 5.9 cm) and weight (72.1 ± 11.3 kg) varied since participants were competing in different weight categories. The study included those who had represented their state in junior national or higher-level competition and were free from any physical condition which might have hampered their normal physical performance.

Ethics and consent

Participants were informed about the study, methodology, possible outcomes, risks, and benefits. Then, the legal guardians of the participants signed an informed consent form that clearly mentioned the participants' right to withdraw at any time from the study. The youth participants provided verbal consent. The study was conducted in the sports biomechanics laboratory of Lakshmibai national institute of Physical Education, Gwalior, India, in accordance with the Declaration of Helsinki (World Medical Association, 2013). The study was part of a doctoral study that was approved by the departmental research committee (DRC) at the Department of Sports Biomechanics, Lakshmibai National Institute of Physical Education, Gwalior, India, with the registration number (No. Academic/Ph.D./409/1284).

Study design

The EMG of the anterior deltoid (AD), biceps brachii (BB), triceps brachii (TB), flexor carpi radialis (FCR), and upper trapezius (UT) muscles were recorded while boxers executed four jab techniques i.e., long-range targeting head (LRH), long-range targeting body (LRB), medium-range targeting head (MRH) and medium-range targeting body (MRB). All the EMG recording were obtained from the same upper-body limb preferred by the boxers to perform the punches. The whole data collection procedure was completed within one day.

Equipment and measurements

To investigate the EMG of the muscles, the BTS FREEEMG device was used (Bioengineering, 2011). The device was composed of EMG probs (up to 16 probs), a USB receiver, and the EMG-Analyzer software. Jang et al. (2018) conducted a study to establish the validity and reliability of the device and reported that the device exhibited moderate to high reliability and acceptable validity. Furthermore, Jang et al. (2018) concluded that the device is very adjustable and useful for any type and intensity of exercise because of its high accessibility and portability. For all the techniques of jab, the EMG of the five selected muscles were recorded at the frequency of 1000 Hz, using five probs and the signals were transferred and analysed using a USB receiver and the EMG-Analyzer software, respectively. The unit of measurement was microvolt (μV).

The participants were using their standard practice gloves. The size and weight of the gloves were as per the guideline of the International Boxing Association (IBA) (AIBA, 2010). As the target for different techniques of jab, medium size boxing punching bag (36" × 18") was used and hung from the practice area ceiling.

Procedure of data collection

The participants were informed and given sufficient time to familiarise themselves with the test procedure. The participants were instructed to remove their upper body wear for smooth placement of the EMG probs. The selected muscles were identified by the manual palpation method mentioned by Kothari et al. (2014). The placement of the EMG probs were undertaken as per the recommendation of the SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) project (Hermens et al., 1999). The locations for the placement of the EMG probs were shaved and cleaned with alcohol swabs (Non Woven Alcohol Swab, Recombigen Clear & Sure, India) to reduce skin impedance. The surface EMG electrodes (H124SG, Adafruit, USA) were stuck to the muscle fibres line and connected to the securely attached wireless EMG probs. The wireless EMG probs were secured with adhesive medical tape (Mendwell Adhesive Tape USP, Prominence Healthcare Pvt. Ltd., India) so that it could not come off during the execution of the techniques of jab. The EMG probs were connected wirelessly to the USB receiver, which was later linked to a laptop to extract the data using the EMG-Analyzer software. The whole BTS FREEEMG system was calibrated as per the user manual (BTS FREEEMG 300 User Manual, 2013).

After adhering the EMG electrodes and the probs on the selected muscles, the participants were given 2 minutes for mild warm-up and shadow boxing with a focus on jab techniques. After the warm-up the participants were again verified for the stickiness of the EMG electrodes and probs. Afterward, the participants were asked to execute the techniques individually. The participants were allowed to complete three valid jab attempts for each of the four assessed techniques, with 1 minute of rest between techniques.

The targets were marked on the hung punching bag using a temporary marker pen according to the participant's height. For the target head, a rectangle was drawn of the size "head length × head width" at the level of the head of the athlete. Similarly, another rectangle was drawn of the size "torso length × shoulder width" for the target body at the participant's body level. For the long-range jab technique, the participants were instructed to take a step and then execute the punch. While for the medium-range jab technique the participants throw the punch from a standing position without significant step. The distance of the leading leg to the punching bag was according to the arm length of the participants. The participants were asked to perform the techniques with their maximum effort without external motivation.

Data analysis

After extracting the data from the USB receiver, the EMG-Analyzer software displayed the analysis reports on the laptop screen. The raw EMG signals were visualised along with the processed peak value, the root mean square, and the average rectified values. However, only the processed peak value (Figure 1) was considered for further analysis. The average values from the three trials were calculated manually using Microsoft Office Excel (Microsoft Office Professional Plus 2019).

Statistical analysis

Means and standard deviations were calculated. Data normality and sphericity assumptions were verified (Shapiro-Wilk test and Mauchly's test of sphericity). A one-way repeated measures analysis of variance (ANOVA) test was applied to compare muscles EMG (AD, BB, TB, FCR, UT) between jab techniques, using the Least Significant Difference (LSD) confidence interval adjustment method as post-hoc. All statistical analyses were performed using the IBM SPSS software for Windows (version 27.0, Armonk, NY: IBM Corp). For all the calculations level of significance was set at 0.05.

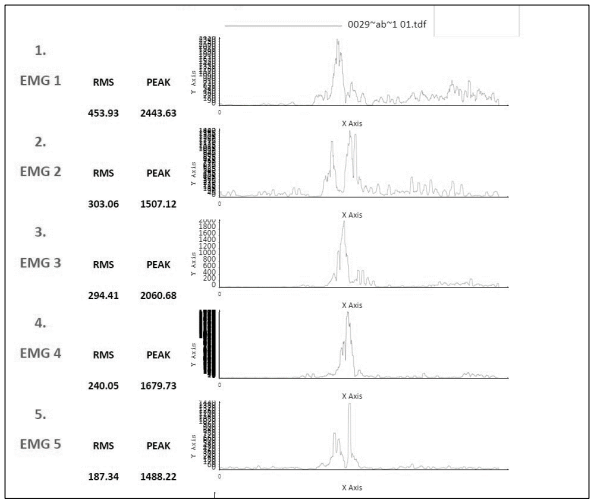

Fig. 1. Processed peak and root mean square values. Note that during jab on head target area, the biceps brachii (EMG 2) experienced activation during preparatory phase of the punch followed by anterior deltoid (EMG 1) and triceps brachii (EMG 3) during elbow extension. The flexor carpi radialis (EMG 4) showed peak activity during impact on the punching bag, followed by peak muscle activity of the upper trapezius (EMG 5) and biceps brachii (EMG 2) during termination phase of the jab.

Results

The results from table 1 display the mean and standard deviation of EMG of the selected muscles for all four techniques of jab, along with the univariate test result of the within-subject factor. The descriptive statistics reveal that for the AD and BB muscles, the technique LRH exhibited the highest peak EMG (AD = 2092.9 ± 411.9, BB = 1392.0 ± 687.3), whereas for the muscles FCR, TB, and UT, the technique MRB exhibited the highest peak EMG (FCR = 1337.2 ± 538.3, TB = 1589.3 ± 600.3, and UT = 1221.2 ± 507.5). However, the F value for the within-subject factor 'Techniques of Jab' was significant only for AD muscle (AD: $F(3, 18) = 9.738$, $p < 0.001$, $\eta p2 = 0.619$, $1-\beta = 0.989$). It indicates that the main effect of the factor 'Techniques of Jab' is significant with a large effect size ($\eta p2 \geq 0.14$) and high power ($1-\beta = 0.989$) only for the muscle AD, which explains that there were significant differences in EMG between different techniques of jab only for AD muscle. Further, the pairwise comparison table 2 among the techniques of jab for the AD muscle reveals that except for the pair MRH versus MRB, all the other pairs exhibited significant differences among themselves. Table 2 reveals that for the AD muscle, the EMG of the technique of jab LRH is significantly higher compared to LRB ($\Delta = 157.5$, $p < 0.001$), MRH ($\Delta = 411.0$, $p = 0.003$), and MRB ($\Delta = 398.3$, $p = 0.010$); while the technique LRB is significantly higher than MRH ($\Delta = 253.5$, $p = 0.024$) and MRB ($\Delta = 240.8$, $p = 0.049$); however, for the pairs MRH

Table 1. Muscle peak EMG (μV) in selected upper-body muscles in youth boxers while performing four jab techniques

Muscle	LRH	LRB	MRH	MRB	Between jab techniques comparison
AD	2092.9 ± 411.9	1935.4 ± 381.6	1681.6 ± 414.6	1694.6 ± 291.4	F (3, 18) = 9.738, p < 0.001, ηp2 = 0.619, 1–β = 0.989
BB	1392.0 ± 687.3	1195.7 ± 404.5	1275.1 ± 433.7	1365.3 ± 590.3	F (3, 18) = 0.520, p = 0.674, ηp2 = 0.080, 1–β = 0.135
FCR	1029.8 ± 502.6	1206.3 ± 479.8	1135.0 ± 465.4	1337.2 ± 538.3	F (3, 18) = 1.505, p = 0.247, ηp2 = 0.201, 1–β = 0.329
TB	1393.3 ± 596.5	1342.9 ± 693.9	1482.9 ± 378.5	1589.3 ± 600.3	F (3, 18) = 0.636, p = 0.601, ηp2 = 0.096, 1–β = 0.157
UT	1019.2 ± 508.7	1192.6 ± 510.5	1030.1 ± 498.4	1221.2 ± 507.5	F (3, 18) = 1.724, p = 0.198, ηp2 = 0.223, 1–β = 0.374

Abbreviations: AD – anterior deltoid; BB – biceps brachii; FCR – flexor carpi radialis; TB – triceps brachii; UT – upper trapezius; LRH – long-range targeting head; LRB – long-range targeting body; MRH – medium-range targeting head; MRB – medium-range targeting body. ηp^2: partial eta squared; 1–β: observed power.

Table 2. Pairwise comparison of anterior deltoid peak EMG (μV) between four different jab techniques

Pairs (jab techniques)	Mean difference
LRH versus LRB	157.5 (p < 0.001) *
LRH versus MRH	411.0 (p = 0.003) *
LRH versus MRB	398.3 (p = 0.010) *
LRB versus MRH	253.5 (p = 0.024) *
LRB versus MRB	240.8 (p = 0.049) *
MRH versus MRB	-12.7 (p = 0.911) *

*: *p* value for difference between jab techniques. *Abbreviations*: LRH – long-range targeting head; LRB – long-range targeting body; MRH – medium-range targeting head; MRB – medium-range targeting body.

and MRB (Δ = -12.7, p = 0.911) no significant difference was observed. An overview of the descriptive statistics of table 1 also reveals that among all the selected muscles, the AD muscle exhibited the highest peak EMG for all the techniques of jab (LRH = 2092.9 ± 411.9, LRB = 1935.4 ± 381.6, MRH = 1681.9 ± 414.6 and MRB = 1694.6 ± 291.4).

Discussion

During the execution of a jab in boxing, the analysis of EMG of muscles such as the biceps brachii, triceps brachii, anterior deltoid, upper trapezius and flexor carpi radialis are crucial due to their key role in the muscular recruitment sequence during punch movement (Dyson et al., 2007; Lockwood & Tant, 1997). A study by Valentino et al. (1990) already reported that there are techniques in the degree of muscle activation over different muscles and found a noticeable difference in the recruitment of muscles during a jab punch versus an uppercut, particularly on the deltoid muscle. However, in the current study the difference in peak muscle activation was observed only for AD muscle.

The current results revealed that the technique LRH exhibited the highest peak muscle activation for the AD and BB muscle, whereas the technique MRB exhibited the highest peak muscle activation for the FCR, TB, and UT muscles. The participants of the study had expressed that during the execution of the LRH technique, they were required to extend their punching arm the most. Previous studies have already explained that in doing so, the AD muscle is primarily responsible for moving the arm forward (Elzanie & Varacallo, 2022). It also explains the finding of pair wise comparison of the techniques of jabs which reveals that muscle activation of the technique LRH is significantly higher compared to LRB, MRH, and MRB, while the technique LRB is significantly higher than MRH and MRB. On the other hand, from an extended forward position of the punching arm, the BB muscle was required to work harder in the LRH technique compared to the other techniques to flex the arm to the original position. That is why the results show that the LRH technique exhibited highest peak muscle activation for the AD and BB muscles.

While performing the techniques targeting the body, the forearm tended to pronate more which caused the FCR and TB to activate more during the execution of those techniques. At the same time, the UT functioned to stabilize the downward movement of the arm while targeting the body. That is why for the muscles FCR, TB, and UT, the MRB technique of jab exhibited the highest peak muscle activation.

In another study, Dyson et al. (2007) reported higher punching force and speed when the target area was head over the body. The study also validated that when a lead arm straight punch is thrown on the head, there is a quarter turn of the torso and pelvis, which adds additional torque to the upper body movement and due to which peak muscular activity might be observed for the deltoid and biceps muscle group. It is observed that FCR begins at the medial epicondyle of the humerus and connects to the second metacarpal at the base, and it is crucial for flexing and abducting the hand at the wrist (Kanevsky et al., 2015), whereas the flexion of the wrist is an involuntary movement during impact on the target area in boxing, so highest peak activation for FCR muscle might be due to more flexion at the wrist joint during the execution of jab in MRB technique. The TB muscle is responsible for the extension of the elbow at shoulder elevation and contributes more to elbow extension (Kholinne et al., 2018), while UT is also responsible for elevation and depression of the shoulder (Shih & Kao, 2011). Hence, the highest peak muscle activation for the TB & UT muscles in the technique MRB might be observed due to more elbow extension and higher shoulder elevation while executing the jab at the body target area in the medium range.

Some potential limitations should be acknowledged. The investigators felt that there was a limitation of sample size in the study. Further studies with greater sample size should attempt to replicate current findings.

Conclusions

Peak muscle activation at five upper-body muscles may vary depending on the jab technique preferred by the youth boxers. However, differences between jab techniques seems relatively small, except for the AD muscle, with a descending pattern of peak EMG for the LRH > LRB > MRH and MRB jab techniques.

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Conflict of Interest

The authors declare no conflict of interest.

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ВПЛИВ РІЗНИХ ТЕХНІК ДЖЕБА НА МАКСИМАЛЬНУ АКТИВАЦІЮ М'ЯЗІВ ВЕРХНЬОЇ ЧАСТИНИ ТІЛА В БОКСЕРІВ-ЮНАКІВ

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Реферат. Стаття: 6 с., 2 табл., 1 рис., 34 джерела.

Мета дослідження полягала в тому, щоб проаналізувати максимальну амплітуду ЕМГ п'яти м'язів верхньої частини тіла під час виконання чотирьох різних технік джеба в боксерів-юнаків.

Матеріали та методи. У боксерів-юнаків національного рівня (n=7, чоловічої статі) оцінювали максимальну амплітуду електроміографії (ЕМГ) переднього дельтоподібного м'яза (ПДМ), двоголового м'яза плеча (ДМП), триголового м'яза плеча (ТМП), променевого м'яза-згинача зап'ястка (ПМЗЗ) та верхнього трапецієподібного м'яза (ВТМ) під час виконання ними чотирьох технік джеба: з дальньої дистанції в голову (ДДГ), з дальньої дистанції в корпус (ДДК), із середньої дистанції в голову (СДГ) та із середньої дистанції в корпус (СДК).

Результати. Джеб ДДГ викликав максимальну амплітуду ЕМГ м'язів ПДМ (2092,9±411,9) та ДМП (1392,0±687,3). Джеб СДК викликав максимальну амплітуду ЕМГ м'язів ПМЗЗ (1337,16±538,28), ТМП (1589,3±600,3) та ВТМ (1221,2±507,5). Проте залежно від техніки виконання джеба лише м'яз ПДМ показував достовірну ($p<0,001$) відмінну амплітуду ЕМГ. Конкретно, джеб ДДГ викликав більшу амплітуду ЕМГ м'яза ПДМ порівняно з джебами ДДК (157,5 [$p<0,001$]), СДГ (411,0 [$p=0,003$]) та СДК (398,3 [$p=0,010$]). Крім того, джеб ДДК викликав більшу амплітуду ЕМГ м'яза ПДМ порівняно з джебами СДГ (253,5 [$p=0,024$]) та СДК (240,8 [$p=0,049$]). Джеби СДГ та СДК (-12,7 [$p=0,911$]) викликали подібну амплітуду ЕМГ м'яза ПДМ.

Висновки: Максимальна амплітуда ЕМГ п'яти м'язів верхньої частини тіла різниться залежно від техніки виконання джеба. Проте ці відмінності здаються відносно невеликими, за винятком м'яза ПДМ, який демонструє спадний характер максимальної амплітуди ЕМГ для технік джеба ДДГ > ДДК > СДГ та СДК.

Ключові слова: бокс, юнацький спорт, м'язи, електроміографія, м'язово-скелетні та нейрофізіологічні явища, фізична підготовка людини.

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ORIGINAL SCIENTIFIC ARTICLE

PATTERN RECOGNITION: THE SPECIFIC FEATURES OF TEACHING THE STANDING LONG JUMP TO 14-YEAR-OLD GIRLS

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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

The study purpose was to determine the specific features of the effect of the number of repetitions and rest intervals on the effectiveness of the standing long jump training program for 14-year-old girls.

Materials and methods. The study participants were 40 girls aged 14. The study participants were informed about all the features of the experiment and gave their consent to participate therein. The study used methods of analysis of scientific and methodological literature, observation, pedagogical experiment, and methods of mathematical statistics. The pedagogical experiment was designed as a full factorial experiment with a 2κ factorial design. The effect of the number of repetitions (6 to 12 times) and the rest interval (60 to 120 s) on the effectiveness of the standing long jump training program for 14-year-old girls was investigated. Discriminant analysis was used for data analysis.

Results. The analysis of the experimental data showed that the modes of alternating physical exercise performance and rest intervals have a statistically significant effect on the formation of the motor skill of standing long jump in 14-year-old girls ($p < 0.001$). It is after the third exercise performance mode that the girls spent the smallest total number of repetitions required for the formation of the standing long jump skill. Thus, the 1st, 4th and 6th series of training tasks are learned faster after the third exercise performance mode, the 3rd series of training tasks is learned faster after the second exercise performance mode, and the 2nd and 5th series of training tasks are learned faster after the fourth exercise performance mode ($p<0.001$).

Conclusions. It was established that the mode of alternating exercises in 3 sets of 2 repetitions with a rest interval of 120 s is classified as the most rational. A specific feature of the formation of the motor skill is that each of the modes can be considered as a priority for one or another motor task. In the investigation of the learning process, discriminant analysis makes it possible to classify work modes and determine the relationship between the motor tasks within the training program.

Keywords: 14-year-old girls, standing long jump, exercise performance modes, discriminant analysis.

Introduction

Forming motor skills (Ivashchenko, Berezhna, & Cieślicka, 2020; Khudolii, Iermakov, & Bartik, 2020; Petrov, Khudolii, & Cieślicka, 2020), developing motor abilities (Khudolii, Ivashchenko, Iermakov, Veremeenko, & Lopatiev, 2019; Marchenko & Bezpalko, 2020; Ivashchenko, Mirosława, Nosko, & Malyshev, 2019), and increasing motor activity (Fisher, Reilly, Kelly, Montgomery, Williamson, Paton, & Grant, 2005; Fernández-Valero, Soto-Sánchez, Páez, Leyton-Dinamarca, Kain, Hurtado, & Reyes-Amigo, 2021; Nurulfa, Lubis, Dlis, Aninggar, & Mamesah, 2021) are the main tasks of school physical education and have a positive effect on the health of school students (Vandoni, Codella, Pippi, Pellino, Lovecchio, Marin, Silvestri, Gatti, Magenes, Regalbuto, Fabiano, Zuccotti, & Calcaterra, 2021; Villafaina, Fuentes-García, Leon-Llamas, & Collado-Mateo, 2021; Vlasova, 2020).

Selection of motor tasks (Thomaidou, Konstantinidou, & Venetsanou, 2021; Suprun, Ivashchenko, & Cieślicka, 2021; Khakovshchenko, 2022), organization of training programs that ensure a guaranteed level of mastery of physical exercises, and control of the quality of training (de Mooij, Fekkes, Scholte, & Overbeek, 2020; Ivashchenko, 2020; Schneeberger, & Jarosch, 2022), and modes of alternating exercise performance and rest intervals (Marchenko, Jagiello, Iermakov, Ivashchenko, & Khudolii, 2021; Marchenko,

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Ivashchenko, Jagiello, Iermakov, Khudolii, & Yermakova, 2022; Shuieva, Ivashchenko, & Jagiello, 2021) are of importance in teaching physical exercises.

In the structure of programs such as algorithmic instructions, it is mandatory to determine the necessary level of motor fitness, which includes motor experience and the level of development of motor abilities (Khudolii, 2009). The achievement of the appropriate level of development of motor abilities is influenced by the accounting and control of the operational, delayed (Khudolii, Ivashchenko, Iermakov, Nosko, & Marchenko, 2019; Ivashchenko, Khudolii, Prusik, & Giovanis, 2020; Khudolii, Iermakov, Ivashchenko, & Nosko, 2020), and cumulative training effect of strength exercises (Veremeenko, 2019; Iermakov, Ivashchenko, & Khudolii, 2021). Optimizing the time allocated to teaching and developing motor abilities is important for increasing the effectiveness of the learning process in a physical education class (Ivashchenko, Iermakov, & Khudolii, 2021).

To substantiate the training program, methods of mathematical statistics are used, such as correlation, factor and discriminant analysis (Ivashchenko, 2020). Since the quality of the implementation of the programs depends on the modes of alternating exercise performance and rest intervals (Shuieva, Ivashchenko, & Jagiello, 2021; Yunak, Ivashchenko, Nosko, & Nosko, 2022; Marchenko, Ivashchenko, Jagiello, Iermakov, Khudolii, & Yermakova, 2022), the choice of discriminant analysis will make it possible to classify work modes and determine the relationship between the motor tasks within the training program (Silverman, Woods, & Subramaniam, 1998; Vandorpe, Vandendriessche, Vaeyens, Pion, Lefevre, Philippaerts, & Lenoir, 2011; Rebelo-Gonçalves, Coelho-e-Silva, Severino, Tessitore, & Figueiredo, 2015).

The study purpose was to determine the specific features of the effect of the number of repetitions and rest intervals on the effectiveness of the standing long jump training program for 14-year-old girls.

Materials and methods

Study Participants

The study participans were 40 girls aged 14. The study participants were informed about all the features of the experiment and gave their consent to participate therein.

Study Organization

The study used methods of analysis of scientific and methodological literature, observation, pedagogical experiment, and methods of mathematical statistics.

The pedagogical experiment was designed as a full factorial experiment with a 2^k factorial design. The effect of the number of repetitions (6 to 12 times) and the rest interval (60 to 120 s) on the effectiveness of the standing long jump training program for 14-year-old girls was investigated (Table 1). The study recorded the number of repetitions necessary for the correct performance of the task in three consecutive repetitions.

Standing long jump technique. Before jumping, the school student places his feet parallel at a distance of 10–15 cm, performs a rhythmic half-squat with the body leaning forward, with arm movements back and forth, without separating the heels from the ground. Significantly leaning the body forward and losing balance, sharply extends the legs and body, makes a wave of the arms forward and upward so that by the end of the take-off, the legs, body and arms form one straight line at an angle of 45°. The main feature of the standing long jump technique (besides the lack of running) is that the take-off is performed simultaneously with both legs.

Table 1. Design of the full factorial experiment with a 2^k factorial design

Experimental groups	N	Number of repetitions, times	Rest interval, s
1	10	6 (3 sets of 2 repetitions)	60
2	10	12 (6 sets of 2 repetitions)	60
3	10	6 (3 sets of 2 repetitions)	120
4	10	12 (6 sets of 2 repetitions)	120

In flight, the school student needs to relax his muscles and maintain a short pause in free flight, before the end of which the school student's body assumes an arched position. In the second half of the flight, the school student prepares for landing: he quickly lowers his arms forward-down-back, pulls his knees to his chest and, extending his legs at the knee joints, 'throws' his lower legs forward. The end of leg extension in the knee joints should coincide with the moment of landing.

Landing, complement the movements by bringing the pelvis forward, strongly arching in the lumbar part of the spine (by bringing the pelvis forward) and rolling over the toes, it is important not to lose balance and not to fall back. To this end, the legs are extremely bent at the knee joints, and the arms are actively extended forward.

Standing long jump exercise training program. The program of algorithmic instructions was organized taking into account the data of Hohin and Hohina (2006, 2008), Khudolii (2009) and included six series of training tasks (Table 2).

Statistical Analysis

The experimental data were processed using the SPSS 20 statistical analysis application software. Discriminant analysis was carried out.

The study protocol was approved by the Ethics Committee of the University. Furthermore, the children and their parents or legal guardians were fully informed about all the special aspects of the study and a signed informed consent document was obtained from all parents.

Results

The experimental data analysis showed that the modes of alternating physical exercises and rest intervals have a statistically significant effect on the formation of the motor skill of standing long jump in 14-year-old girls ($p<0.001$). It is after the third exercise performance mode that the girls spent the smallest total number of repetitions required for the formation of the standing long jump skill. Thus, the 1st, 4th and 6th series of training tasks are learned faster after the third exercise performance mode, the 3rd series of training

Table 2. Standing long jump exercise training program

Information frame (what we perform)	Operational frame (how we perform)	Control frame (proceed to learn the next exercise)
	First series of training tasks:	
30 s rope jumping.	а) on two legs with forward rotation; б) on two legs with backward rotation.	If the school student performs 40 to 50 jumps, then proceed to the next exercise.
Jumps with straight legs pulled up.	Taking off with two legs, in place.	If the school student performs 10 to 15 jumps, then proceed to the next exercise.
Multiple forward jumps.	On two legs, 8 to 12 jumps.	If the school student performs 3 series, then proceed to the next exercise.
	Second series of training tasks:	
Performing imitative movements with arms, in place.	Half-squats with the torso bends forward, arm movements back and forth, without separating the heels from the surface.	If the school student performs 3-4 series of 2-3 rhythmical movements, then proceed to the next exercise.
Take the correct landing position and fix it for 5 s.	Squat on the whole foot, feet parallel at a distance of 10–15 cm, hands forward outward, head straight.	If the school student performs 4 to 6 times, then proceed to the next exercise.
Vertical jump in place.	Landing in a squat on the toes with a transition to the whole foot.	If the school student performs 10 to 12 times, then proceed to the next exercise.
	Third series of training tasks:	
Jumps on two legs with the knees pulled up to the chest.	Taking off with two legs, in place.	If the school student performs 10 to 12 times, then proceed to the next exercise.
From a lying support, push the arms and legs to squat, arms forward.	When performing this exercise, the school student needs to ensure that after pushing with his hands and legs, there is an airborne phase, the flight phase.	If the school student performs 10 to 12 times, then proceed to the next exercise.
Bringing the pelvis forward.	By strongly arching in the lumbar part of the spine.	Be able to perform in a series of 5 attempts.
Multiple jumps forward-up from a squat.	2-3 series of 10–15 times.	If the school student performs, then proceed to the next exercise.
	Fourth series of training tasks:	
Multiple jumps up and forward in jumps from foot to foot.	2 series of 10–15 times.	If the school student performs, then proceed to the next exercise.
Squats on one leg.	10 to 12 squats on each leg.	If the school student performs 2-3 series, then proceed to the next exercise.
Jumping out of a squat on one leg.	Repeat 3-4 times on each leg.	If the school student performs 2-3 series, then proceed to the next exercise.
	Fifth series of training tasks:	
Jumps on two legs over obstacles 50 cm high.	Perform with a stronger push of the legs.	If the school student performs 3–5 series of 4–6 times, then proceed to the next exercise.
Jumps on two legs with forward movement.	Complicating the exercise by touching landmarks with hands.	If the school student performs 4–6 series of 4–6 times, then proceed to the next exercise.
Standing jump with double take-off onto an elevated support.	Pay attention to take-off.	If the school student performs 2 series of 10 times, then proceed to the next exercise.
	Sixth series of training tasks:	
Standing long jump preceeded by 2-3 rhythmic squats with the torso bends forward.	Perform the exercise as quickly as possible, keeping to the technique.	Be able to perform in a series of 3–5 attempts.
Standing long jump with back-and-forth arm movements without leaving the heels off the ground.	Perform the exercise as quickly as possible, keeping to the technique.	Be able to perform in a series of 3 attempts.
Standing long jump.	Perform the exercise in accordance with the technique described above.	The correct performance of a series of 3–5 attempts.

tasks is learned faster after the second exercise performance mode, and the 2nd and 5th series of training tasks are learned faster after the fourth exercise performance mode ($p<0.001$) (Table 3).

The conducted discriminant analysis indicates the statistical significance of the obtained discriminant functions (Tables 4, 5). The first and second discriminant functions explain 93.9% of the variation in the results and have high canonical correlation values. Testing of the functions indicates their reliability in the classification of the modes of exercise performance and rest intervals based on the results of formation of the motor skill of standing long jump in 14-year-old girls.

The standardized coefficients of the discriminant functions made it possible to establish the weight of motor tasks

Table 3. Group Statistics. Tests of Equality of Group Means

Training tasks	Exercise performance modes								F	p
	1		2		3		4			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
1st series of training tasks	4.6	0.69921	6.2	0.42164	3.3	0.67495	4.0	0.66667	39.043	0.000
2nd series of training tasks	11.2	1.81353	11.5	1.35401	9.7	1.33749	7.9	1.52388	11.794	0.000
3rd series of training tasks	7.2	1.03280	5.9	0.99443	11.6	1.26491	8.0	0.94281	52.482	0.000
4th series of training tasks	9.8	1.22927	9.4	1.42984	6.0	0.81650	11.8	1.31656	38.933	0.000
5th series of training tasks	10.5	1.58114	12.7	1.49443	13.2	1.54919	9.7	1.33749	12.803	0.000
6th series of training tasks	6.8	2.61619	10.5	3.56682	5.6	2.98887	12.0	3.16228	9.471	0.000
Total repetitions	50.1	1.49535	56.2	1.54352	49.4	1.43865	53.4	1.49161		

Table 4. Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	10.497	67.1	67.1	0.956
2	4.192	26.8	93.9	0.899
3	0.955	6.1	100.0	0.699

Table 5. Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 3	0.009	161.830	18	0.000
2 through 3	0.099	78.798	10	0.000
3	0.512	22.794	4	0.000

Table 6. Standardized Canonical Discriminant Function Coefficients

Series of training tasks	Function		
	1	2	3
1st series of training tasks	0.511	0.501	0.407
2nd series of training tasks	0.315	0.165	-0.843
3rd series of training tasks	-0.844	-0.185	0.164
4th series of training tasks	0.284	-0.853	-0.146
5th series of training tasks	-0.304	0.491	0.440
6th series of training tasks	0.099	0.047	0.722

under different exercise performance modes. Thus, in the analysis of the four exercise performance modes, the third and first series of training tasks have the greatest weight (first function); in the analysis of 2-4 exercise performance modes, the fourth series of training tasks has the greatest weight (second function); and in the analysis of 3-4 exercise performance modes, the second and sixth series of training tasks have the greatest weight (third function) (Table 6).

The structure coefficients of the discriminant functions indicate a correlation between the motor tasks and the function values. Thus, the third and first series of training tasks have the highest correlation with the first function; the fourth and fifth series of training tasks have the highest correlation with the second function; and the second and sixth series of training tasks have the highest correlation with the third function (Table 7).

Table 7. Structure Matrix

Series of training tasks	Function		
	1	2	3
3rd series of training tasks	-0.645	-0.008	0.033
1st series of training tasks	0.490	0.401	0.245
4th series of training tasks	0.397	-0.608	0.210
5th series of training tasks	-0.114	0.458	0.227
6th series of training tasks	0.170	-0.185	0.598
2nd series of training tasks	0.129	0.379	-0.466

Table 8. Functions at Group Centroids

Exercise performance modes	Function		
	1	2	3
1	1.342	-.399	-1.542
2	3.317	2.198	0.691
3	-4.988	1.160	0.094
4	0.328	-2.959	0.758

The Functions at Group Centroids analysis shows that the third and second modes of exercise performance are diametrically distinguished by the total effect on the formation of the motor skill of standing long jump. The third mode of exercise performance has the greatest total effectiveness in the formation of the motor skill (Table 8).

Discussion

The study found out the specific features of the formation of the motor skill of standing long jump in 14-year-old girls depending on the modes of alternating exercise performance and rest intervals. It was established that the mode of alternating exercises in 3 sets of 2 repetitions with a rest interval of 120 s is classified as the most rational. The obtained data complement the results of the study on the influence of work modes on the formation of motor skills (Marchenko et al, 2021, 2022; Shuieva et al., 2021).

A specific feature of the formation of the motor skill is that each of the modes can be considered as a priority for one or another motor task. On the one hand, in the process of the motor skill formation, a physical education teacher can change over from one mode to another; on the other hand,

choosing the best mode based on the total score improves the controllability of the learning process. So, the proposed exercise performance modes characterize the integrity of the learning process and contribute to increasing the motor activity of girls. The data complement the results of the study on the organization of the learning process having an effect on the increase in motor activity of school students (Fisher et al., 2005; Fernández-Valero et al., 2021; Nurulfa et al, 2021).

The analysis of the standardized and structure discriminant function coefficients made it possible to identify the training tasks that have the greatest weight and the highest correlation with the results of the discriminant functions. The obtained data give grounds for asserting that the training tasks are interconnected and characterize an integral standing long jump training program for 14-year-old girls. The data complement the results of the study on the importance of selecting motor tasks and organizing training programs (Thomaidou et al., 2021; Suprun et al., 2021; Kharkovshchenko, 2022) and the results of the study on discriminant analysis making it possible to classify work modes and determine the relationship between the motor tasks within the training program (Silverman et al., 1998; Vandorpe et al., 2011; Rebelo-Gonçalves et al., 2015).

The effectiveness of using discriminant analysis is confirmed by the fact that 95% of the data were classified correctly (Table 9). A graphical display of the results of the classification of the modes of performance of training tasks in the process of teaching the standing long jump to 14-year-old girls makes it possible to choose the best option (Fig. 1).

Table 9. Classification Results[a]

		Exercise performance modes	Predicted Group Membership				Total
			1	2	3	4	
Original	Count	1	8	0	0	2	10
		2	0	10	0	0	10
		3	0	0	10	0	10
		4	0	0	0	10	10
	%	1	80.0	.0	.0	20.0	100.0
		2	.0	100.0	.0	.0	100.0
		3	.0	.0	100.0	.0	100.0
		4	.0	.0	.0	100.0	100.0

a. 95.0% of original grouped cases correctly classified.

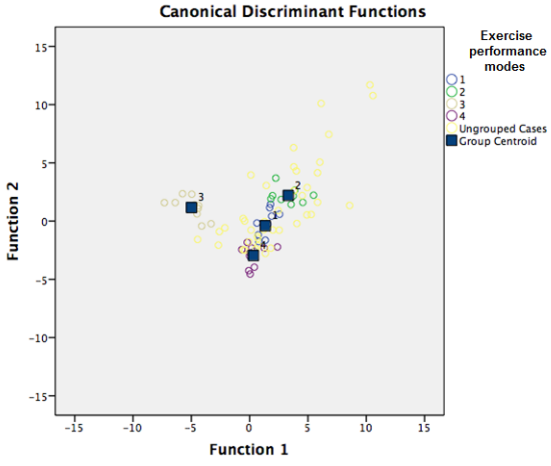

Fig. 1. Canonical discriminant functions. A graphical display of the results of the classification of the modes of performance of training tasks in teaching the standing long jump to 14-year-old girls: ▪ – centroids for training task performance modes 1, 2, 3, 4.

Conclusions

It was established that the mode of alternating exercises in 3 sets of 2 repetitions with a rest interval of 120 s is classified as the most rational. A specific feature of the formation of the motor skill is that each of the modes can be considered as a priority for one or another motor task.

In the investigation of the learning process, discriminant analysis makes it possible to classify work modes and determine the relationship between the motor tasks within the training program.

Conflict of Interest

The authors declare no conflict of interest.

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РОЗПІЗНАННЯ ОБРАЗІВ: ОСОБЛИВОСТІ ПРОЦЕСУ НАВЧАННЯ СТРИБКУ У ДОВЖИНУ З МІСЦЯ ДІВЧАТ 14 РОКІВ

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

Реферат. Стаття: 7 с., 9 табл., 1 рис., 34 джерела.

Мета дослідження – визначити особливості впливу кількості повторень та інтервалів відпочинку на ефективність програми навчання стрибку у довжину з місця дівчат 14 років.

Матеріали і методи. У дослідженні прийняли участь 40 дівчат 14 років. Учасники дослідження були ознайомлені з особливостями проведення експерименту і надали згоду на участь в ньому. У дослідженні використані методи аналізу науково-методичної літератури, спостереження, педагогічний експеримент, методи математичної статистики. Педагогічний експеримент був організований за планом ПФЕ типу $2^{к}$. Вивчався вплив кількості повторень (6-12 раз) та інтервалу відпочинку (60-120 с) на ефективність програми навчання стрибку у довжину з місця дівчат 14 років. Для аналізу даних був використаний дискримінантний аналіз.

Результати. Аналіз експериментальних даних показав, що режими чергування виконання фізичних вправ та інтервалів відпочинку статистично достовірно впливають на формування рухової навички стрибку у довжину з місця дівчат 14 років ($p < 0.001$). Найменшу сумарну кількість повторень на формування навички стрибку у довжину з місця дівчата витратили після третього режиму виконання вправ. Так, 1, 4 та 6 серії навчальних завдань швидше засвоюється після третього режиму виконання вправ, 3 серія навчальних завдань – після другого режиму виконання вправ, 2 та 5 серії навчальних завдань – після четвертого режиму виконання вправ ($p < 0,001$).

Висновки. Встановлено, що режим чергування вправ 3 підходи по 2 рази з інтервалом відпочинку 120 с класифікується як найбільш раціональний. Особливістю формування рухової навички є те, що кожен з режимів може розглядатися як пріоритетний для того чи іншого рухового завдання. У дослідженні процесу навчання дискримінантний аналіз надає можливість здійснити класифікацію режимів роботи і визначити взаємозв'язок рухових завдань програми навчання.

Ключові слова: дівчата 14 років, стрибок у довжину з місця, режими виконання вправ, дискримінантний аналіз.

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REVIEW ARTICLE

STANCE OF SPORTS AND FITNESS: A SCIENTOMETRIC REVIEW

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Abstract

Background. Sport and fitness are physical requirements in the same way that humans require food and water. On the other hand, sport and fitness is a highly complex field of study, complicating attempts to define critical terms, resulting in a relative lack of scientometric analysis.

The study goal is to look at the development of sport and fitness research around the world, using the Scopus and Web of Science databases as its foundation.

Materials and methods. Publications are gathered using the Scopus and Web of Science databases as well as scientometric parameters, including worldwide publication trends, the authors who receive the most citations, the amount of citations, and author keywords.

Results. The results show the authors' keywords analysis was inspected based on their relationship to physical activity, physical exercise, and physical training. The United States was the most active country, with 601 publications. As expected, the United States is a leader in physical activity promotion, with 19.3 percent of the population participating in sports and exercising daily in 2019. The International Journal of Environmental Research and Public Health from Switzerland leads 68 publications, which is another noteworthy finding. Additionally, according to this analysis, Ortega, F.B., of the School of Medicine, University of Granada, Madrid, Spain, is the author who publishes the most documents with 33 in total.

Conclusions. According to our research, the top five keywords that gained traction over the previous two years were "Cardiorespiratory Fitness," "Body Composition," "Health," "Physical Activity," and "Adolescents." The study value to the field of sports and fitness is that it provides readers and upcoming researchers with a wide range of sports and fitness trends from the past and present. Additionally, the study findings will aid future academics in predicting potential industry trends.

Keywords: Sports and fitness, Physical activity, Cardiorespiratory fitness, Scientometric.

Introduction

Fitness became extremely popular toward the end of the twentieth century. And as the fitness industry grew in prominence over the next decade, it sparked increased interest in newspapers and other media outlets (Agerbo, 2016). It is also the shreds of evidence that wearable sports and fitness technologies have found commercial success (Vidal et al., 2021). Wearable technology, the top fitness trend worldwide since 2016, is evolving rapidly and unpredictably, and the wearables industry is expected to be worth US$27 billion by 2022 (Ash et al., 2020; Düking et al., 2018; Thompson, 2018). In Europe, 40,000 sports and fitness facilities attract 40 million customers, while the same customer base in the United States generates annual revenue of around 22 billion USD (Avourdiadou & Theodorakis, 2014). The United States Department of Labor reported over 260,000 instructors in 2012. European countries have seen the same trend: the Ministry of Youth Affairs and Sports in France recorded 10,000 gyms in 2013 (Fontan et al., 2017). Furthermore, a recurring theme in the marketing and service literature is the need for more comprehensive models to clarify the role of the main

drivers explaining customer loyalty (behavioural intentions and purchase decisions), particularly in the context of sports and fitness (Theodorakis et al., 2014). This demonstrates that sport and fitness are an unavoidable requirement for every individual to support various activities and productivity. It is an up-and-coming field of science in the future.

The world's population now includes sports and physical education as part of their lifestyles (Sofyan et al., 2022). Keeping health as a top priority and advancing education reforms emphasising sports are both imperatives that must be upheld (Chen & Chen, 2017). In addition to traditional fitness activities, exercise may assist in achieving fitness goals (Beaudet et al., 2004). People who participate in fitness activities work to change their body capital in terms of physical appearance (e.g., lean, toned) and bodily functions (e.g., strong body) (Stewart et al., 2013). Understanding the factors that influence sports participation is critical for encouraging physical activity and the development of an active lifestyle (De Meester et al., 2020). Exercise and fitness are allotted a limited amount of time (Crook, 2013). Nonetheless, as sports and fitness grow in popularity, so does the demand for professionals in sports information. As a result, sports information becomes more accessible to the general public and the sports community.

When it comes to health benefits, exercise is a two-edged sword. The beneficial effect is primarily achieved through physical activity, which is a significant component of most sports (Malm et al., 2019). Sport and fitness, on the other hand, is a very complex field of study, making it challenging to define critical terms (Kielty, 2010). Recent research indicates that fitness and exercise accompany various social, economic, and physical environmental factors, but some issues, such as how people engage in fitness activities, have received little attention (Wu et al., 2018). Sports as a form of physical fitness should embrace the idea of low-carbon energy, promote physical activity in an environment that is energy-efficient, foster a vibrant fitness culture, encourage people to lead healthy lives through scientific fitness, protect the environment in a variety of ways, and make an energy-saving and low-carbon contribution to the sports industry (Li, 2012).

Several upstream studies have been conducted. People with lower levels of physical fitness are frequently in poorer health (Robertson et al., 2000). Adolescents' negative impact on secondary health conditions can be reduced by improving their basic motor skills and physical fitness as they enter adulthood (Foley et al., 2008). It is well established that maintaining a high level of physical fitness has numerous positive effects on adolescents' mental and physical health, including preventing obesity, cardiovascular and metabolic illness, and musculoskeletal issues (i.e., depression, anxiety, stress, and quality of life) (Biernat, 2011; Esteban-Cornejo et al., 2014; Janssen & Leblanc, 2010; Smith et al., 2014). Popular among kids, sport is a systematic kind of physical activity that has been connected to a range of psychological and social health outcomes, including improved social skills, lower depressive symptoms, higher self-esteem, and higher competence (Eime et al., 2013).

Due to the importance of sport and fitness, many studies have been carried out to scale most of the topics related to physical activity (Barber, 2007; Elbe et al., 2017; Fenton et al., 2016), national fitness policies (Tan, 2015), exercise and the environment (Thorpe et al., 2021), fitness and health (Grant et al., 2014), recovery and rehabilitation (Morton et al., 2016), multi-activity sports (Gerdin & Pringle, 2017), event marketing (Kurscheidt et al., 2003), neuromuscular and metabolic (Vachon et al., 2020), fitness center business (León-Quismondo et al., 2020), fitness industry (Zhang & Wang, 2012). In addition, several scientometric studies have been conducted regarding the evaluation of sports source titles (Blaginin et al., 2020; Elahi et al., 2020; Kusugal, 2018); positive youth development (Qi et al., 2022); athletic performance (Lombardo & Emiah, 2014); sports science (Yaminfirooz et al., 2014); eSports (Vanegas et al., 2018); sports sociology (Tian & Wise, 2020); sport sciences researchers (Soufi et al., 2018); fitness model (Ke, 2013).

Despite the importance of exercise and sports, scientometrics research in this area has not received much attention. The goal of this study is to analyze major works in the disciplines of sports and fitness that were published between 1919 to 2022. It is crucial to spot trends in research that has been published in journals in order to summarize the state of the literature at the time of this study. Responses to the following research questions were sought:

1. What are the most well-known sources, representative nations, and important organizations in the field of sport and fitness research?
2. What are the author's main keyword sources and influential sports and fitness-related topics?
3. How the major author keyword in the sports and fitness industries has changed over the past few decades?

Reasons for Scientometric Analysis

Using mathematical statistics, computing technology, and other mathematical techniques, scientometrics is a quantitative analysis of the input, output, and process of scientific activity (Zhou et al., 2019). Scientometrics is the creation of quantitative research techniques for the examination of the growth of science as a process for the transmission of knowledge (Chellappandi & Vijayakumar, 2018; Gonzales et al., 2021; Mingers & Leydesdorff, 2015; Ramy et al., 2018), communication in science, and science policy (Mohan & Kumbar, 2021; Velmurugan & Radhakrishnan, 2015), while analyzing patterns and the slow progression of scientific findings (Nyika et al., 2021). In comparison to the sociology of science, scientometrics has advanced significantly, and it now more closely resembles library and information science (Leydesdorff & Milojević, 2015). To have a deeper knowledge, scientometric analysis is required (Lai et al., 2017).

Scientometrics frequently employs statistical and mathematical techniques to quantitatively and qualitatively examine scientific literature (Nath & Jana, 2021). The benefits of research collaboration have been amply demonstrated through the application of scientometrics and social network analysis (Ceballos et al., 2017). Scientometric data is a tool for analyzing the quality and productivity of scientific research, as well as the breadth and advancement of scientific research (Wani & Zainab, 2017; Young et al., 2015). ScientoPy is a script-based Python tool for performing temporal scientometric analysis. We can use temporal analysis to pinpoint the emergence of a new phenomenon and its

development into a trend or emerging issue (Ruiz-Rosero et al., 2017). Throughout the course of this study, scientometric indicators pertaining to publication, topic, source title, and citation trends and progressions were examined (Li et al., 2016). Numerous bibliographic databases are analyzed using the scientometric methodology (Martynov et al., 2020). Locating and extracting papers on a research-related topic is the first stage in performing a scientometric study (Malakoutikhah et al., 2021).

Materials and methods

The number of publications in any field of study contributed to persuasive arguments for scholars to collect relevant (Aziz et al., 2022). In order to fully comprehend the patterns of sport and fitness research, this study uses information framework mapping methods to analyze the research situation and construct the existing theoretical structure (Abdullah, 2021), the objectives of the research must be made clear early on in this review (Abdullah & Abd Aziz, 2021). ScientoPy software was used to analyze this scintometric analysis. A special piece of software for analyzing bibliographic records is called ScientoPy. It is a Python script that creates a list of the most popular themes by author, author, and nation keywords, as well as related papers (Pabon et al., 2020), and it removes the chance of bias that can happen in individual studies (Ruiz-Rosero et al., 2017). hroughout the course of this study, scientometric indicators pertaining to publication, topic, source title, and citation trends and progressions were examined (Li et al., 2016). Numerous bibliographic databases are analyzed using the scientometric methodology (Martynov et al., 2020). Locating and extracting papers on a research-related topic is the first stage in performing a scientometric study (Malakoutikhah et al., 2021). However, analyzing author names (such as those on a primary list of authors) poses a risk of bias in the study because of potential name similarity.

Search Strategy

On October 8, 2022, data was collected from two well-known databases with high impact factors, Scopus and Web of Science (WoS). Initially, the string search strategy used TITLE-ABS-KEY in Scopus and Topic in WoS, but the amount of metadata was very large, and many articles were not related to sports and fitness after manual checking of existing documents. As a result, the search strategy was modified to use the search string TITLE. As a result, 3,013 documents were obtained from the Scopus database and 3,267 documents from the WoS database. The keyword terminology is well-known and not novel, particularly among sports researchers. For instance, there are a lot of published data in other, more well-known topics and disciplines. Additionally, publications whose authors did not use the acronym sports and fitness in terms that correspond to the terminology have been located using the conjunction "OR." In table 1, the search string and data retrieval in both databases are explained.

Data repossession and management

All duplicate articles can be removed by Scientopy software during data pre-processing. In this study, repossession data was pre-processed. ScientoPy processed data at this stage using the following document types: conference paper, article, review, and proceeding paper (Ruiz-Rosero et al., 2019). This research excluded books, book series, and letters. The simplification of author names is another function of pre-processing. The author's initial and last names frequently don't match up in published works. By applying preprocessing, ScientoPy may condense names, accents, and abbreviations. due to the fact that names are shortened or simplified while discussing things like countries, language, and organisations (Pabon et al., 2020). Figure 1 shows the accuracy of data collection and using PRIMA.

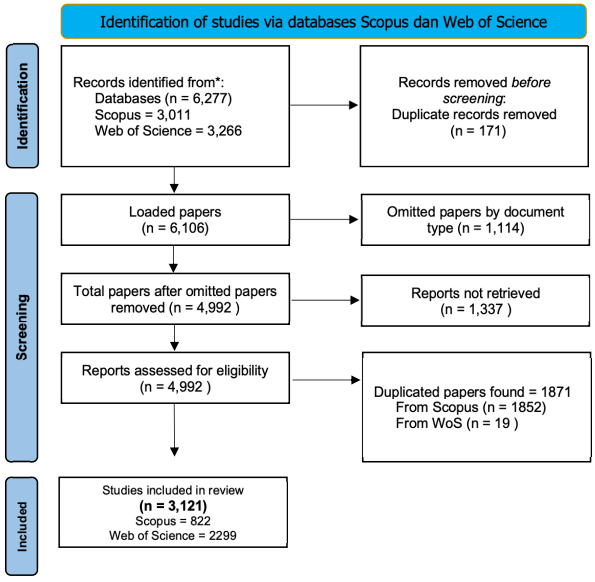

Fig. 1. Flow diagram of searches of databases and registers

Table 1. The search string and retrieval data of sports and fitness

Database	Search Field	Search String
Scopus	TITLE-ABS-KEY = 38,839 document results	TITLE-ABS-KEY (("sport*" OR "physical activ*" OR "physical exercise*" OR "physical training") AND ("fitness"))
	TITLE = 3,011 document result	TITLE (("sport*" OR "physical activ*" OR "physical exercise*" OR "physical training") AND ("fitness"))
Web of Science	TOPIC = 36,880 results from Core Collection	Results for ("sport*" OR "physical activ*" OR "physical exercise*" OR "physical training") AND ("fitness") (Topic)
	Tilte = 3,266 results from Core Collection	Results for ("sport*" OR "physical activ*" OR "physical exercise*" OR "physical training") AND ("fitness") (Title)

Results

The researcher conducts and delivers a process analysis in this section that enables the reader to comprehend the current state of the sport and fitness research landscape as well as anticipated publication patterns that will be helpful for future study. The time frame covered by our review investigation is from January 1 of 1990 to December 31, 2021. The initiation year is preconfigured by default in the ScientoPy software since the software suggests this configuration. Both databases' history of sports and fitness papers reveals a striking trend, where this industry has expanded greatly since 2013. 126 publications came from both databases this year. Additionally, 482 (18.08%) papers released in the two most recent years (2020 to 2021) have been published, of which 234 (8.77%) documents in 2020 (188 documents in WoS and 46 documents in Scopus) and 248 (9.31%) documents in 2021 have been published (215 documents in WoS and 33 documents in Scopus).

However, by making changes to the ScientoPy global settings file, we can alter the filter for this particular document type. The most common form of document tracked was an article, which had up to 2264 published manuscripts. With an AGR of 29.05, it can be concluded that there has been an upward trend or growth in the quantity of documents produced on a given subject. Accordingly, depending on the type of article document, the average number of documents issued each year varies from the preceding year. With a total of 215 manuscripts, review articles are the second most common type of document. The third to sixth types of documents are 181 proceedings paper, conference paper (40), book chapter (20), and two articles in press, respectively.

According to an in-depth search of the ScientoPy software, of all the types of documents available, reviews receive the most citations. Janssen and LeBlanc's (2010) review, "Systematic review of the health benefits of physical activity and fitness in school-aged children and youth," published in the International Journal of Behavioral Nutrition and Physical Activity, BioMed Central Ltd., United Kingdom, received 2,742 citations. This review explains that physical activity has been linked to a variety of health benefits. The dose-response connections seen in observational research imply that your health will improve as you increase your physical activity level. The outcomes of experiments demonstrate that high-risk children's health can be improved by even modest levels of physical activity (e.g., obese). To reap major health benefits, one must engage in physical exercise of at least moderate intensity. High-intensity activities might potentially be more advantageous. The largest health benefit came from aerobic-based exercises, with the exception of bone health, which needed high-impact weight-bearing activities.

Based on the data retrieved from the ScintoPy software, Table 2 lists the number of authors who regularly produced articles on sports and fitness. The total number of publications, Average Growth Rate (AGR), Average Documents per Year (ADY), Percentage of Documents in the Last Years (PDLY), and the author's h-index are all listed in the table. The top five authors who have made at least 29 publications and have contributed to sport and fitness are listed in Table 2. Citing key researchers in our investigation helps with both distribution and scientific acclaim. One of the lead authors is Ortega, F.B., who has 33 published publications and works at the Unit for Preventive Nutrition, Department of Biosciences and Nutrition at NOVUM, Karolinska Institutet, Huddinge, Sweden, and Department of Physiology, School of Medicine, University of Granada, Madrid, Spain.

One of the articles written by Ortega, F.B. (2010) has been published and received the most citations written with Ruiz, J.R., Hurtig-Wennlof, A., Vicente-Rodrguez, G., Rizzo, N.S., Castillo, M.J., and Sjostrom, M., entitled "Cardiovascular fitness modifies the associations between physical activity and abdominal adiposity in children and adolescents: the European Youth Heart Study". The findings from this study provide information that abdomen adiposity is adversely correlated with cardiovascular fitness, and it appears that cardiovascular fitness modifies the relationships between physical activity and abdominal adiposity. The main factor that appears to be connected to abdominal obesity in under-fit children and adolescents is time spent engaging in vigorous physical activity. This discovery should be taken into account as lifestyle intervention tactics are developed further. It is necessary to confirm the findings from the high-fit group.

The average growth rate (AGR) each year is –1.5, meaning that the number of documents released for a topic does not increase significantly. This suggests that the author suffers a decrease in the average number of documents published every year when compared to the previous year. The average number of documents published each year is increasing, with an average of 2.05 documents per year (ADY) and a positive trend. Documents in recent years as a percentage (PDLY) are 15.02, indicating a good trend. Additional authors in the field of fitness and sport are listed in Table 2.

Table 2. The top five most active authors

Pos.	Author	Total	AGR	ADY	PDLY	h Index
1	Ortega, F.B.	33	-1.5	2.05	15.02	22
2	Ruiz, J.R.	32	-0.5	0.05	3.01	22
3	Blair, S.N.	30	-1.0	0.05	3.03	22
4	Ekelund, U.	29	0.05	2.00	13.08	19
5	Mota, J.	29	-1.0	1.00	6.09	17

Popular source titles, representative countries, and key institutions

Each author who contributes to a publication is connected to a certain organization. Scientopy also utilizes this data in the process. This analysis enhances the reputation of the organization and motivates people to keep reporting it in order to improve its ranking. Journals, conference proceedings, and books all qualify as sources. The top 10 sources are listed in Figure 2 according to the quantity of articles that were published between 1990 to 2021.

The scientific sources with the most associated publications have been gathered into a list. The top 10 scientific sources for sports and fitness research are shown in Figure 2 by order of publication. This analysis detects the current sports and fitness-related research publications. This results shows that, with 68 published articles, the International Journal of Environmental Research and Public Health is the

top scholarly source for sports and fitness-related publications. The Journal of Sports Sciences is in third place with 45 documents, Medicine and Science in Sports and Exercise is in second place with 54 documents, and the Journal of Physical Activity & Health is in fourth place with 41 documents. These four scientific sources are the only ones with more than 40 publications. The International Journal of Environmental Research and Public Health has attracted 72.01% of publications pertaining to sports and fitness, which is in line with recent trends (2020 and 2021). Theory I Practical Fizicheskoy Kultury (25.07%) and the Journal of Sports Sciences (22.02%) are two further scientific journals that have produced papers more than 20% in 2020 and 2021.

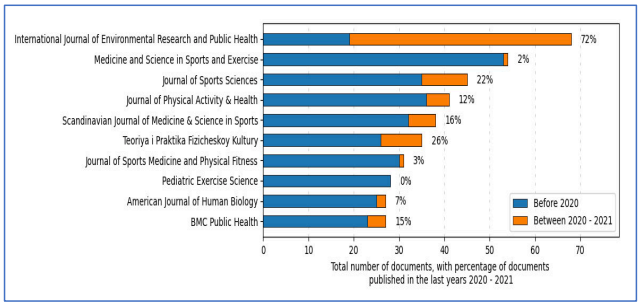

Fig. 2. The 10 most active scientific sources in publishing manuscripts related to sports and fitness

The nations with the greatest number of publications in this area have been collated in a list. The top ten nations, as determined by sports and fitness publications, are shown in Figure 3. Countries that are actively researching sports and fitness are identified through country analysis. Figure 3 shows that the United States has 601 publications. Second, with 232 publications, is the Spain, followed by Spain with 212 publications. Only these three countries have published more than 218 academic scholarly works, and the last is the United Kingdom with 214 publication.

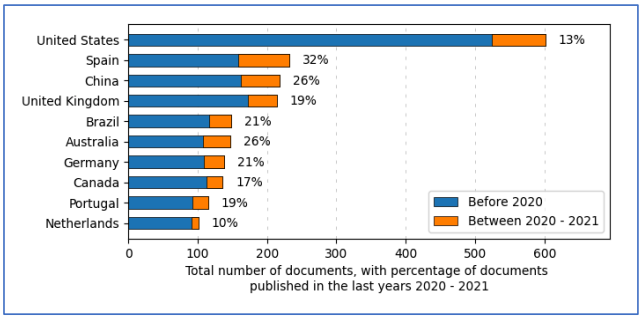

Fig. 3. The top ten most active countries in the field of sport and fitness

Publications list authors according to their specific institution or affiliation. Future cooperation amongst scholars have been made possible by their knowledge of which instituions best represent sports and fitness. The top ten organizations and nations that publish studies on sports and fitness are shown in a bar graph in Figure 4. The University of Granada in Spain has the most articles, according to Figure 4 of this report (68 publications). With 53 publications, the University of Porto in Portugal took second place. The University of Jyväskylä in Finland, with 41 publications, is in third position. Despite being in tenth place, the University of Southern Denmark in Denmark has the highest PDLY (40.9%) of the nine other universities when it comes to working and conducting research on sports and fitness.

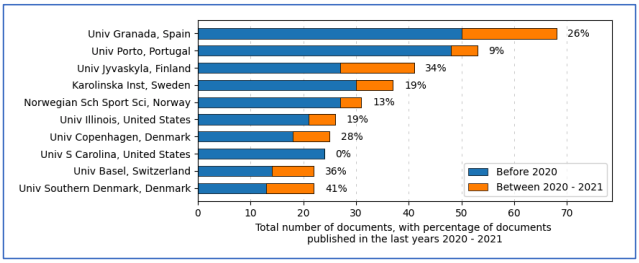

Fig. 4. The top ten most active institutions in the field of sport and fitness

The author's keyword base and influential topics

Author keywords are the words that the writers have specifically selected to characterize the content of a publication. The writers' keywords made it easier for readers and potential scholars to find important passages in articles. Many electronic search engines, databases, and journal websites use author keywords to discover pertinent publications. Using the authors' keywords, ScientoPy might then follow the development of a research question or search thesis. This section looks into the authors' main keywords from earlier sports and fitness studies. To finish the workflow, research trends were found based on the authors' keywords. Similar terms with British and American spellings, as well as singular and plural keywords, have been recommended to be mixed. These manual exercises aid in data arrangement and prevent term duplication, producing findings that are more reliable.

By analysing the top author's keywords with the highest AGR, ScientoPy can spot hot auhtors keyword (as described in the "Topic growth indicators" section). Figure 5 charts the development of the most popular trending topics in the area of sports and fitness. The total number of documents is plotted using a logarithmic scale against the year of publication on the left side of this progression map. As a result, the first row on the X-axis denotes the year the topic study was started, while the last line on the Y-axis displays the total number of documents produced for each topic. On the right's Y-axis, the AGR of each topic for the years 2021–2022, as well as the PDLY, are displayed. This graph can be used to determine the topics that have the highest AGR and highest PDLY. As a result, "physical activity" (29,00) was the trending topic with the highest absolute increase, while "cardiorespiratory fitness," (30,04), "body composition," (24,07) and "health" (24,02) were the three terms with the highest relative growth. Ten hot themes based on the author's keywords are shown in Figure 5.

Using cluster mapping, this study determined the co-occurrence of the authors' keywords by identifying themes or issues related to sports and fitness. ScientoPy was used to do preliminary processing on a combination of Scopus and WoS metadata datasets before the VOSviewer was used to produce a network map. Additionally, this study mapped the co-occurrence of the writers' keywords using a thesaurus

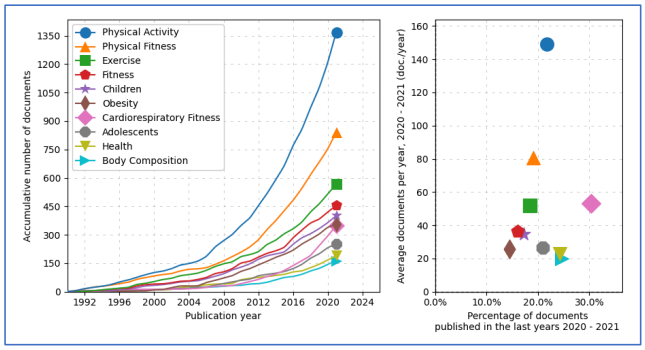

Fig. 5. Top 10 trending topics based on the author's keyword evolution plot related to sport and fitness

file. When combining similar terms, spelling changes, and singular or plural terms, such as accelerometer and accelerometry, sport and sports, thesaurus files are crucial.

Figure 6 compares the number of times a keyword appears in VOSviewer to the size of the node. The keyword will be more noticeable the darker the stain is. The thickness of the line between the terms, which represents the degree of co-occurrence, determines the strength of the association. The author keyword is also shown in Figure 6 as an overlay graphic, emphasizing its connections to other keywords with the use of color, node size, text size, and connecting line thickness. 29 keywords were discovered to meet the current standard of having a minimum of 30 occurrences and 3,990 total keywords. In the diagram, blue nodes represent previously identified structures, whereas red nodes represent newly discovered structures.

The results showed that "physical activity" was the keyword that appeared the most with 699 times, and had a total link strength of 1068. "physical fitness" (491 occurrences, 659 total link strength), "exercise" (316 occurrences, 441 total link strength), "fitness" (229 occurrences, 353 total link strength), "adolescents" (173 occurrences, 338 total link strength), "children" (160 occurrences, 319 total link strength), "obesity" (148 occurrences, 297 total link strength), "cardiorespiratory fitness" (179 occurrences, 274 total link strength), "health" (96 occurrences, 167 total link strength), "body composition" (78 occurrences, 140 total link strength), "accelerometry" (74 occurrences, 122 total link strength), and "youth" 66 occurrences, 111 total link strength). Only these 12 keywords have a total link strength above 100.

The VOSviewer results enabled us to deduce that the most frequently used keywords in 2013 were "cardiovascular disease" with 40 occurrences (77 tls). For these keywords, the article by Myers, J., et al. (2015), entitled "Physical Activity and Cardiorespiratory Fitness as Major Markers of Cardiovascular Risk: Their Independent and Interwoven Importance to Health Status" is the article that received the most citations, namely 401 citations. This review demonstrates that with losses so pronounced in recent generations, current patterns of physical activity are undoubtedly the lowest in human history, and forecasts for the future suggest additional global declines. Recent developments in statistical and epidemiological approaches have made it possible to measure the separate impacts of cardiorespiratory fitness and physical activity on health outcomes. Based on more than 50 years of epidemiological research, it is now well recognized that higher levels of cardiorespiratory fitness and physical activity are associated with improved health outcomes.

The most recent keyword that was initiated after 2016 was "cardiorespiratory fitness," with an occurrence of 179.

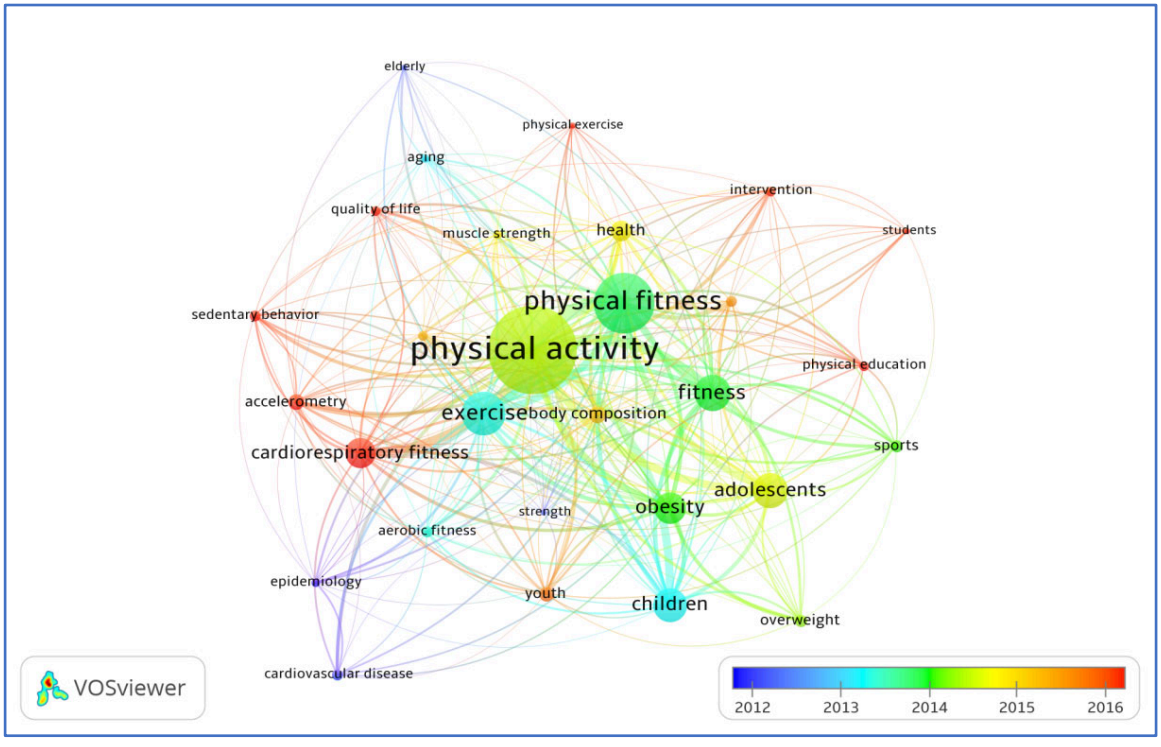

Fig. 6. Overlay visualization of the co-occurrence of authors' keywords

This keyword had (274 total link strength). Other keywords that emerged after 2016 included "accelerometry" (74 occurence, 122 total link strength), "sedentary behavior" (43 occurence, 80 total link strength), "physical education" (50 occurrence, 70 total link strength), "quality of life" (40 occurrence, 66 total link strength), "intervention" (32 occurrence, 65 total link strength), "students" (31 occurrence, 39 total link strength), "physical exercise" (41 occurrence, 36 total link strength).

Discussion

One of the most crucial processes in scientometrics analysis is pre-processing because the quality of the data affects the quality of the results (Cobo et al., 2011). One of the most crucial preprocessing stages that enables data quality, especially when working with datasets from two separate databases, is the elimination of duplication. This is crucial since even one article manuscript may contain more than two data in the Database, despite the fact that we claim to be able to filter metadata that may contain duplicate data.

Based on their excellence in scientific work for various academic fields, Scopus and Web of Science have proven to be the top data sources and have high impact factors. The scope and content of the well-known bibliometric databases Web of Science (WoS) and Scopus are the product of the indexation philosophies of their proprietors (Stahlschmidt & Stephen, 2022). However, major databases limit their capacity to offer an adequate selection of research materials. Although large databases do offer research, their scope is much wider and diverse than subject-specific resources (Marconcin et al., 2022). As a result, many universities require their professors to publish their scientific work in Scopus-indexed journals to increase the prestige of the university, attract new students, and absorb research funds. In addition, the university requires full-time professors to post articles on the Web of Science. From the other side, students, for example, we can see that publication in Scopus/WoS is a fairly formidable challenge that must be overcome. Even in many countries, Indonesia, for example, to complete a doctoral program (PhD), must publish academic papers in Scopus indexed journals. The negative impact of this rule is that many students are trapped in predatory journals. Not a few students are slow in completing their studies, and in the extreme, they drop out of college. Of course, this is inhumane, because with one condition that is not fulfilled (cannot publish articles on Scopus), doctoral students must thwart the struggle. That is a proven fact.

The first paper in this sports and fitness review, entitled "Physical Exercise and Physiological Fitness," was published in 1919. The Journal of the American Medical Association, 73(1), 37, was published. This paper tells us that physical exercise is not uncommon to the point of excessive, resulting in final injury rather than benefit. Although intensive training is generally beneficial, failure to adapt to the increasing demands of work is always a concern and a clue that alternative methods of improving organisms should be found (1919). It is interesting to examine more deeply the benefits and disadvantages of excessive physical activity and exercise. Not infrequently and in many cases, if the activity is carried out excessively, it can damage psychological, anatomical, and physiological factors, even to the level of triggering death. Exercise capacity and activity level have long been recognized as predictors of cardiovascular and overall mortality (Chang & Froelicher, 1994; Pate et al., 1995). Peak exercise capacity as measured in metabolic equivalents is the best predictor of mortality in normal subjects and of cardiovascular disease (Myers et al., 2002).

The United States is the most active country in the world in promoting sports and fitness, and the country is concerned about it. Some of the most recent evidence in this regard is as follows: 1) The Bureau of Labor Statistics estimates that 19.3% of Americans participated in sports and exercise every day in 2019. The participation rate of men was higher (20.7%) than that of women (18 percent). This includes engaging in sports, fitness, and other leisure activities, 2) In 2019, Americans spent an average of 30 minutes per day engaging in sport, exercise, and leisure activities, 3) Hiking, camping, riding, fishing, and running & jogging are some of the most well-liked outdoor pursuits in the US., 4) In 2019, more than 50 million individuals went hiking, while more than 60 million people ran, jogged, and engaged in trail running, 5) High school athletics play a significant role in American sports culture. In the 2018–19 academic year, 4.53 million male students engaged in high school athletics, with football being the most popular sport with over one million participants. Around 3.4 million female students participated in the overall student body in 2018–19. With over 488 thousand participants, track and field had the most participation overall. With more than 450 thousand participants in 2019, volleyball was also very popular (Statista Research Department, 2022). Thus, it is clear why the United States was ranked as the most productive countries in this study.

As scholars continue to study the convergence of spots and fitness, more critical attention to the problem and a theoretical and practical orientation are required. There is no doubt that every professional must respect the authentic aspects and fitness needs of the personality in carrying out daily activities. Perhaps more importantly, scholars should seek to critically engage with theoretical and conceptual models from all disciplines when studying sports and fitness. Physical activity is certainly very beneficial for the condition of the body.

Meanwhile, the hot topic is cardiorespiratory fitness. The results of research conducted by Burden et al. (2022) show that adolescents who engage in 20 minutes of vigorous physical activity per day on average have maximal cardiorespiratory fitness, and there is little evidence that engaging in more or less intense physical activity is beneficial. In addition to always being related to physical health and fitness, cardiorespiratory fitness is also related to cognitive function and psychological well-being. Among school-age children, cognitive performance and cardiorespiratory fitness are important correlates and predictors of psychological well-being. When compared with groups of students with lower psychological well-being, those with higher levels demonstrated greater cardiorespiratory fitness, performance on concentration tasks, and attention accuracy (Chen et al., 2022). Children with high cardiorespiratory fitness have greater cognitive function than children with low cardiorespiratory fitness (Álvarez-Bueno et al., 2019). Cardiorespiratory health and cognitive processing speed are substantially related to depression, pain, and fatigue (Sandroff et al., 2019). Improving

cardiorespiratory fitness can increase cognitive processing speed without affecting the effects of fatigue, discomfort, or sadness (Gao & Zhou, 2022).

Physical activity or sports to improve fitness is a basic need that must be met to be able to stay strong in carrying out daily work routines. Therefore, various elements must be considered in encouraging the willingness of individuals to develop their identity through sports, especially exercises that prioritize the values of independence and prudence in implementing exercise interventions. The public must be very aware of the importance of increasing their fitness level with various programs. Programs such as providing exercise frequency, exercise intensity, duration of exercise, and type of exercise must really be adapted to the conditions and needs of society in general, not just non-athletes. Because giving intervention to athletes is very clear in accordance with the standards of each type of sport. Thus, further development of the constellation between physical activity, sports, and even physical education in schools is urgently needed to obtain more comprehensive information to prevent unwanted things from occurring, such as physical, kinetic, and even death.

Conclusions

This study has demonstrated the remarkable growth trajectory of sports and fitness research since 2013. Sports and fitness research is gaining traction due to the involvement of academics and practitioners, which requires a lot of scrutiny in this area. Exercise, physical activity, and sports are an inseparable part of many people's lives, especially when it comes to fitness. Thus, fitness is something that must be obtained by every individual to be able to support and carry out daily work activities. Not only that, good fitness is also expected to improve cognitive, affective, and psychomotor abilities. Therefore, it indirectly attracts and facilitates current and future researchers who want to explore deeper to become interested in sports and fitness.

This research is expected to be a stepping stone for future work in developing sports and fitness research on topics such as exercise and fitness and their impact on improving the psychological elements; the impact of exercise and fitness on people with autism; and in-depth studies of certain themes or issues discussed in this study. This research However, this analysis is only a starting point that can be disseminated with more in-depth investigations, such as a systematic literature review, meta-analysis, thematic analysis, and empirical studies, to obtain more accurate information related to this research in terms of content, methods, discussion, and results. We can also conduct research by examining the elements of the basic theory of ideals, reality, practicality, nature, and humanism, which are analyzed concretely in the field of sports and fitness. In fact, most of the research on fitness and exercise has been carried out in Western countries (Europe and America) where modern sports are dominant, with good technological support or in developed countries with strong sports histories and traditions, such as China. Little research has been done by developing countries in the field of exercise and fitness. Therefore, it is highly recommended for further researchers to explore information about physical activity and exercise in developing countries. Because not a few small and developing countries have good sports achievements.

The search strings that were used to conduct this study are mostly to blame for its limitations. The metadata is incorporated into the text throughout using the keyword "sports and fintess". The debate can alter slightly if more keywords are utilized. Additionally, the results of this study's keyword analysis have been predicted to spur the creation of fresh concepts, allowing for more effective dissemination and communication of academic works related to sports and fitness research as well as the emergence of new, more pertinent ideas and concepts.

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Conflict of interest

In writing this review, the author declared that there were no conflicts of interest.

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ПОЗИЦІЯ СПОРТУ ТА ФІЗИЧНОЇ КУЛЬТУРИ: НАУКОМЕТРИЧНИЙ ОГЛЯД

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

Реферат. Стаття: 12 с., 2 табл., 6 рис., 84 джерела.

Спорт і фізична культура є фізичними потребами так само, як люди потребують їжі та води. З другого боку, спорт і фізична культура є надзвичайно складною галуззю дослідження, що ускладнює спроби визначення критичних термінів, що призводить до відносної відсутності наукометричного аналізу.

Мета цього дослідження полягає в тому, щоб розглянути розвиток досліджень у галузі спорту та фізичної культури в усьому світі, використовуючи бази даних Scopus та Web of Science як його основу.

Матеріали та методи. Публікації збирають за допомогою баз даних Scopus та Web of Science, а також параметрів наукометрії, включаючи світові тенденції публікацій, авторів, які отримують найбільше цитувань, кількість цитувань і ключові слова авторів.

Результати. Результати показують, що аналіз ключових слів авторів перевірявся на основі їх зв'язку з фізичною активністю, фізичними вправами та фізичною підготовкою. Найактивнішою країною виявилися Сполучені Штати, де вийшла 601 публікація. Як й очікувалося, Сполучені Штати є лідером у сприянні розвитку фізичної активності: у 2019 році 19,3 відсотка населення займаються спортом і виконують вправи щодня. Міжнародний журнал досліджень навколишнього середовища та громадського здоров'я зі Швейцарії очолює 68 публікацій, що є ще одним значним відкриттям. Крім того, згідно з цим аналізом, Ортега Ф.Б. з Медичної школи Університету Гранади, Мадрид, Іспанія, є автором, який публікує найбільше документів – загалом 33.

Висновки. Згідно з нашим дослідженням, топ-п'ять ключових слів, які набули популярності протягом попередніх двох років, були такі: "Кардіореспіраторна витривалість", "Склад тіла", "Здоров'я", "Фізична активність" і "Підлітки". Цінність цього дослідження для галузі спорту та фізичної культури полягає в тому, що воно надає читачам і майбутнім дослідникам широкий спектр спортивних і фізкультурних тенденцій минулого та сьогодення. Крім того, результати цього дослідження допоможуть майбутнім науковцям передбачити потенційні тенденції галузі.

Ключові слова: спорт і фізична культура, фізична активність, кардіореспіраторна витривалість, наукометричний.

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