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[Teorià ta Metodika Fìzičnogo Vihovannâ]



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IMPROVING GUNTINGAN SKILLS BY USING SIMPLE TRAINING TOOLS

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Abstract

Study purpose. The purpose of this study was to determine the effect of training using simple training tools, namely rubber band, ropes and foam sticks, on the Guntingan skills of Pencak Silat athletes.

Materials and methods. This study used an experimental method with a pretest-posttest control group design. In this design there were two sample groups, namely the experimental simple training tools group and the simple guntingan skills training group. 60 athletes from Betako Merpati Putih PPS Pencak Silat School at MA Al-Khairiyah Jakarta participated in this study, divided into two groups where the experimental group included 30 students and the control group included 30 students. This study used a waist guntingan test instrument which consists of 26 aspects of assessment that were validated by 3 experts in Pencak Silat.

Results. There are significant differences in the participants' test results before and after they were given training using simple tools and traditional training to improve guntingan skills, but there is a difference in the effect of each of the guntingan skill trainings in the two groups. The training using simple training tools has better effect on the guntingan skills than the traditional training method.

Conclusions. Unconventional training tools are effective to be used in Pencak Silat guntingan skills training. The improvement of athletes in performing guntingan skills shows that simple training tools can be used for Pencak Silat training. Further study could observe the effect of the tools used in this study on other Pencak Silat skills, or skills in other martial arts and sports.

Keywords: guntingan, pencak silat, training tools.

Introduction

Student Pencak Silat championships which are held in various events and schools can increase the number of participating athletes, so that excellent and potential athletes will emerge. The existence of Pencak Silat in schools helps the development of potential or talented Pencak Silat athletes in Indonesia. Pencak Silat, as one of the indigenous martial art of Indonesia (Kasmandana et al., 2019), has been introduced in high school, where students are taught various basic techniques of Pencak Silat (Sin & Ihsan, 2020). Basic technique is a

system or way of doing a fundamental movement. Basic techniques have a very big role in forming other special techniques because basic techniques are the initial foundation. Forming reliable and skillful athletes requires good basic techniques, which must be done correctly, so that there are no continuous errors in developing advance techniques (Widiastuti et al., 2019). There are various Pencak Silat techniques that must be mastered by athletes. The techniques consist of three basic techniques, namely attack, defense and bottom techniques. Of the three basic techniques, the bottom technique is the basic technique of Pencak Silat which is considered very important for athletes to master. According to (Listiana & Isdaryono, 2019), the bottom technique of pencak silat is considered quite effective and efficient to be executed because in the process of implementing the motion, the bottom technique is

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the basic technique of pencak silat which is carried out by interfering the balance position of the opponent. Guntungan is one of Pencak Silat techniques which drops an opponent by clamping the legs on target's neck, waist, or legs so that the opponent falls (Setyo Kriswanto, 2015). This cutting technique name refers to the final shape, which when viewed from the front, where 2 crossed cutting legs resemble the shape of a pair of scissors, in an oblique position resting on both hands (Babang et al., 2020; Ihsan, 2018). In a competition, the type of guntungan technique that usually used is the flying guntungan with the opponent's waist as the target.

There are 4 stages in the motion of the waist clipping, which are:



Fig. 1. Guntungan Stage (Lubis & Wardoyo, 2016):
(1) Initial position, (2) preparatory position,
(3) execution position, (4) final position

(1) Initial position : The basic stance is the initial stance taken by an athlete that prepares to attack or defense. The basic stance is divided into two, namely open and close stance. The open stance is a basic stance with the position of the hands and arms not covering the body, while the close stance is a basic stance with the position of the hands and arms protecting the body. Open stance is the initial position which usually used in applying guntungan technique. (2) Preparatory position in this position, hands are used as the support for body weight. This is performed in order to make athletes comfortable in executing guntungan techniques. Both hands are placed in front of the feet to have an explosive start when executing jumping motion of guntungan technique. (3) Execution position : In this position, athlete clamps down on the opponent's waist. Athlete's knees and legs clamp towards the opponent's waist so that the guntungan that is made really sticks to the target. When performing the guntungan technique, the fighter pins the opponent in the direction of the waist or groin so that the focused energy will be greater and more impactful. (4) Final guntungan position is a follow through from the execution position, whether the guntungan is successful or not. This position is also useful for shifting the center of gravity of the opponent, so that the opponent's balance is messed and the opponent falls more easily.

Effective training requires good planning, and the media that will be used in the training also requires good planning. Using the right training tools or other media can support improving athletes' skills and performance (Swandana et al., 2021; Wijayanti et al., 2021). Therefore, the selection of training tools must be in accordance with athlete needs so that it can achieve the expected goals. *This study aims* to determine the improvement of Pencak Silat guntungan skills using simple training tools, namely rubber band, ropes and foam sticks. These training tools are cheap or even free, waste and recyclable, tools.

Materials and Methods

Study participants

60 athletes from Betako Merpati Putih PPS Pencak Silat School at MA Al-Khairiyah Jakarta were participated in this

study, divided in to 30 students on experimental group and 30 on control group.

Study organization

The method used in this study was an experimental method with a pretest-posttest control group design. In this design there were two sample groups, namely the experimental simple training tools group and the simple guntungan skills training group.

The research was carried out for 2 months, a total of 18 training sessions, with training frequency of 3 times a week. The experiment group used simple tools (rubber tire wastes, ropes, and foam sticks) as the training aid, while the control group used traditional guntungan skills training methods.

Rubber tire wastes were used as performance enhancement tools, similar to training rubber bands, which came from used rubber tires. The rubber tires were cut and then modified so that can later be used for training aids. Other training tools used in this study are ropes (Samsudin et al., 2021). The ropes in this study were useful for basic stance trainings, so that the basic stance produced can be maximized and achieve the perfect shape. One of the tools that usually used in martial art trainings is sandbag. Sandbag is one of the training equipments which used as a target for martial arts athletes to train their kick and punch (Taufik et al., 2021). Instead of sandbag, foam sticks were used as the training target in this study, because foam sticks are elastic, easy to obtain, and affordable.

Before and after the trainings, athletes perform right and left waist guntungan skills as the pre-test and post test. This study used a waist guntungan test instrument which consists of 26 aspects of assessment that have been validated by 3 Pencak Silat experts.

Statistical analysis

The statistical analysis technique used the Statistic Package for Social Science (SPSS) version 21 software. The used the Shapiro-Wilk test, the Paired Sample T-Test with significant level ($p \leq 0.05$). All data displayed Mean $\pm$ Standard Deviation (SD)

Results

The description of the data is a general description of each variable as a support in the following discussion. Through this general description, the initial conditions and after the treatment of the variables studied will emerge. The data of the waist guntungan skills were obtained from the results of the waist guntungan test instrument which consists of 26 aspects of assessment.

The data was collected from the results of the pre-test and post-test with 2 different groups (experimental group and control group) before and after the training process using simple training tools and traditional training methods. The summary of the data description of the improvement of waist cutting skills can be seen in Table 1.

The next step is to test the similarity of the two averages (one side). This was done to determine the effect of the training using simple training tools and traditional training on the guntungan skills. The results of the significance test can be seen in Tables 2 and 3.

Table 1. General description of waist guntingan skills pre-test and post-test

Descriptive Statistics Paired Samples Statistics					
		Mean	N	SD	SE Mean
Pair 1	Pre_test_1	4083.20	30	395.216	72.156
	Post_test_1	6123.53	30	1064.712	194.389
Pair 2	Pre_test_2	3927.33	30	468.864	85.603
	Post_test_2	4148.40	30	366.751	66.959

Table 2. Paired Sample T Test of Training using Simple Training Tools and Traditional Training On Guntingan Skills Improvement

Paired samples correlations				
		N	Correlation	Sig.
Group 1	Media Tools	30	0.997	0.000
Group 2	Simple Media	30	0.214	0.000

From the results of the paired sample t test calculation, it was obtained that the value of $0.00 < 0.05$ of experiment group and $0.00 < 0.05$ of the control group, which means that there are significant differences before and after being given training using simple tools and traditional training to improve guntingan skills.

From the calculation results in Table 3, it was obtained from the experiment group was -10.167 while the control group was -2.285. This shows that the T_{count} value of the experiment group is greater than T_{Sig} or is outside the H_0 acceptance value, and this means that there is a difference in the effect of each guntingan skill trainings from the two groups. It can be concluded that there is a difference in the effect of training using simple training tools and traditional training on the Pencak Silat guntingan skills. Furthermore, it can be said that the training using simple training tools has better effect on the guntingan skills than the traditional training method.

Discussions

Training tools have been widely used to as performance enhancement, assessment tools, and injury prevention (Hecimovich et al., 2018; Langholz et al., 2016; Rapp & Tirabeni, 2020). Trainers need training tools that can make it easier to give examples of movement (Syamsiyah et al., 2020). However, unconventional training method and equipments can be an effective way to train combat sports athletes (Santana & Fukuda, 2011). This study used simple training tools which are affordable and easy to obtain, and can be said as

unconventional training tools, because the tools used in this study are slightly different from the tools that usually used in Pencak Silat trainings.

Some training tools has been used for Pencak Silat in previous studies such as (Amrullah, 2016) who used Training Resistance Xander to improve the athletes' crescent kick performance, and (Sinulingga et al., 2018) who developed a training tool to improve punching speed of Pencak Silat athletes. While these tools are effective to improve the performances of Pencak Silat athletes, the tools are expensive or hard to obtain. In addition, several previous studies used simpler training models and tools to improve the ability of pencak silat athletes. (Lestiyono & Purwono, 2020) used agility ladder and cone to improve the kick ability of Pencak Silat athletes, while (Babang et al., 2020) and (Efendi, 2022) specifically improved guntingan skills using imagery training and audio visual media respectively.

Equipments that are simple, easy to obtain, and can be used in training process, are suitable to be implemented in Pencak Silat schools (Sudarmanto et al., 2018). The tools used in this study are not only able to improve guntingan skill performances, but also easy to obtain because they are general goods that can be found in daily life which also affordable. In addition, the use of waste in cardiorespiratory training has been proven to be effective in improving cardiorespiratory performance (Widiastuti et al., 2019). The rubber bands used in this study were made from rubber tire wastes, which are free, and can indirectly help the utilization of wastes into useful goods.

This study shows significant differences before and after being given training using simple tools and traditional training to improve guntingan skills. There were also differences obtained between the experiment group and the control group, which shows that there is a difference in the effect of each guntingan skill trainings from the two groups. It can be concluded that the training using simple training tools has better effect on the guntingan skills than the traditional training method.

This study is limited to the implementation of simple training tools to improve the guntingan skills of Pencak Silat athletes. Further study could observe the effect of the tools implemented in this study on other Pencak Silat skills, or other martial arts and sport skills.

Conclusion

Unconventional training tools are effective to be used in Pencak Silat guntingan skills training. The improvement of athletes in performing guntingan skills shows that simple training tools can be used for Pencak Silat training. Furthermore, it can be said that the training using simple training

Table 3. t-Test: Paired Two Sample for Means Group

Paired Differences									
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pre_test_1 - Post_test_1	-2040.333	1099.210	200.687	-2450.785	-1629.882	-10.167	29	.000
Pair 2	Pre_test_2 - Post_test_2	-221.067	529.809	96.730	-418.901	-23.233	-2.285	29	.030

tools has better effect on the guntingan skills than the traditional training method. However, further study could observe the effect of the tools implemented in this study on other Pencak Silat skills, or other martial arts and sports.

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Conflict of interest

No potential conflict of interest was reported by the authors.

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УДОСКОНАЛЕННЯ НАВИЧОК ВИКОНАННЯ ТЕХНІКИ КИДКА «НОЖИЦІ» З ВИКОРИСТАННЯМ ПРОСТИХ ТРЕНУВАЛЬНИХ ЗАСОБІВ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

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Метою цього дослідження було визначення впливу тренувань із використанням простих тренувальних засобів, а саме: гумової стрічки, канатів і пінопластових палиць, на навички виконання техніки кидка «ножиці» у спортсменів, які займаються бойовим мистецтвом пенчак-силат.

Матеріали та методи. У цьому дослідженні використовували експериментальний метод із планом попереднього та підсумкового тестування з використанням контрольної групи. Цей план передбачав вибірку з двох груп: експериментальної групи, у якій використовували прості тренувальні засоби, і групи, у якій проводили прості тренування з навичок виконання техніки кидка «ножиці». Учасниками цього дослідження стали 60 спортсменів зі школи бойових мистецтв пенчак-силат «Мерпаті путі» («Білий голуб»), розташованої в мусульманському релігійному навчальному закладі «Аль-Хайрія», Джакарта (Індонезія), яких розділили на дві групи: експериментальну (30 учнів) і контрольну (30 учнів). Як засіб тестування для оцінки показників у дослідженні використовували виконання техніки кидка «ножиці» із захопленням обома ногами талії суперника, що складається з 26 аспектів оцінки, правильність яких підтвердили 3 експерти з пенчак-силату.

Результати. Існують статистично значущі відмінності в результатах тестування учасників до та після проходження ними тренування з використанням простих засобів і звичайного тренування з метою вдосконалення навичок виконання техніки кидка «ножиці», але вплив кожного типу тренувань з метою вдосконалення навичок виконання техніки кидка «ножиці» у цих двох групах є відмінним. Тренування з використанням простих тренувальних засобів краще впливає на навички виконання техніки кидка «ножиці», ніж тренування звичайним методом.

Висновки. Нестандартні тренувальні засоби є ефективними для застосування під час тренування з метою вдосконалення навичок виконання техніки кидка «ножиці» у пенчак-силаті. Покращення показників спортсменів у виконанні навичок техніки кидка «ножиці» свідчить про те, що прості тренувальні засоби можна використовувати для тренувань із пенчак-силату. У подальших дослідженнях можливо спостерігати вплив засобів, які використовували в цьому дослідженні, на інші навички пенчак-силату або навички інших бойових мистецтв і видів спорту.

Ключові слова: техніка кидка «ножиці», пенчак-силат, тренувальні засоби.

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ORIGINAL SCIENTIFIC ARTICLE

SURVEY OF BASIC MOVEMENT SKILLS IN ELEMENTARY SCHOOL STUDENTS IN THE MIDST OF THE COVID-19 PANDEMIC

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Abstract

The study purpose was to determine a survey of basic locomotor, non-locomotor, and manipulative movement skills in elementary school students in Kecamatan Kandangan Kabupaten Kediri East Java in the midst of the COVID-19 pandemic.

Materials and methods. This study used a descriptive research design with a quantitative research type, for the method used in this research was a survey method. The population of elementary school students in Kecamatan Kandangan was 2997 elementary school students. Determination of the sample size used the Accidental purposive sampling technique; as many as 471 participants of grades 4, 5, and 6 were selected from elementary schools located in Kecamatan Kandangan Kediri East Java. The data collection technique used in this study was a survey technique with data collection instruments using questionnaires created with Google Forms application. Data analysis was carried out in this study using a descriptive percentage test.

Results. The impact of COVID-19 did not interfere with students' skills in performing locomotor and non-locomotor movements, but greatly interferes with students' skills in performing manipulative movements.

Conclusions. Learning PJOK during the COVID-19 pandemic did not interfere with students' skills in performing locomotor and non-locomotor movements, but interferes with students' skills in performing manipulative movements.

Keywords: basic movement skill, locomotor, non-locomotor, manipulative, COVID-19 pandemic, elementary school students.

Introduction

The world has experienced the disaster of COVID-19 from the end of 2019 until now. COVID-19 or coronavirus is a large family of viruses where the shape resembles an egg with spikes on the surface that are shaped like a crown, therefore this virus is called corona. The coronavirus was discovered in the 1960s in the nasal cavities of patients with colds. COVID-19 did not take long to change the level of disease spread from endemic to pandemic. Indonesia has been severely affected by the COVID-19 outbreak. The impact of COVID-19 in the world starts from the economic aspect, the

health aspect is no exception as well as the education aspect (Kurniawan, 2020). Education is one of the sectors most affected by the coronavirus. Education has changed because of COVID, so education is done online. One of the educations affected by COVID is Physical Education. Physical education is a learning process to improve physical fitness and develop motor skills, knowledge, sportsmanship and emotional intelligence (Indrawani, 2019). Many countries have decided to close schools, colleges and universities. In Indonesia, the efforts made to cut the chain of transmission of the COVID-19 virus, the government has decided that face-to-face learning from elementary school to university is not allowed. This causes problems in the world of education (Purwanto et al., 2020).

The COVID-19 pandemic has caused face-to-face learning to be replaced by online learning. This is because the

spread of the virus is so fast that many parties are not prepared to deal with this disaster. Starting from the government, educators, parents and students must face this problem directly (Kurniawan, 2020). So that the COVID-19 pandemic brings complex obstacles to education and learning providers in schools that must be carried out online (Simbolon & Arif Rakhman, 2021). One of the impacts of learning is on Physical Education, Sports and Health (Handayani, 2020). Due to the COVID-19 pandemic, sports activities have been disrupted. This is a serious problem in the world of education. All students do not want boredom in their lives, because boring learning is something that is not fun. If the teaching and learning process does not start with something interesting, it can affect student interest in PJOK learning, so that learning objectives are not achieved (Musitoh, 2018).

Physical Education, Sports and Health are subjects that students learn at school. These subjects include material on sports, game sports, and material on environmental health and body health. Learning Physical Education, Sports and Health is a subject consisting of theory and practice (Hidayat, 2019). The practice in physical education, sports and health is that students are required to move according to the material in learning. One of the scopes of physical education is the formation of motion, which includes the desire to move, appreciate space, time and form including the feeling of rhythm, recognize the possibility of one's own motion, have confidence in motion and feelings of attitude (kineshetic) and enrich the ability to move (Amung & Saputra, 2000).

The basic movement is the behavioral pattern of the student who has physical characteristics through the activity of the movement. As a child, basic movements need to correspond to their growth process. Fundamental Movement Skills (FMS) usually developed as a child, then refined into contextual and sport-specific skills. These skills include movement (running, hopping, etc.), manipulation or object control (catch, throw, etc.), and stability (balancing, etc., and twist) skill (Lubans, Morgan, Cliff, & Barnett, 2010). Clark etc. Basic motor skills are considered a basic component of exercise and have been proposed to form the basis of professional and sport-specific motor skills needed to participate in a variety of physical activities (Clark, Barnes, Holton, Summers, & Stratton, 2016). In this way, it can be said that the basic movements are the basic movements for children to perform various movements such as play, sports, and dance in the social environment. It can be divided into spontaneous movements, non-spontaneous movements, and manipulative movements (Desmita, 2009).

Basic movement skills in physical education have been taught at the elementary school level (Pratama & Nurrochmah, 2020). Basic movement is a basic skill that aims to develop various basic sports technical skills that involve body movements (Wiarto, 2015). However, due to online learning of children's movements which can usually be routinely carried out every week at school, children can play and move freely with their friends to be hampered. According to (Prayitno, 2014) that the movement skills that need to be developed in elementary school children are fundamental movement abilities, namely the basic locomotor, non-locomotor, and manipulative movement abilities. Locomotor movement skills (such as walking, running, jumping and rolling), non-locomotor (bending,

stretching, twisting, rocking). Basic manipulative movements (kicking, throwing, running, up and down stairs, climbing, etc.). The ability and basic technical skills of locomotor, non-locomotor and manipulative movements of elementary school students need special attention. Movement development in childhood is very prominent. Completion or improvement of basic movements occurs in childhood. Towards adolescence, increasingly complex movements can be mastered with the ability to utilize movement skills according to their needs. In the end, in early adulthood, various organs of the body reach the peak of functional development, and physical maturity reaches the peak of maturity. However, the development of children's movements has been disrupted by the current COVID-19 pandemic.

Based on initial observations on Sports Physical Education teachers in Kandungan District that due to the COVID-19 pandemic, so that they have to carry out online learning, it will affect the movement of children. This certainly affects the basic locomotor, non-locomotor, and manipulative movements in elementary school children. The results of previous studies with the research title "Analysis of Basic Movements for Children aged 6-7 Years" which showed the overall results of basic movements of junior high school students were in the sufficient category, in which the locomotor basic movements with a percentage of 77.4% were in the sufficient category, non-locomotor basic movements with a percentage of 74.5% in the sufficient category, and manipulative basic movements with a percentage of 79% in the good category (Kurniawan, 2019). Another study with the title "Analysis of Basic Motor Movements for Class VII Students of SMP Negeri 1 Kuok District, Kampar Regency" which shows the overall results of the basic movements of junior high school students in the sufficient category, which in the locomotor basic motion with a percentage of 49.1% in the sufficient category, basic movement non-locomotor with a percentage of 65.6% in the good category, and basic manipulative movements with a percentage of 49.5% in the sufficient category (Rezki, 2016). However, the basic locomotor, non-locomotor, and manipulative movement skills in the midst of the COVID-19 pandemic are still unclear.

Based on the above background, the researcher wants to conduct research on a survey of locomotor, non-locomotor, and manipulative basic movement skills in the midst of the COVID-19 pandemic in elementary school students.

Materials and methods

Study participants

This study used a descriptive research design with a quantitative research type, for the method used in this research is the survey method. The population of elementary school students in Kandungan sub-district is 2997 students. Determination of the sample using accidental purposive sampling technique which combines accidental data collection techniques with data collection techniques for certain purposes. Based on the accidental purposive sampling technique, 471 samples of grades 4, 5, and 6 were obtained from elementary schools located in Kecamatan Kandungan Kediri East Java.

Study organization

This research was carried out in the midst of the COVID-19 pandemic in all public elementary schools in Kecamatan Kandangan Kabupaten Kediri, the research was carried out in April-May 2021. This research has conducted an ethical test before implementation. Ethical clearance in this study with certificate number 165/EC/KEPK/UNUSA/2021 obtained from the health research ethics commission, Nahdlatul Ulama University, Surabaya. The technique and data collection carried out in this study were survey techniques with data collection instruments using questionnaires created used google forms app. In this study, there were 20 questions related to locomotor, non-locomotor, and manipulative basic movements.

Statistical analysis

The questionnaire must be tested for validity and reliability. If it was valid and reliable, the research can be continued in the form of distributing questionnaires in the form of google forms to the research sample. The questionnaire in this study using a Likert scale is used to measure attitudes, opinions, and perceptions of a person or group of people about social phenomena. For the purposes of quantitative analysis, the answers can be scored, for example: SS (Strongly Agree), S (Agree), N (Neutral), TS (Disagree), STS (Strongly Disagree). In all these statements entirely a statement to be given a score of 5, 4, 3, 2, 1 (Sugiyono, 2016).

Calculate the percentage with the formula :

$$P = (F/N) \times 100\%$$

Description:

P = percentage number (%)

f = frequency of respondents' answers

N = total score

To determine the percentage obtained by the results of research and calculation of the percentage descriptive then interpreted into the sentence. The next step is to find out the level of these criteria, then the score obtained (in %) with descriptive analysis according to the percentage results. There are 4 classifications, including very good with a percentage of 75-100%, good classification with a percentage of 50-74%, sufficient classification with a value of 25-49%, and the last one is poor classification with a value of 0-24%.

Results

Table 1 shows that the sample comes from 14 different schools in the Kecamatan Kandangan Kabupaten Kediri, East Java (SDN Medowo 1, SDN Mlancu 3, SDN Karang Tengah 3, SDN Kandangan 1, SDN Kandangan 2, SDN Kandangan 3, SDN Jeruk Wangi, SDN Kasreman, SDN Jombang, SDN Mlancu 1, SDN Mlancu 2, SDN Mlancu 4, SDN Medowo 2, and the last SDN Medowo 3. The total sample was 471 students which is divided into 304 men and 167 women. In class 4 samples amounted to 147 students, class 5 amounted to 166 students and class 6 amounted to 158 students.

Based on Table 2, the validity test shows that all the question items used are P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20 were declared valid with r value > 0.098 (n=471)

Table 1. Characteristics of the Research Sample

No	Which school are you from	Gender		Class		
		Man	Woman	4	5	6
1.	SDN Medowo 1	25	12	12	15	10
2.	SDN Mlancu 3	12	7	6	7	6
3.	SDN Karang Tengah 3	15	10	8	7	10
4.	SDN Kandangan 1	35	12	18	17	12
5.	SDN Kandangan 2	25	20	15	15	15
6.	SDN Kandangan 3	30	18	15	15	18
7.	SDN Jeruk Wangi	23	15	10	18	10
8.	SDN Kasreman	23	12	12	9	14
9.	SDN Jombang	19	11	12	7	11
10.	SDN Mlancu 1	20	15	8	15	12
11.	SDN Mlancu 2	22	10	8	7	17
12.	SDN Mlancu 4	18	7	6	12	7
13.	SDN Medowo 2	27	13	12	18	10
14.	SDN Medowo 3	10	5	5	4	6
TOTAL		304	167	147	166	158

Table 2. Validity Test

No	Question Items	r-count	p-value	Information
1.	P 1	0.641	0.010	Valid
2.	P 2	0.808	0.000	Valid
3.	P 3	0.866	0.000	Valid
4.	P 4	0.841	0.000	Valid
5.	P 5	0.680	0.005	Valid
6.	P 6	0.786	0.001	Valid
7.	P 7	0.689	0.005	Valid
8.	P 8	0.802	0.000	Valid
9.	P 9	0.795	0.000	Valid
10.	P 10	0.573	0.026	Valid
11.	P 11	0.643	0.010	Valid
12.	P 12	0.866	0.000	Valid
13.	P 13	0.841	0.000	Valid
14.	P 14	0.680	0.005	Valid
15.	P 15	0.837	0.000	Valid
16.	P 16	0.648	0.009	Valid
17.	P 17	0.706	0.003	Valid
18.	P 18	0.680	0.005	Valid
19.	P 19	0.866	0.000	Valid
20.	P 20	0.795	0.000	Valid

or p-value < 0.05. If all items have been declared valid, it can be continued with reliability testing.

Table 3. Reliability Test

N of items	Cronbach's Alpha Reliability Test
20	0.958

Based on Table 3, the reliability test using Cronbach's Alpha shows the Cronbach's Alpha coefficient value of 0.958. If the coefficient value of Cronbach's Alpha > 0.6 then

it can be said that the instrument in this study was reliable so that it can be used in research.

The instrument in this study has been tested for validity and reliability which shows that all items are valid and reliable, so that they can be used as research instruments.

Table 4. Normality Test

Number of samples	Kolmogorov-Smirnov Test
471	0.068

Based on Table 4 the Normality Test using the Kolmogorov-Smirnov Test shows that the research data is normally distributed.

Descriptive Percentage

Table 5. Question Item Number 1

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	25	5.3	5.3	5.3
2	446	94.7	94.7	100.0
Total	471	100.0	100.0	

Based on table 5, the sample who answered the question items strongly disagreed with 5.3% (bad classification) and those who answered disagreed with 94.7% (very good classification). These results show that due to the COVID-19 pandemic, learning PJOK online does not interfere with my skills in shifting movements (shifting the body to the left/right).

Table 6. Question Item Number 2

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	22	4.7	4.7	4.7
2	449	95.3	95.3	100.0
Total	471	100.0	100.0	

Based on table 6, the sample who answered the question items strongly disagreed with 4.7% (bad classification) and those who answered disagreed with 95.3% (very good classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my walking skills.

Table 7. Question Item Number 3

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	19	4.0	4.0	4.0
2	452	96.0	96.0	100.0
Total	471	100.0	100.0	

Based on table 7, the sample who answered the question items strongly disagreed with 4.0% (bad) and those who answered disagreed with 96.0% (very good). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my running skills.

Table 8. Question Items Number 4

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	16	3.4	3.4	3.4
2	455	96.6	96.6	100.0
Total	471	100.0	100.0	

Based on table 8, the sample who answered the question items strongly disagreed with 3.4% (bad classification) and those who answered disagreed with 96.6% (very good classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my skills in jumping movements.

Table 9. Question Item Number 5

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	4	.8	.8	.8
2	28	5.9	5.9	6.8
3	23	4.9	4.9	11.7
4	114	24.2	24.2	35.9
5	302	64.1	64.1	100.0
Total	471	100.0	100.0	

Based on table 9, the sample who answered the question items strongly disagreed with 0.8% (bad classification) and those who answered disagreed by 5.9% (bad classification), neutral as much as 4.9% (bad classification), agreed as much as 24.2% (enough classification), and strongly agreed at 64.1% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in rolling movements.

Table 10. Question Items Number 6

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	13	2.8	2.8	2.8
2	458	97.2	97.2	100.0
Total	471	100.0	100.0	

Based on table 10, the sample who answered the question items strongly disagreed with 2.8% (bad classification) and those who answered disagreed with 97.2% (very good classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my skills in the movement of pedaling my legs and arms.

Table 11. Question Item Number 7

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	18	3.8	3.8	3.8
2	453	96.2	96.2	100.0
Total	471	100.0	100.0	

Based on table 11, the sample who answered the question items strongly disagreed with 3.8% (bad classification)

and those who answered disagreed with 96.2% (very good classification). As a result of the COVID-19 pandemic, PJOK learning is carried out online without interfering with bending and stretching movement skills.

Table 12. Question Item Number 8

	Frequency	Percent	Valid Percent	Cumulative Percent
1	20	4.2	4.2	4.2
Valid 2	451	95.8	95.8	100.0
Total	471	100.0	100.0	

Based on table 12, the sample who answered the question items strongly disagreed with 4.2% (bad classification) and those who answered disagreed with 95.8% (very good classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my skills in doing stretching movements.

Table 13. Question Items Number 9

	Frequency	Percent	Valid Percent	Cumulative Percent
1	21	4.5	4.5	4.5
Valid 2	450	95.5	95.5	100.0
Total	471	100.0	100.0	

Based on table 13, the sample who answered the question items strongly disagreed with 4.5% (bad classification) and those who answered disagreed with 95.5% (very good classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my skills in doing circular movements.

Table 14. Question Items Number 10

	Frequency	Percent	Valid Percent	Cumulative Percent
1	23	4.9	4.9	4.9
Valid 2	448	95.1	95.1	100.0
Total	471	100.0	100.0	

Based on table 14, the sample who answered the question items strongly disagreed with 4.9% (bad classification) and those who answered disagreed with 95.1 % (very good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in bending movements.

Table 15. Question Item Number 11

	Frequency	Percent	Valid Percent	Cumulative Percent
1	17	3.6	3.6	3.6
Valid 2	454	96.4	96.4	100.0
Total	471	100.0	100.0	

Based on table 15, the sample who answered the question items strongly disagreed with 3.6% (bad classification) and those who answered disagreed with 96.4% (very good

classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my skills in pushing and pulling movements.

Table 16. Question Item Number 12

	Frequency	Percent	Valid Percent	Cumulative Percent
1	14	3.0	3.0	3.0
2	303	64.3	64.3	67.3
Valid 3	100	21.2	21.2	88.5
4	23	4.9	4.9	93.4
5	31	6.6	6.6	100.0
Total	471	100.0	100.0	

Based on table 16, the sample who answered the question items strongly disagreed with 3.0% (bad classification) and those who answered disagreed at 64.3% (good classification), neutral as much as 21.2% (bad classification), agreed as much as 4.9% (bad classification), and strongly agreed at 6.6% (bad classification). Due to the COVID-19 pandemic, PJOK learning is done online, it doesn't interfere with my skills in lifting and lowering movements.

Table 17. Question Items Number 13

	Frequency	Percent	Valid Percent	Cumulative Percent
1	3	.6	.6	.6
2	11	2.3	2.3	3.0
Valid 3	14	3.0	3.0	5.9
4	116	24.6	24.6	30.6
5	327	69.4	69.4	100.0
Total	471	100.0	100.0	

Based on table 17, the sample who answered the question items strongly disagreed with 0.6% (bad classification) and those who answered disagreed by 2.3% (bad classification), neutral as much as 3.0% (bad classification), agreeing as much as 24.6% (enough classification), and strongly agreeing 69.4% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in kicking movements

Table 18. Question Item Number 14

	Frequency	Percent	Valid Percent	Cumulative Percent
1	3	.6	.6	.6
2	11	2.3	2.3	3.0
Valid 3	14	3.0	3.0	5.9
4	116	24.6	24.6	30.6
5	327	69.4	69.4	100.0
Total	471	100.0	100.0	

Based on table 18, the sample who answered the question items strongly disagreed with 0.6% (bad classification) and those who answered disagreed by 2.3% (bad classifica-

tion), neutral as much as 3.0% (bad classification), agreeing as much as 24.6% (enough classification), and strongly agreeing 69.4% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my throwing skills.

Table 19. Question Items Number 15

	Frequency	Percent	Valid Percent	Cumulative Percent
	1	24	5.1	5.1
Valid	2	447	94.9	100.0
Total	471	100.0	100.0	

Based on table 19, the sample who answered the question items strongly disagreed with 5.1% (bad classification) and those who answered disagreed with 94.9% (very good classification). Due to the COVID-19 pandemic, learning PJOK is done online, it doesn't interfere with my skills in moving up and down stairs.

Table 20. Question Item Number 16

	Frequency	Percent	Valid Percent	Cumulative Percent
	2	11	2.3	2.3
	3	14	3.0	5.3
Valid	4	116	24.6	29.9
	5	330	70.1	100.0
Total	471	100.0	100.0	

Based on table 20 that the sample who answered the question items disagreed by 2.3% (bad classification), neutral as much as 3.0% (bad classification), agreed as much as 24.6% (enough classification), and strongly agreed at 70.1% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in catching the ball.

Table 21. Question Item Number 17

	Frequency	Percent	Valid Percent	Cumulative Percent
	2	11	2.3	2.3
	3	15	3.2	5.5
Valid	4	121	25.7	31.2
	5	324	68.8	100.0
Total	471	100.0	100.0	

Based on table 21 that the sample who answered the question items disagreed by 2.3% (bad classification), neutral as much as 3.2% (bad classification), agreed as much as 25.7% (bad classification), and strongly agreed at 68.8% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in dribbling.

Based on table 22, the sample who answered the question items strongly disagreed with 0.6% (bad classification) and those who answered disagreed by 2.3% (bad classification), neutral as much as 3.0% (bad classification), agree-

Table 22. Question Item Number 18

	Frequency	Percent	Valid Percent	Cumulative Percent
	1	3	.6	.6
	2	11	2.3	3.0
Valid	3	14	3.0	5.9
	4	116	24.6	30.6
	5	327	69.4	100.0
Total	471	100.0	100.0	

ing as much as 24.6% (enough classification), and strongly agreeing 69.4% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in throwing balls.

Table 23. Question Item Number 19

	Frequency	Percent	Valid Percent	Cumulative Percent
	1	1	.2	.2
	2	9	1.9	2.1
Valid	3	14	3.0	5.1
	4	123	26.1	31.2
	5	324	68.8	100.0
Total	471	100.0	100.0	

Based on table 23, the sample who answered the question items strongly disagreed with 0.2% (bad classification) and those who answered disagreed with 1.9% (bad classification), neutral as much as 3.0% (bad classification), agreed as much as 26.1% (bad classification), and strongly agreed at 68.8% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in bouncing the ball.

Table 24. Question Items Number 20

	Frequency	Percent	Valid Percent	Cumulative Percent
	2	11	2.3	2.3
	3	15	3.2	5.5
Valid	4	123	26.1	31.6
	5	322	68.4	100.0
Total	471	100.0	100.0	

Based on table 24, the sample who answered the question items disagreed by 2.3% (bad classification), neutral as much as 3.2% (bad classification), agreed as much as 26.1% (bad classification), and strongly agreed at 68.4% (good classification). Due to the COVID-19 pandemic, PJOK learning is carried out online so that it interferes with my skills in hitting the ball.

Discussion

The results showed that due to the COVID-19 pandemic which caused PJOK learning to be carried out online, most aspects of locomotor skills were not disrupted. Among them

are not disturbing students' skills in shifting movements (shifting the body to the left/right) with the highest percentage value answering disagreeing at 94.7%, not disturbing student skills in walking with the highest percentage value answering disagreeing at 95.3%, not disturbing student skills in running with the highest percentage value answered disagreed by 96.0%, did not interfere with students' skills in jumping movements with the highest percentage value answered disagreed by 96.6%. However, due to the COVID-19 pandemic, online PJOK learning has disrupted students' skills in rolling over with the highest percentage score strongly agreeing at 64.1%. This may be influenced by the habits of students who are not active, such as when learning is carried out at school. Inactive habits will cause weight gain so that it affects students' skills in rolling over.

In the aspect of non-locomotor skills that due to the COVID-19 pandemic causing PJOK learning to be carried out online it does not interfere with students' skills in the movement of pedaling their feet and hands with the highest percentage value answering disagree by 97.2%, it does not interfere with students skills in bending and stretching movements with the highest percentage value answering disagreed by 96.2%, did not interfere with students' skills in stretching movements with the highest percentage value answering disagreed by 95.8%, did not interfere with students' skills in doing circular movements with the highest percentage value answering disagreed by 95.5%, did not interfere with students' skills in doing bending movement with the highest percentage value answered disagreed by 95.1%, did not interfere with my skills in doing pushing and pulling movements with the highest percentage value answering disagreed by 96.4%, did not disturb strength skill in doing lifting and lowering movements with the highest percentage value answering disagreed at 64.3%, it did not interfere with students' skills in moving up and down stairs with the highest percentage value answering disagreeing at 94.9%. However, due to the COVID-19 pandemic, online PJOK learning disrupts students' skills in kicking movements with the highest percentage score strongly agreeing at 69.4 and disrupting students' throwing skills with the highest percentage answering strongly agreeing at 69.4%.

In the aspect of manipulative skills that due to the COVID-19 pandemic causing PJOK learning to be carried out online, it interferes with students' skills in catching the ball with the highest percentage value answering strongly agree at 70.1%, disturbing students' skills in dribbling the ball with the highest percentage value answering strongly agree at 68.8%, disturbing students' skills in throwing balls with the highest percentage value answering strongly agree at 69.4%, disturbing students' skills in throwing balls with the highest percentage values answering strongly agreeing at 68.8%, disturbing students' skills in hitting balls with the highest percentage values answering very agree by 68.4%.

Basic movement is an important aspect in the world of education, especially for physical education and health subjects. Basic motion is the basis or foundation for developing various sports activities that will be carried out or that are of interest to someone to achieve the objectives of the exercise carried out (Bakhtiar, 2015). Basic movement skills are divided into three kinds of movement skills, namely (1) locomotor movement skills (2) non-locomotor movement skills, and (3) manipulative movement skills (Hanief & Sugito, 2015). Based on the explanation above, it shows that the

impact of COVID-19 does not interfere with students' skills in performing locomotor and non-locomotor movements, but greatly interferes with students' skills in performing manipulative movements. This may be due to the impact of the COVID-19 pandemic. For locomotor and non-locomotor movements, students can still perform optimally at home, but for manipulative movements, students cannot optimally perform at home. Locomotor motion is a movement that causes the movement of the fulcrum even though it only leaves the pedestal from place A to B, even though a few seconds such as jumping and jumping in place is called locomotor motion, while non-locomotor motion is motion that will not leave the fulcrum such as standing in place, sit ups, back up on In general, and for manipulative motion, it is a movement that uses control objects in its implementation such as kicking, throwing and others (Firdaus & Nurrochmah, 2021). Manipulative movement is a number of forms of the whole basic human movement (Irfandi, 2018). The COVID-19 pandemic that has hit the whole world has paralyzed the economic, socio-cultural and educational sectors. The new policy issued by the Indonesian government is the existence of large-scale restrictions, causing all necessary activities to start from home or online (Qori'ah, Tegarinfisa, Hendratno, & Purwoto, 2022). The COVID-19 pandemic brings complex obstacles to education and learning providers in schools that must be implemented online (Simbolon & Arif Rakhman, 2021). Learning that is done online causes children's movements which can usually be routinely carried out every week at school, children can play and move freely with their friends to be disturbed. Basic movements are the basis for learning and developing more complex sports technical skills (Nusufi, 2016). Whereas elementary school children need to develop fundamental movement skills, namely the basic locomotor, non-locomotor, and manipulative movement abilities (Prayitno, 2014; Logan & Robinson, LE, 2012). Locomotor motion is a movement that is characterized by a change of place or carried out by a movement of the body or body (Qomarullah & Hidayatullah, MF, 2014). Non-locomotor motion is a movement that is carried out without moving the body or body. While manipulative motion is a movement that is carried out using a tool as an object, this movement ability is developed (Morgan & Barnett, LM, 2013). Manipulative movement is a type of movement that requires good coordination. Because the manipulative movement involves several elements of motion that must be coordinated into one good and harmonious movement pattern. The types of manipulative movements include: throwing, catching, kicking and other types of movements whose implementation requires good coordination (Pratomo, 2011). The explanation indicated that student coordination during the COVID-19 pandemic was disrupted, thus disrupting their manipulative movements. It is the teacher's job to provide lessons that are able to improve students' manipulateness, so that students' deceptive ability to move can be good again.

Previous studies have conducted studies on longitudinal and cross sectional studies (Livonen & Sääkslahti, 2014). The results obtained are mostly stated that boys have a tendency to master manipulative basic movement skills better than girls. One of the reasons for the uniformity of these findings is based on the differences in the pattern of activities carried out by the two genders both at school and outside of school. Male students have a tendency to do more

physical activities outside the room (outdoor) compared to female students. One of the dominant activities carried out is sports activities (Bailey, Wellard, Dismore, & H, 2005). In this study, the research sample was male and female, and it was found that manipulative movements were disrupted so that the COVID-19 pandemic had a very large effect on students so they could not participate in learning at school. This results in impaired student manipulative movement abilities.

Conclusion

In the aspects of locomotor skills were not disrupted. Students' skills in shifting movements with the highest percentage value answering disagreeing at 94.7%, did not disturbing skills in walking 95.3%, did not disturbing skills in running 96.0%, did not interfere skills in jumping movements 96.6%. Disrupted students' skills in rolling over 64.1%. In the aspect of non-locomotor skills does not interfere the movement of pedaling their feet and hands 97.2%, it does not interfere bending and stretching movements 96.2%, did not interfere stretching movements with the highest percentage value answering disagreed by 95.8%, did not interfere in doing circular movements 95.5%, did not interfere in doing bending movement 95.1%, did not interfere in doing pushing and pulling movements 96.4%, did not disturb strength skill in doing lifting and lowering movements 64.3%, it did not interfere in moving up and down stairs 94.9%, disrupts in kicking movements 69.4 % and disrupting students' throwing 69.4%. In the aspect of manipulative skills, interferes catching the ball 70.1%, disturbing sin dribbling the ball 68.8%, disturbing in throwing balls 69.4%, disturbing in throwing balls with the 68.8%, disturbing in hitting balls 68.4%.

Conflicts of interest

The authors declare that they have no conflict of interest.

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Suggestions and recommendations

There is a need for further research using the right form of play in learning to improve the manipulative movement skills of elementary school students. It is recommended that the research be divided into upper and lower classes so that the differences can be known.

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ОПИТУВАННЯ З МЕТОЮ ОЦІНКИ ОСНОВНИХ РУХОВИХ НАВИЧОК УЧНІВ ПОЧАТКОВИХ ШКІЛ У РОЗПАЛІ ПАНДЕМІЇ COVID-19

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Реферат. Стаття: 9 с., 24 табл., 30 джерел.

Метою цього дослідження було визначення результатів опитування з метою оцінки основних локомоторних, нелокомоторних і маніпуляційних рухових навичок учнів початкових шкіл у районі Канданган, регентство Кедірі, Східна Ява (Індонезія), у розпалі пандемії COVID-19.

Матеріали та методи. У цьому дослідженні використовували план описового дослідження та тип кількісного дослідження, тому що методом, який використовували в цьому дослідженні, був метод опитування. Генеральна сукупність учнів молодших класів у районі Канданган становила 2997 учнів молодших класів. Для визначення розміру вибірки використовували метод випадкової цілеспрямованої вибірки; було відібрано 471 учасника серед учнів 4, 5 та 6 класів початкових шкіл, розташованих у районі Канданган, регентство Кедірі, Східна Ява (Індонезія). Методом збору даних, який використовували в цьому дослідженні, був метод опитування, при цьому застосовували засоби збору даних із використанням анкет, створених за допомогою застосунку Google Форми. Аналіз даних у цьому дослідженні проводили з використанням описового вибіркового тесту.

Результати. Вплив пандемії COVID-19 не зашкодив учнівським навичкам виконання локомоторних і нелокомоторних рухів, але великою мірою шкодить учнівським навичкам виконання маніпуляційних рухів.

Висновки. Навчання фізичної культури, спорту та здорового способу життя під час пандемії COVID-19 не зашкодило учнівським навичкам виконання локомоторних і нелокомоторних рухів, але шкодить учнівським навичкам виконання маніпуляційних рухів.

Ключові слова: основні рухові навички, локомоторні, нелокомоторні, маніпуляційні, пандемія COVID-19, учні початкових шкіл.

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ORIGINAL SCIENTIFIC ARTICLE

DEVELOPING A BASKETBALL LEARNING MODEL USING THE TEACHING GAME FOR UNDERSTANDING (TGfU) APPROACH TO IMPROVE THE EFFECTIVENESS OF HOTS IN ELEMENTARY SCHOOLS

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Abstract

Study purpose. The researcher realizes that not all physical education teachers in elementary schools provide basketball lessons and some teachers still use conventional learning techniques. This study aims to determine the effectiveness of a basketball learning model with the TGfU approach to increase HOTS and reduce bullying.

Materials and methods. This study used a quantitative approach to test the validity of the content and constructs as well as the effectiveness of the learning model. The experimental subjects in this study were fifth-grade students totaling 165 respondents from 5 elementary schools in Central Java, Indonesia. Data analysis of small-scale trials used Explanatory Factor Analysis (EFA) path analysis, and that of large-scale trials used Confirmatory Factor Analysis (CFA) path analysis. The paired-samples t-test was used to analyze the effectiveness of HOTS and the reduction of bullying.

Results. The result of this study is a basketball learning model that utilizes the TGfU approach to increase HOTS and reduce bullying behavior in the form of a guidebook.

Conclusions. The developed model can increase HOTS and reduce bullying and will affect students' cognitive, affective and psychomotor learning outcomes. So that the learning model is easy, safe, and makes students more enthusiastic about learning.

Keywords: basketball lessons, bullying, higher-order thinking skills, teaching game for understanding.

Introduction

Learning basketball games based on Teaching Game for Understanding (TGfU) can improve Higher Order Thinking Skills (HOTS) and basketball games based on TGfU can also reduce bullying behavior greatly, almost every game activity at the provincial, national, and international levels, basketball games became one of the games of choice to be held because it can absorb the public's interest and is also rich in values and character strengthening in elementary schools (Barquero-Ruiz et al., 2021; García-López et al., 2019; Riyanto & Widiyanto, 2021). The basketball learning process consists of teaching

methods, time, and learning materials (Bavli, 2016). Learning models can be defined as ways or styles used by teachers to convey their messages to students on the field and in class (Gil-Arias et al., 2020; Mu'arifin et al., 2022; O'Leary et al., 2020).

Therefore, it is important to note that those who wish to develop basketball skills, learn how to do so using basketball materials. Basketball is a sport that is played in groups. A game is played between two teams of five players each, with each team competing for the higher points by shooting the ball into their opponent's ring (Jarrett & Light, 2019; Nathan, 2017; Pritchard & Morgan, 2022). To achieve optimal performance, individual players must possess several technical and tactical skills, express high-level motor skills, explosive power, speed, and agility (Bracco et al., 2019; Heemsoth et al., 2022; Levenberg et al., 2020). One or two hands can be used to pass the ball from player to player.

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However, adequate care must be taken when doing this to prevent the ball from falling into the opponent's hands. Players sometimes carelessly pass the ball to their teammates without resorting to some tactics to trick their opponents (Bavli, 2016; Jarrett & Light, 2019). Teachers are expected to choose suitable lessons such as the TGfU approach to teaching students the game of basketball. According to (Morales-Belando et al., 2021), TGfU is designed to focus on developing tactical decision-making within a game framework. Besides that, the TGfU approach can also increase HOTS and reduce bullying behavior (Barquero-Ruiz et al., 2021; Harvey et al., 2018; Wood, 2017).

Based on the results of research in elementary schools, it is known that physical education teachers do not use an approach model in learning basketball games but use conventional learning methods, besides that some elementary schools have also not implemented basketball learning due to equipment constraints. This makes the act of learning the game of basketball commonplace using common standards of behavior. The absence of an attractive approach model makes the game of basketball boring and uninteresting for students (Gubby & Wellard, 2016). This study implies that using a tactical approach to teaching students the game of basketball can develop their critical understanding and effective response to the dynamics and complexities of the game and can reduce bullying behavior in elementary schools.

Materials and methods

Study participants

The experimental subjects in this study were fifth-grade students totaling 165 respondents consisting of 5 elementary schools in Central Java, Indonesia. The subjects for the small-scale trial used 2 elementary schools with the research subjects totaling 35 fifth-grade students. Subjects for the wide-scale test used five schools by random sampling, both public and private schools. Research subjects with a total of 130 students.

Type of Research

This research is research and development. This study develops a product that is used in a learning approach using fifth-grade elementary school students. According to (Daryono et al., 2021; Healy et al., 2020; Huang et al., 2020; Mingaleva & Vukovic, 2020), research and development are defined as a method or technique used to produce and test the effectiveness of a particular product. Therefore, this study aims to develop basketball learning with the Teaching Game for Understanding (TGfU) approach to increase HOTS and reduce bullying behavior (Barquero-Ruiz et al., 2021; Harvey et al., 2018; Wood, 2017). Fifth-grade students of SD Se-Central Java became the data used in carrying out this research.

Data Collection Techniques and Instrument

Data collection techniques used questionnaires and tests, questionnaires were used to measure variable responses (Daryono et al., 2020; Setyadi et al., 2021) to experts in the form of Teaching games for understanding (TGfU) ap-

proaches and higher-order thinking skills (HOTS) in basketball learning. The data collection instruments consist of 1) Test instrument, a test in the form of multiple-choice (dichotomies 0 and 1) with five answer choices, which refers to indicators of higher-order thinking skills totaling 25 questions; 2) Validation sheet, carried out by two experts, namely: instrument expert for validation of test instruments and evaluation expert for validation of TGfU and HOTS assessments (Subay et al., 2019). Furthermore, the validation was carried out by three sports teachers to determine the practicality and response of teachers as teachers in the school environment (Riyanto & Widiyanto, 2021).

Data Analysis Techniques

The content validity analysis technique with quantitative analysis using the Aiken's V formula. The construct validity test uses path analysis. Explanatory Factor Analysis (EFA) on a small-scale test (Hazriyanto et al., 2019; Hidayat et al., 2018; Saifurrahman et al., 2021) and a large-scale test using Confirmatory Factor Analysis (CFA) Path analysis (Boonk et al., 2020; Hariyanto et al., 2022; Ye et al., 2021). The analytical technique to test the effectiveness of the learning model product on increasing HOTS and reducing bullying behavior uses an effectiveness test using pre-experimental research, and pre-test and post-test designs using paired-samples t-test.

Results

Product Test Results: Content Validity

Validation is done by giving text in the form of a validation sheet to instrument experts and evaluation experts, then analyzed using Aiken's V formula to calculate the coefficient of content validity. The results of the validation analysis of basketball learning experts consist of 20 question items (in Table 1).

Validation was carried out to see the content and effectiveness of the initial product for the three sports teachers and then analyze the items of the TGfU-based basketball learning test to increase HOTS and reduce bullying behavior according to the validator's assessment using the Aiken's V formula to calculate the content validity coefficient. While Table 2 shows the calculation of Aiken's V coefficient based on a sports teacher validation composed of 20 items.

Based on table 2, the results show that all multiple-choice items consisting of 20 items of the TGfU-based basketball learning test to increase HOTS and reduce bullying behavior items are in the valid category with the lowest index of 0.666667 and the highest 1.00. Interpretation is done using criteria less than 0.6 then the validity is said to be low, between 0.6-0.8 in the medium category, and if more than 0.8 is said to be high (Acevedo-De-los-Ríos & Rondinel-Oviedo, 2021; Kriswanto et al., 2022; Rusijono et al., 2020). The instrument validation for assessing the TGfU-based basketball learning model to increase HOTS and reduce bullying behavior consisted of 40 questionnaire items, all declared feasible to be used or tested.

Learning Model Trial: Construct Validity

Small-scale tests were carried out after obtaining validation approval from experts, both material expert valida-

Table 1. Results of the Validation Analysis of Basketball Learning Experts

Question Number	Coefficient V Aiken's	Criteria	Question Number	Coefficient V Aiken's	Criteria
1	0.888889	Eligible to use	11	1	Eligible to use
2	0.888889	Eligible to use	12	0.777778	Eligible to use
3	1	Eligible to use	13	0.888889	Eligible to use
4	0.888889	Eligible to use	14	0.888889	Eligible to use
5	1	Eligible to use	15	0.888889	Eligible to use
6	0.888889	Eligible to use	16	0.888889	Eligible to use
7	1	Eligible to use	17	0.777778	Eligible to use
8	0.888889	Eligible to use	18	0.888889	Eligible to use
9	0.888889	Eligible to use	19	0.777778	Eligible to use
10	0.666667	Eligible to use	20	0.888889	Eligible to use

Table 2. Results of the Validation Analysis of Sports Teachers

Question Number	Coefficient V Aiken's	Criteria	Question Number	Coefficient V Aiken's	Criteria
1	1	Eligible to use	11	0.777778	Eligible to use
2	1	Eligible to use	12	0.888889	Eligible to use
3	1	Eligible to use	13	0.888889	Eligible to use
4	1	Eligible to use	14	1	Eligible to use
5	1	Eligible to use	15	0.888889	Eligible to use
6	0.777778	Eligible to use	16	1	Eligible to use
7	0.777778	Eligible to use	17	1	Eligible to use
8	0.888889	Eligible to use	18	0.888889	Eligible to use
9	0.666667	Eligible to use	19	0.888889	Eligible to use
10	0.888889	Eligible to use	20	1	Eligible to use

Table 3. Total Variance Explained of Eigenvalues

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.781	36.130	36.130	5.781	36.130	36.130
2	3.528	22.051	58.182	3.528	22.051	58.182
3	2.983	18.641	76.823	2.983	18.641	76.823
4	1.532	9.573	86.395	1.532	9.573	86.395

Table 4. Rotated Component Matrix

Construct	Component			
	1	2	3	4
Passing Ball (A)	0.964	0.058	0.058	0.053
Dribbling Ball (B)	0.953	0.076	0.074	0.066
Putting the Ball in the Ring (C)	0.934	0.094	0.067	0.171
Defending Ball (D)	0.938	0.095	0.014	0.159
Game Appreciation (E)	0.089	0.924	0.070	0.066
Tactical Awareness (F)	0.065	0.911	0.068	0.055
Making Decision (G)	0.066	0.916	0.009	0.034
Skill Execution (H)	0.086	0.929	0.053	0.034
Problem Solving (I)	0.049	0.004	0.943	0.214
Decision Making (J)	0.033	-0.017	0.843	0.383
Critical Thinking (K)	0.083	0.242	0.732	0.041
Creative Thinking (L)	0.036	-0.012	0.940	0.249
Insulting (M)	0.064	0.353	0.052	0.727
Pushing (N)	0.098	-0.021	0.457	0.751
Hitting (O)	0.146	-0.021	0.253	0.935
Tempting (P)	0.194	-0.029	0.259	0.918

tion and practitioner expert validation, and were declared eligible for field trials. The small-scale field trial involved two public elementary schools with fifth-grade students. The data obtained from the small-scale trial were in the form of an evaluation based on the TGfU-based assessment aimed at increasing HOTS and reducing bullying behavior.

Based on the EFA test, the KMO value was 0.724 more than 0.50 (Hariyanto et al., 2022; Hidayat et al., 2018). The Bartlett test value with Chi-square is 1.097 and significant at 0.000, it can be concluded that the factor analysis test can be continued. Based on the output Eigenvalues in Table 3, from the nine variables analyzed, it turns out that the extraction results in four factors based on the eigenvalue >1 (Hazriyanto et al., 2019; Saifurrahman et al., 2021). The four factors can explain the variation of 86.395%.

Based on the output rotated component in Table 4, it is clear that those clustered in factor 1 are conformity to the curriculum, safe facilities, the opportunity to try basketball basic movements, and good communication in each team with a loading factor above 0.560. The indicators clustered on factor 2 are improving eye, foot, and hand coordination, according to the level and ability of students, TGfU is more fun and easy to do, each with a factor loading above 0.739.

While those grouped on factor 3 are responsive when catching a team's pass, able to make the right decisions to score, able to make decisions to prevent a score from happening, catch the right ball, each with a loading factor above 0.583. While those who grouped on factor 4 were kicking the feet, insulting, teasing, and pushing each with a loading factor of 0.636.

Based on the construct validity test or the feasibility of implementing the basketball learning model using a questionnaire instrument, with Explanatory Factor Analysis (EFA) it was found that the questionnaire instrument was by the content validity of the experts (Daryono et al., 2020; Hidayat et al., 2018). The assessment of the model using a questionnaire instrument was carried out by 3 judges or raters including physical education teachers to see if the model was easy, practical, and safe to use.

Field Test: Construct Validity

Qualitative input to the three items in the learning model carried out in the field, including it is necessary to arrange the language in the activity material in easy-to-understand language for physical education teachers. Revisions have been made to improve the language so that it is easy for teachers to understand the model users. Then the next step is testing the broad scale.

Based on the results of the analysis of Table 5, it was found that all items in the instrument were said to be reliable. It is said to be reliable because it meets the requirements that the standard loading is above 0.7 (based on Smart PLS-SEM calculations). Based on the table of construct reliability and validity, the AVE values of each HOTS, PB, and TGfU variable were obtained, namely 0.852, 0.666, 0.677, and 0.761. The AVE value >0.5 (Hariyanto et al., 2022; Hidayat et al., 2018) describes adequate convergent validity, which means

Table 5. Criteria for Calculating Construct Reliability (CR)

Items	Factor Loading	Construct Reliability	Decision
Passing Ball (A)	0.760	0.893	Reliable
Dribbling Ball (B)	0.829	0.893	Reliable
Putting the Ball in the Ring (C)	0.939	0.893	Reliable
Defending Ball (D)	0.751	0.893	Reliable
Game Appreciation (E)	0.854	0.927	Reliable
Tactical Awareness (F)	0.859	0.927	Reliable
Making Decision (G)	0.868	0.927	Reliable
Skill Execution (H)	0.908	0.927	Reliable
Problem Solving (I)	0.770	0.888	Reliable
Decision Making (J)	0.884	0.888	Reliable
Critical Thinking (K)	0.863	0.888	Reliable
Creative Thinking (L)	0.737	0.888	Reliable
Insulting (M)	0.945	0.958	Reliable
Pushing (N)	0.946	0.958	Reliable
Hitting (O)	0.945	0.958	Reliable
Tempting (P)	0.853	0.958	Reliable

that one latent variable can explain more than half of the variance of the indicators on average. While the Cronbach alpha values for each variable are 0.942, 0.841, 0.864, and 0.895 and the composite reliability (CR) values are 0.958, 0.888, 0.893, and 0.927 both aspects of reliability measurement are above 0.70 (Boonk et al., 2020; Saifurrahman et al., 2021), so the evaluation to measure the model structure on instrument reliability has been fulfilled. Following the model fit-table, the SRMR value or Standardized Root Mean Square, the value is $0.096 < 0.10$, then the model is fit. The output at the NFI value is 74.4%, which means that the model has been good at

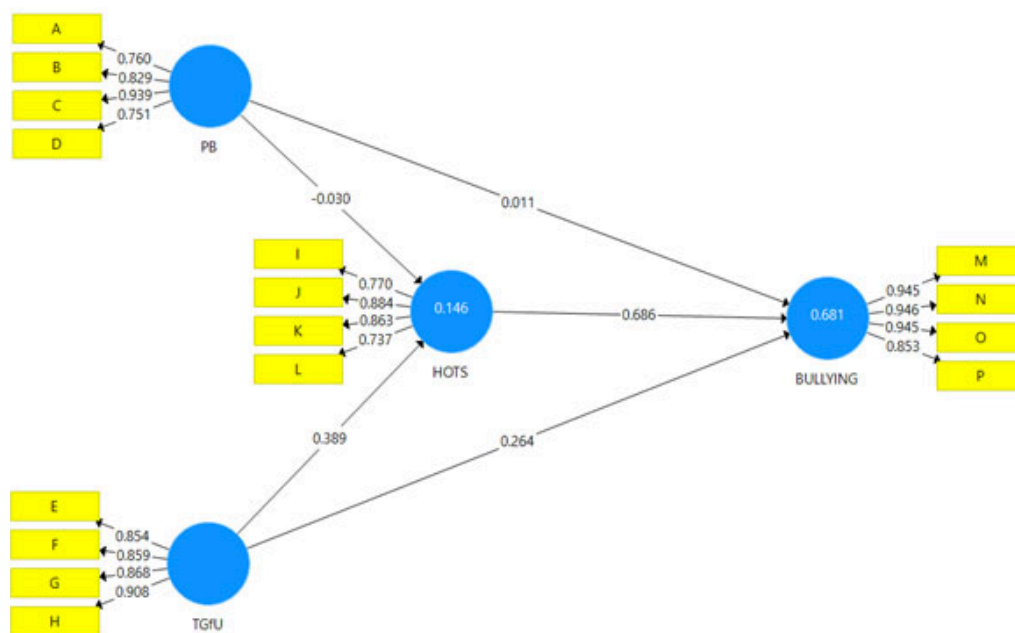


Fig. 1. Structural Model Path Coefficients

Table 6. Paired Samples Correlations

	Variable	N	Correlation	Sig.
Pair 1	Pre-Test and Post-Test	39	0.791	0.000

Table 7. Paired Samples Test

Variable		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test and Post-Test	-1,77E+06	511.012	.81827	-1.934.88	-1.603.58	-21.621	38	.000

measuring the variables studied. So it can be concluded that the fit model is met with the data.

Results of the Effectiveness Test of the Basketball Learning Model to Increase HOTS and Reduce Bullying Behavior

Based on the results of data collection from 4 meetings the basketball game learning model was presented to students, following the results of the pre and post-test differences about the effectiveness of the learning model to increase HOTS and reduce bullying behavior in two elementary schools in Central Java Indonesia, the data obtained are as in Table 6 and 7.

Based on the results of the study, the results of the mean difference between pre and post-tests were tested using t-test analysis, the results were $0.000 < 0.05$, so there was a significant difference in learning outcomes and student bullying behavior before and after being given the TGfU approach with the basketball learning model.

Discussion

This research resulted in the development of basketball learning based on the Teaching Game for Understanding (TGfU) to increase HOTS and reduce bullying behavior in elementary schools. Teaching Game for Understanding (TGfU)-based basketball learning to improve HOTS and reduce bullying behavior focuses on basketball basic motion materials such as dribbling, passing, catch, and shooting. The HOTS questions in this study consisted of 25 multiple choice questions with five answer choices including levels C4 (analyzing), C5 (evaluating), and C6 (making). The HOTS concept used in this study refers to the revision of the concept of HOTS in Bloom's Taxonomy.

The characteristics of multiple-choice questions calculated with the help of the Microsoft Excel program show that from the 25 items two questions are not valid. These results indicate that the quality of validity is good because the number of valid items is more than 50%. This means that HOTS questions can measure what should be measured. The average level of reliability of the item is 0.97, so it can be concluded that the item has a very strong level of reliability. The average difficulty level is 0.33 in the medium category. The average discriminatory power test is 0.42 in the good category, and the average discriminatory power index is 0.56 in the good category (Fudin & Hariyadi, 2020). This TGfU-based basketball learning can increase HOTS and reduce bullying behavior in elementary school students. Especially in the basic motion material of dribbling, passing, catch, and shooting. The test that contains higher-order thinking ques-

tions (HOTS) encourages students to think about the subject matter and can reduce bullying behavior (Wood, 2017).

Based on the results of the learning process obtained from student assessments through the assessment of the TGfU approach by practicing basketball games. The results of observations in this large-scale trial show that all the learning steps with the TGfU approach are in the good category. Activities carried out at the beginning of the teacher's learning provide a stimulus to students so that students and teachers interact with each other, before learning the basketball game the teacher provides theory in the basketball game before practicing in the field, after that students are able to respond and ask questions with the teacher, so that basketball game learning can be active and can increase HOTS and reduce bullying behavior in the learning process so that learning goes as expected.

This research is in line with the results of a study by (Barquero-Ruiz et al., 2021; Morales-Belando et al., 2021) which has given a positive response or as expected to the TGfU model where the level of suitability of the response reaches the very good category, both for aspects of the learning approach that have fulfilled the elements of active, innovative, creative, effective and psychomotor learning. Research (Bracco et al., 2019; Heemsoth et al., 2022) provides research recommendations that the response to this TGfU model believes that this TGfU model is very suitable for the objectives of physical education learning where the level of suitability of the response reaches above 75%. Based on the discussion, it can be concluded that sports education teachers gave a good response to the Teaching Games for Understanding (TGfU) approach, to be applied in (García-López et al., 2019; Harvey et al., 2018) sports learning. Based on the conclusions of this study, it is suggested that the TGfU approach can be used as an alternative in physical education learning. In particular, the suggestions in this study are addressed to physical education teachers to always be creative in achieving learning goals by utilizing various learning models.

Based on the results of data analysis and hypothesis testing that has been carried out by the TGfU model regarding students' Higher Order Thinking Skills (HOTS), this study is in line with the results of research by (García-López et al., 2019; Gil-Arias et al., 2020; Morales-Belando et al., 2021) that can improve the passing ability of elementary school students' sports and extracurricular learning. This shows that the basic concept of playing through the TGfU model has considerable effectiveness on the learning outcomes of basic technical training in sports and extracurricular

learning. The results of (Heemsoth et al., 2022) research have proven the theories that have been described above that the Teaching Games For Understanding model can improve the basic technical skills of sports and extracurricular learning, if given in the form of basic concepts of playing to students who take part in sports and extracurricular learning.

The TGfU learning model helps students to achieve learning goals by learning in groups and working together. This is in accordance with opinion that the concept of TGfU-based learning also places more emphasis on student activity. Students are able to develop not only most of their psychomotor skills but also their affective and cognitive domains are well developed (Licorish et al., 2018; Pondee et al., 2021). In addition, research is relevant to research conducted by the author, namely research from (Lameras et al., 2021; Levenberg et al., 2020) which examines the effect of the TGfU Learning Model in the Dodgeball Game on Throwing and Catching Skills. These results indicate that the Teaching Game For Understanding (TGfU) learning model using the dodgeball game media can improve and develop throwing and catching skills. Based on the fact that Teaching Game for Understanding is widely used for learning sports and games, there are still few studies showing the use of the TGfU learning model (Jarrett & Light, 2019; Pritchard & Morgan, 2022).

The final product of the TGfU-based basketball learning model to increase HOTS and reduce bullying behavior and can affect the learning outcomes of fifth graders, (Jayantilal & O'Leary, 2017; O'Leary et al., 2020) research also provides recommendations that TGfU can be applied to fifth grade elementary school students, namely being able to carry out active movements when learning physical education, doing dribbling, passing, catching, shooting in addition to cooperation, and honesty. Then in this TGfU approach, students are able to involve their cognitive, affective, and psychomotor aspects in basketball games such as games, appreciation games, tactical awareness, decision making, skill execution and performances (Heemsoth et al., 2022; Nešković, 2020; Pritchard & Morgan, 2022).

Students still need guidance from the teacher to understand the rules of playing basketball with the TGfU approach to increase HOTS and reduce bullying behavior. The steps for learning basketball games with the TGfU approach to increase HOTS and reduce bullying behavior consist of 6 steps, namely: Game, Game Appreciation, Tactical Awareness, Decision Making, Execution Skill, and Performance. The efficiency of using the TGfU-based basketball learning model is seen from the time of use, and learning resources. In terms of time, this learning media allows children to play according to the desired time.

The TGfU-based basketball learning model developed can be used as an alternative learning. Overcoming the limitations of teachers in delivering material, providing knowledge about active movement in learning to students so that they are able to apply movements in learning the game of basketball. This affects the learning of the TGfU-based basketball game, which is a learning environment that provides support and opportunities for students to make active movements in learning the game of basketball. Cheerfulness, sincerity, opportunities to work together, and honesty also provide a good learning environment for students.

Conclusions

The feasibility of the basketball learning model with the TGfU approach to increase HOTS and reduce bullying behavior in elementary schools can be said to be both content and empirically feasible. So that the learning model is easy, safe, and makes students more enthusiastic about learning. Effectiveness can be measured using the paired-sample t-test method to find out how much influence and improvement in student learning outcomes are given before and after the TGfU approach is given. The TGfU approach also shows that the basketball game is very well developed and increases HOTS and reduces bullying behavior. Because there is a significant difference before and after being given a learning model with the TGfU approach. This research is expected to be a reference for future researchers on how to increase HOTS and reduce bullying behavior among students in the learning process of physical education in elementary schools. The hope is that this learning material can be applied to alternative learning models that already exist.

Acknowledgement

Thank you to all the experts, teachers and students participated in this research. Hopefully, the results of this research are useful in learning.

Conflict of interest

There is no conflicts of interest to declare.

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РОЗРОБКА МОДЕЛІ НАВЧАННЯ БАСКЕТБОЛУ З ВИКОРИСТАННЯМ ПІДХОДУ «НАВЧАННЯ ГРИ ДЛЯ РОЗУМІННЯ» (НГДР) ДЛЯ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ НАВИЧОК МИСЛЕННЯ ВИЩОГО ПОРЯДКУ (НМВП) У ПОЧАТКОВИХ ШКОЛАХ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 7 табл., 1 рис., 39 джерел.

Мета дослідження. Автор дослідження усвідомлює, що не всі вчителі фізичного виховання в початкових школах проводять заняття з баскетболу, а досі використовують традиційні методи навчання. Метою цього дослідження є визначення ефективності моделі навчання баскетболу з використанням підходу НГДР для підвищення НМВП та зниження рівня булінгу.

Матеріали та методи. У цьому дослідженні використовують кількісний підхід для перевірки правильності змісту та структурних компонентів, а також ефективності цієї моделі навчання. Учасниками експерименту в цьому дослідженні були загалом 165 п'ятикласників із 5 початкових шкіл у Центральній Яві, Індонезія. Для аналізу даних маломасштабних випробувань використовували пат-аналіз «Аналіз пояснювальних факторів», а для аналізу даних великомасштабних випробувань використовували пат-аналіз «Аналіз підтверджувальних факторів». Для аналізу ефективності НМВП та зниження рівня булінгу використовували t-критерій Стюдента для парних вибірок.

Результати. Результатом цього дослідження є викладена у формі посібника модель навчання баскетболу з використанням підходу НГДР для підвищення НМВП та зниження рівня булінгу.

Висновки. Розроблена модель може підвищувати НМВП та знижувати рівень булінгу та впливатиме на когнітивні, емоційні та психомоторні результати навчання учнів. Таким чином, ця модель навчання є легкою, безпечною та додає унціям ентузіазму до навчання.

Ключові слова: заняття з баскетболу, булінг, навички мислення вищого порядку, навчання гри для розуміння.

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ORIGINAL SCIENTIFIC ARTICLE

MODERATE-INTENSITY EXERCISE DECREASES CORTISOL RESPONSE IN OVERWEIGHT ADOLESCENT WOMEN

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Abstract

The study purpose was to demonstrate the effect of moderate-intensity exercise on reducing cortisol levels in overweight adolescent women.

Materials and methods. This study is an actual trial study with a pre-test randomized control group design involving 20 overweight adolescent women aged 19–22 as research subjects who were randomly divided into two groups, namely CNG (n = 10, control group) and EXG (n = 10, moderate-intensity exercise group). The moderate-intensity exercise intervention was performed for 40 minutes on a treadmill. Cortisol levels were measured using an Enzyme-linked immunosorbent assay (ELISA) kit. Data analysis technique used t-test of independent samples and correlation test using Pearson's correlation coefficient with Statistical Package for Social Sciences (SPSS) version 21.

Results. Cortisol levels were obtained as a result of the best means between CNG and EXG (222.57 ± 56.04 vs 225.56 ± 63.96 ng/mL, ($p \geq 0.05$)), post-test cortisol levels between CNG and EXG ($238, 27 \pm 77.94$ vs 118.13 ± 12.90 ng/mL, ($p \leq 0.001$)) and cortisol Δ between CNG vs EXG (15.71 ± 13.14 vs $-107.43 \pm 21, 13$ ng/mL, ($p \leq 0.001$)). Cortisol levels also showed a positive relationship with markers of overweight ($p \leq 0.05$).

Conclusions. Based on the study results, it was concluded that the cortisol response decreased after moderate-intensity exercise and found a positive relationship between cortisol levels and markers of overweight. These results could be used as a long-term approach to modifying an active lifestyle to reduce stress levels.

Keywords: cortisol, exercise, metabolic syndrome, overweight, stress.

Introduction

The prevalence of overweight and obesity is increasing over the years (Chu et al., 2017) with the greatest increase in women of all age groups (The Global Burden of Disease

(GBD) 2015 Obesity Collaborators, 2017). According to reports from several countries, the prevalence of overweight and obesity among 11- and 13-year-olds ranges from 5% to more than 25% (ENHIS, 2009). The increasing prevalence of overweight and obesity is not only occurring in developed countries but is increasing significantly in developing countries, not only among adults but also among children and adolescents (Seidell & Halberstadt, 2015). Even developing countries like Indonesia have problems with overweight and obesity (Shrimpton & Rokx, 2013). Based on the results of

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the 2013 Health Basics Study, the prevalence of overweight and obesity among adolescents aged 13 to 15 years was 11.2% and 4.8%, respectively (Risksdas, 2018). Overweight is the accumulation of too much fat in adipose tissue, often associated with inactivity, unhealthy food consumption, and increased consumption under stressful conditions (Urbanet-to et al., 2021). However, this issue is not widely understood.

Stress occurring in overweight individuals may result in a greater pathophysiological burden than in normal weight individuals (Heraclides et al., 2012). Stress not only causes a number of non-communicable diseases, but it also leads to a decrease in a person's immunity, facilitating disease (Glaser & Kiecolt-Glaser, 2005). In overweight women, ongoing stress exposure also has an impact on reproductive organs and mental disorders (Foss & Dyrstad, 2011; De Vriendt, 2009). Chronic stress can induce physiological responses in the form of increased mobilization of energy stores (Torres & Nowson, 2007), including increased gluconeogenesis and lipolysis to compensate for stress (Foss & Dyrstad, 2011). Chronic stress in overweight women may also increase the risk of developing type 2 diabetes (T2D) (Heraclides et al., 2012). Therefore, the stress experienced by overweight people must be managed properly.

Exercise is one of the proven modalities for the treatment of overweight and obesity (Niemi et al., 2021). On the other hand, exercise also has a positive effect on reducing stress levels, which is characterized by a decrease in the cortisol response (Gerber et al., 2020; Caplin et al., 2021). Exercise can reduce the activation of the hypothalamic-pituitary-adrenal (HPA) axis (Caplin et al., 2021), which is the main mechanism that regulates cortisol secretion through an endocrine feedback mechanism neurology (Pauli et al., 2006; Sugiharto, 2012; Corazza et al., 2014; Pranoto et al., 2020). However, based on the reports of several studies, it is still found that there is a difference in the results regarding the effect of exercise on lowering cortisol levels. According to the study conducted by Irandoust & Taheri (2018) reported a decrease in cortisol levels after high intensity interval training (HIIT) intervention in obese women. Study of Koc (2018) reported that there was no significant difference in cortisol levels between before and after exercise in athletes and sedentary subjects. The study of Karacabey (2009) reported increased cortisol levels after exercise for 12 weeks in obese children. However, the study by Singh et al. (2019) reported a decrease in cortisol levels after moderate-intensity acute exercise. Similarly, the study by Davitt et al. (2017) reported that plasma cortisol levels decreased after a moderate-intensity endurance exercise intervention in obese women. However, study of Koch (2010) reported that cortisol levels increased 120 min after exercise at 60% HRmax intensity.

The aim of this study was to demonstrate the effect of moderate-intensity exercise on reducing cortisol levels in overweight adolescent women. We hypothesized that increasing cortisol levels in overweight subjects with moderate-intensity exercise would significantly reduce cortisol levels.

Material and Methods

Study protocol

20 overweight adolescent women between the ages of 19-22 were enrolled as subjects in the study. The inclusion

criteria for this study were individuals with a body mass index (BMI) between 25.52 kg/m² – 28.72 kg/m² (mean $\pm$ SD BMI 27.48 $\pm$ 1.07 kg/m²), normal blood pressure, normal resting heart rate (RHR), oxygen saturation (SpO₂) 96% – 99% (mean $\pm$ SD SpO₂ 97.75 $\pm$ 0.87%). The exclusion criteria for this study were people with chronic medical conditions, such as diabetes, lung disease, and coronary heart disease, who were on a weight loss program. Written informed consent was obtained prior to conducting the study. The procedures used in this study adhered to the principles of the World Medical Association (WMA) Declaration of Helsinki regarding the ethical conduct of research involving human subjects.

Exercise protocol

The physical training program is implemented and supervised by professional staff from the Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Jakarta, Indonesia. Strength training is performed intensively with an intensity of 60-70% HRmax for 40 minutes with details of 5 minutes warm-up with an intensity of 50-60% HRmax, 30 minutes of the main exercise perform continuous exercise with an intensity of 60-70% HRmax and 5 min of cooling with an intensity of 50-60% HRmax (Rejeki et al., 2021). Exercise was performed from 07:00 to 09:00 on a treadmill (Pulsar 4.0 HP Cosmos Sports & Medical, NussdorfTraunstein, Germany) (Nedić et al., 2017; Rejeki et al., 2022). Heart rate monitoring during exercise using a Polar heart rate monitor (Polar Heart Rate Sensor H10, Inc., USA) (Rejeki et al., 2022).

Anthropometry and cortisol response measurements

Measure body height with an altimeter (Seca® Handheld Altimeter, North America). Measure body weight using a digital scale (OMRON model HN289, Omron Co., Osaka, Japan). Body mass index (BMI) was calculated by dividing body weight (kg) by body height (m²) (Nimptsch et al., 2019; Adji et al., 2021; Raharjo et al., 2021). Blood pressure was measured with an OMRON digital sphygmomanometer (OMRON Model HEM7130 L, Omron Co., Osaka, Japan) in the non-dominant arm 3 times in a row with an interval of 12 min (Rejeki et al., 2022; Andarianto et al., 2022; Yosika et al., 2020). Measure RHR and SpO₂ with a Beurer pulse oximeter (Pulse Oximeter PO 30, Beurer North America LP, Hallandale Beach, FL, USA) (Rejeki et al., 2022). A blood sample was obtained 30 min before and 24 h after exercise on 4 ml cubital vein. The blood sample was inserted into the Vacutainer tube, after which the blood sample was centrifuged for 15 min at 3000 rpm. Serum was separated and stored at -80°C for cortisol levels analysis the next day. Check cortisol levels using the Enzyme Linked Immunosorbent Assay (ELISA) kit method (Catalog No: MBS269825; MyBioSource; San Diego, CA, USA) with a sensitivity of 0-5 ng/mL and range detection is 15.6 ng/mL – 1000 ng/mL.

Statistical analysis

Statistical analysis used the Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSS Inc., Chicago, IL, USA). Normality test using Shapiro-Wilk test. To find out

the difference in cortisol levels before and after the exercise in each group, a different paired t-test was performed, while to find the difference in cortisol levels between CNG and EXG, another t-test for independent samples was performed. The potential relationship between markers of overweight and cortisol levels was assessed using Pearson's correlation coefficient test. All data are shown with mean $\pm$ standard deviation (SD). All statistical analyzes used a threshold of significance ($p \leq 0.05$).

Results

The results of the analysis of the characteristics of the study subjects, including age, body weight, body height, body mass index, systolic blood pressure, diastolic blood pressure, resting heart rate, and storm oxygen saturation in both groups, shown in Table 1 below.

Table 1. Characteristics of research respondents

Variable	Unit	n	CNG	EXG	p-value
Age	yrs	10	20.40 $\pm$ 1.17	20.30 $\pm$ 1.16	0.850
Body weight	kg	10	65.66 $\pm$ 3.21	66.44 $\pm$ 4.70	0.670
Body height	m	10	1.55 $\pm$ 0.03	1.55 $\pm$ 0.04	0.644
Body mass index	kg/m ²	10	27.47 $\pm$ 0.99	27.49 $\pm$ 1.15	0.969
Systolic blood pressure	mmHg	10	118.00 $\pm$ 9.19	120.00 $\pm$ 8.17	0.613
Diastolic blood pressure	mmHg	10	76.00 $\pm$ 9.66	79.00 $\pm$ 8.76	0.476
Resting heart rate	bpm	10	70.60 $\pm$ 6.11	71.10 $\pm$ 3.93	0.830
Oxygen saturation	%	10	97.70 $\pm$ 0.82	97.80 $\pm$ 0.92	0.801

Description: CNG: control group; EXG: Moderate-intensity exercise group. Values obtained using t-test of independent samples compared between CNG and EXG. Data are presented as mean $\pm$ SD.

Based on Table 1, it can be seen that the average data on the characteristics of the study subjects tend to be the same. The results of the t-test of independent samples showed that there was no significant difference in the mean data on the characteristics of the study subjects ($p \geq 0.05$).

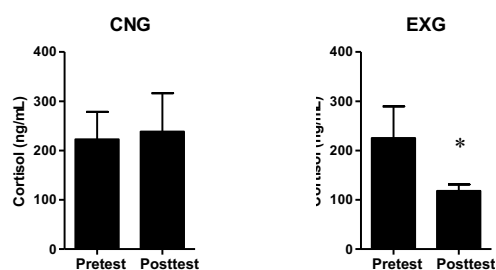


Fig. 1. Cortisol levels pretest and posttest on CTG and ECG.

Description: CNG: control group; EXG: Moderate-intensity exercise group. (*) Shows a significant difference with the best sample in the paired t-sample test ($p \leq 0.001$). Data are displayed as mean $\pm$ SD

Based on Figure 1, it can be seen that the cortisol level on CNG between best and after test tends to be the same, while on EXG, it shows a decrease in cortisol level between best and after test. The results of the paired sample t-test on CNG between the sample before and after the test showed no significant difference (222.57 ± 56.04 vs 238.27 ± 77.94 ng/mL, ($p \geq 0.05$), while EXG showed a significant difference (225.56 ± 63.96 vs 118.13 ± 12.90 ng/mL, ($p \leq 0.001$)).

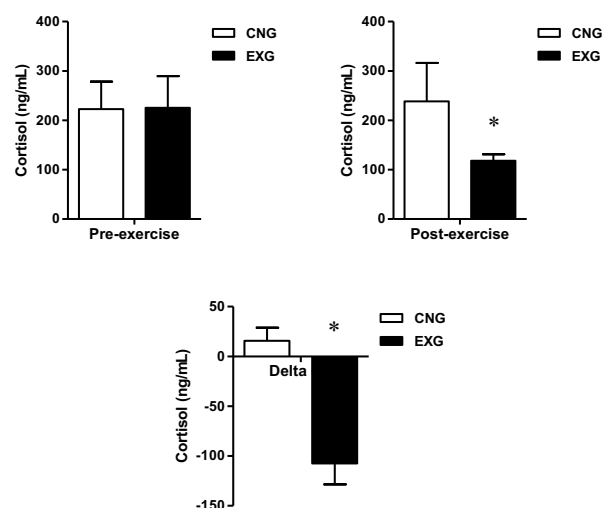


Fig. 2. Cortisol levels pretest, posttest, delta (Δ) between CNG vs. EXG. *Description:* CNG: Control group. EXG: Moderate-intensity exercise group. (*) The t-test of independent samples shows a significant difference from CNG ($p \leq 0.001$). The data is expressed as mean $\pm$ SD

Based on Figure 2, it can be seen that the pretest cortisol levels between CNG and EXG tend to be the same, while the posttest and delta (Δ) levels show a decrease in cortisol levels. The results of the Independent Samples t-Test pretest between CNG and EXG did not show a significant difference (222.57 ± 56.04 vs. 225.56 ± 63.96 ng/mL, ($p \geq 0.05$)), while the posttest and Δ showed a significant difference (238.27 ± 77.94 vs. 118.13 ± 12.90 ng/mL, ($p \leq 0.001$)) and (15.71 ± 13.14 vs. -107.43 ± 21.13 ng/mL, ($p \leq 0.001$)). The relationship between pretest cortisol levels and overweight markers is presented in Figure 3.

Based on Figure 3, it can be seen that the pretest cortisol levels positive correlation with body weight (BW) ($r = 0.570$, $p = 0.009$), body mass index (BMI) ($r = 0.688$, $p = 0.001$), FAT ($r = 0.695$, $p = 0.001$), fat mass (FM) ($r = 0.799$, $p = 0.000$), free fat mass (FFM) ($r = 0.772$, $p = 0.000$), waist circumference (WC) ($r = 0.626$, $p = 0.003$) and shows a moderate correlation between variables. However, other markers of overweight, such as hip circumference (HC) ($r = 0.529$, $p = 0.016$), and waist to hip ratio (WHR) ($r = 0.469$, $p = 0.037$) showed a weak positive correlation with cortisol levels.

Discussion

The results showed no significant difference in mean cortisol levels between before and after the test in the control group (CNG), while the moderate-intensity exercise (EXG) group showed a difference. on the mean decrease in cortisol

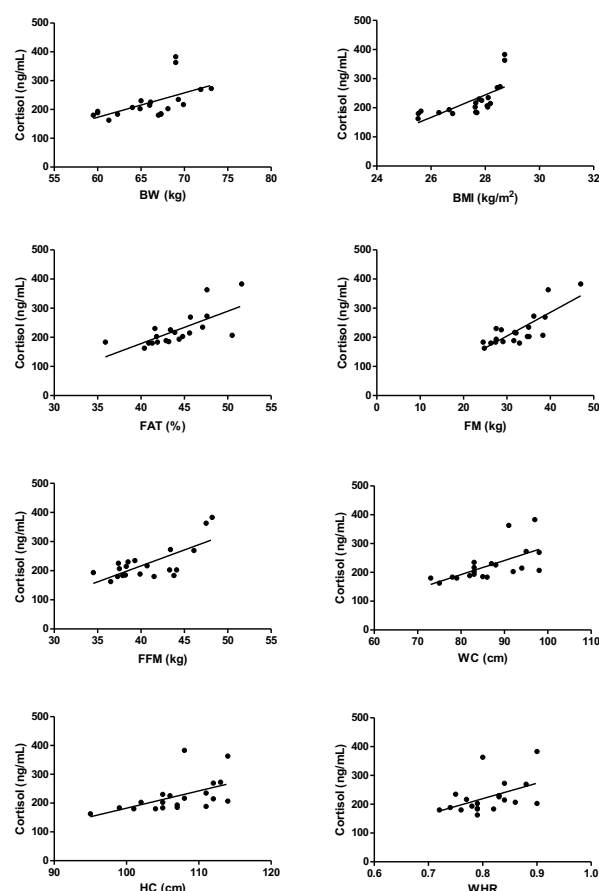


Fig. 3. A positive relationship between pretest cortisol levels and markers of overweight. Description: Value (r) and (p-value) were obtained using the Pearson correlation coefficient test

levels between pre-test and post-test (Figure 1). Based on Figure 2, it can be seen that pre-test cortisol levels between CNG and EXG tend to be almost the same, while post-test and delta (Δ) levels indicate decreased cortisol levels. This is consistent with the study of Kong et al. (2016) concluded that cycle exercise at 65% of maximal oxygen consumption resulted in a 13% decrease in cortisol levels in obese women. Reduced cortisol levels may be due to the effects of moderate-intensity exercise intervention. Regular moderate-intensity exercise can increase the secretion of endorphins, thereby inhibiting the activity of the HPA axis and reducing the sympathetic nervous system (Rimmele et al., 2007; Anderson & Shivakumar, 2013). Inhibition of HPAaxis activity may modulate cortisol secretion through a neuroendocrine feedback mechanism (Sugiharto, 2012; Corazza et al., 2014).

During exercise, cortisol secretion can be affected by duration, intensity, type of exercise (Mukarromah et al., 2016), physical fitness, and nutritional status (Beaven et al., 2008). This study used moderate intensity exercise (60-70% HRmax). Exercise performed at moderate intensity can induce positive stress (eustress) (Sugiharto, 2012), while excessive and prolonged exercise can induce negative stress (distress) may increase oxidative damage, thereby increasing the risk of injury (Mrakic-Sposta et al., 2015). The results showed that moderate-intensity exercise significantly reduced cortisol levels compared with the

control group (Fig. 2). According to Popovic et al. (2019) exercise performed at an intensity of at least 60% VO_2max can reduce the cortisol response. Research by Kong et al. (2016) using 18-30 years old female subjects with a BMI of 2330 kg/m^2 who received a moderate-intensity exercise intervention (60% VO_2max) using a 40 minute work cycle that showed decreased cortisol levels. Research by Singh et al. (2019) also reported decreased cortisol levels after moderate-intensity acute exercise. Tomiyama (2019) also reported that moderate-intensity exercise can reduce stress levels, which are characterized by lower cortisol levels. Thus, moderate-intensity exercise could be used as a method to reduce stress levels in overweight adolescent women.

The main finding of this study was that moderate-intensity exercise significantly reduced cortisol levels. These results could be used as a long-term approach to active lifestyle modifications to reduce cortisol levels as a marker of stress levels and prevent the risk of complications from the effects of being overweight. The limitation of this study is that only one marker was used as a stress marker, namely cortisol level, so evidence of a reduction in stress level markers has not yet been established given less precise. Further study is recommended to add other parameters related to stress levels, such as catecholamines, epinephrine, norepinephrine, HPA axis, adrenocorticotrophic hormone (ACTH), and corticotropin releasing hormone (CRH). In addition, future research is also recommended to demonstrate the effects of long term exercise (chronic exercise) on reducing cortisol levels by involving adolescent and young respondents overweight youth.

Conclusion

Overall, these results indicate that the cortisol response is reduced after a 40-minute single session of moderate-intensity exercise and found a positive relationship between basal cortisol levels with markers of overweight.

Conflict of interest

All authors declare that they have no competing interests.

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ВПРАВА ПОМІРНОЇ ІНТЕНСИВНОСТІ ЗНИЖУЄ РІВНІ КОРТИЗОЛУ В ЮНИХ ЖІНОК ІЗ НАДЛИШКОВОЮ ВАГОЮ

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Метою дослідження було продемонструвати вплив виконання вправи помірної інтенсивності на зниження рівнів кортизолу в юних жінок із надлишковою вагою.

Матеріали та методи. Це дослідження є дослідженням на базі поточного клінічного дослідження, побудоване за планом попереднього тестування з рандомізованим розподілом учасників і з використанням контрольної групи. Учасницями дослідження стали 20 юних жінок із надлишковою вагою віком від 19 до 22 років, які методом випадкового відбору були розподілені на дві групи: CNG (n = 10, контрольна група) та EXG (n = 10, група, у якій виконували вправу помірної інтенсивності). Інтервенційну вправу помірної інтенсивності виконували протягом 40 хвилин на тренажері «бігова до-

ріжка». Вимірювання рівнів кортизолу здійснювали за допомогою набору для фермент-зв'язаного імуносорбентного аналізу (ELISA). Як метод аналізу даних використовували t-критерій Стюдента для незалежних вибірок і перевірку кореляції з використанням коефіцієнта кореляції Пірсона, обробку даних здійснювали з використанням ПЗ Statistical Package for Social Sciences (SPSS) версії 21.

Результати. Були одержані та порівняні значення рівнів кортизолу як результат оптимальних середніх значень у групах CNG та EXG ($222,57 \pm 56,04$ проти $225,56 \pm 63,96$ нг/мл, ($p \geq 0,05$)), підсумкових рівнів кортизолу в групах CNG та EXG ($238,27 \pm 77,94$ проти $118,13 \pm 12,90$ нг/мл, ($p \leq 0,001$)) та значення дельти (Δ) кортизолу в групах CNG та EXG ($15,71 \pm 13,14$ проти $-107,43 \pm 21,13$ нг/мл, ($p \leq 0,001$)). Значення рівнів кортизолу також показали позитивний зв'язок із маркерами надлишкової ваги ($p \leq 0,05$).

Висновки. На підставі результатів дослідження було зроблено висновок про те, що після виконання вправи помірної інтенсивності рівні кортизолу знижувалися, і було встановлено позитивний зв'язок між рівнями кортизолу та маркерами надлишкової ваги. Ці результати можна використовувати як перспективний підхід до змінювання активного способу життя з метою зниження рівнів стресу.

Ключові слова: кортизол, вправа, метаболічний синдром, надлишкова вага, стрес.

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THE EFFECT OF SIX-WEEK PLYOMETRIC TRAINING ON ENHANCING SPORTS PERFORMANCE OF ADOLESCENT STUDENTS

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Abstract

Numerous studies have documented that plyometric training is an effective method to improve sports performance. **The purpose of this study** was to compare the effects of six weeks of plyometric training on strength, speed, and power.

Materials and methods. An experimental study using a pretest-posttest control group design was conducted on 30 Perisai Diri athletes. They were randomly divided into three groups: the plyometric jumping jack (JJ) group, the countermovement jump (CMJ) group, and the tuck jump (TJ) group. The respondents in the TJ and CMJ groups were then assigned to six weeks of exercise consisting of three sets each session (18 sessions in total), with intensities ranging from 60% to 80%. Pretest and posttest were conducted to obtain data on strength and explosive power. Data were analyzed using SPSS 21 and presented in mean and standard deviation. Paired sample t-test was performed to compare the differences between the groups before and after the training they were given. One-way ANOVA was used to examine multiple comparison in the gains of strength and power between the groups.

Results. The results showed that the students' strength and power in all groups increased significantly ($p < 0.05$) after six weeks. Differences between the groups were found in strength ($p = 0.000$), which was the case between TJ-CMJ pair ($p = 0.001$) and TJ-C pair ($p = 0.000$). Between-group differences were also found in power ($p = 0.017$), which was the case between TJ-CMJ and TJ-C pairs ($p < 0.05$).

Conclusions. Based on these findings, it was concluded that plyometric training was able to improve strength and leg muscle power of non-trained individuals.

Keywords: countermovement jump (CMJ), plyometric training, power, tuck jump (TJ), strength, stretch-shortening cycle (SSC), student.

Introduction

Plyometric training (PT) is one of the most frequently used method in all sport activities (Benzidane et al., 2015) especially among people playing dynamic sports (Vácz et al., 2013). There are many factors contributed to the rising popularity of PT in the last decades, one of them is due to its flexibility that can be done by individuals at any intensity levels, ranging from low-intensity exercise to high intensity unilateral drills (de Villareal et al., 2010). Plyometric train-

ing has been extensively used to improve explosive sport performance and considered as one of the effective training methods for its comprehensive motor and neuromuscular control benefits (Buckthorpe & Della Villa, 2021). Furthermore, besides PT can produce fast and explosive movements (Anwer & Nuhmani, 2015), several studies have confirmed that PT is considered an essential part of a health-promoting lifestyle in young individuals (Peitz et al., 2018) making PT becomes one of the most effective training methods that is not only used by athletes and professionals, but also people of all ages to improve both physical (Sole et al., 2021) and muscular fitness (Peitz et al., 2018).

Plyometric training consists of wide range of movements such as jumping, running, kicking, hopping, bounding, (Davies et al., 2015), tackling (Slimani et al., 2016) and

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throwing (de Villareal et al., 2010). These explosive movements are produced by a sequence of rapid eccentric muscle contraction (lengthening movement or deceleration) followed immediately by a quick concentric contraction (shortening movement or acceleration) in the shortest possible time (Bedoya et al., 2015; Makaruk et al., 2014). This process is referred as stretch-shortening cycle (SSC) and is one of the underlying mechanisms of plyometric training (Aloui et al., 2021; Vetrovsky et al., 2019; Wang & Zhang, 2016). SSC works by utilizing the elastic properties of connective tissue and muscle fibres, facilitating them to gather elastic energy through the deceleration phase and launch it immediately during acceleration phase to produce greater muscle's mechanical works (Radnor et al., 2018; Sole et al., 2021) and maximal force (Idrizovic et al., 2018).

For the last decades, studies about the benefits of plyometric training have been observed so often, with most studies agreed that PT is a great type of exercise to improve balance (Ramachandran et al., 2021), agility (Asadi, 2012), and speed (Michailidis et al., 2013). Recent studies have found that plyometric training when combined with a periodized strength training program, is able to improve vertical jump performance, muscular power, acceleration, and proprioception in general (Mazurek et al., 2018; Slimani et al., 2016). Aloui et al. (2021) in their experiment on soccer player reported that eight-weeks of plyometric training improved jump performance, balance, sprinting, and change-of-direction (CoD). Another study employing eight weeks of PT in athletes found that PT when combined with balance training program gave better effect on shuttle run and sprint performance (Chaouachi et al., 2014). In addition to that, a systematic plyometric training for lower limb has been found to be an effective method to improve strength and power of muscle legs (Shafeeq et al., 2013). Strength and power are one of the most important skills in sports, where individuals qualified of these factors would highly contribute to their performance in the field (Vácz et al., 2013). Thus, plyometric training is often used by athletes playing in sports that required explosive movements such as volleyball (Ben Ayed et al., 2020), soccer (Sedano et al., 2011), and basketball (Ivanović et al., 2022).

Despite many benefits of plyometric training on increasing performance in athletes, little is known whether this training can give similar results on non-athlete or non-trained individuals. Moreover, little information is available to determine whether short term PT can actually enhance physical performances. Previous studies related to plyometric training were mostly done in long-term duration (8 weeks) (Hariyanto et al., 2022). Therefore, this study was conducted to analyse the effects of six-weeks plyometric trainings on sport-specific performance of high school students, especially strength and power of muscle legs.

Materials and methods

Study participants

It was a quasi-experimental study with pretest-posttest control group design. A total of 30 non-trained high school students were randomly selected using simple random sampling. The inclusion criteria of this study were: (1) male students; (2) age 16-19 years old; (3) had no chronic conditions

that would affect their ability to perform the exercise; and (4) had no injuries of the lower limbs. All participants were informed the details of experimental procedure and instructed to avoid consuming alcohol and heavy activity at least 24 hours prior to testing. Afterward, each participant was assigned to one of three groups: tuck jump (TJ), countermovement jump (CMJ), and control group (C), with each group consisted of 11 subjects. An individual written informed consent was acquired before the experimental began.

Study organization

All participants were assigned to respective plyometric training (TJ and CMJ) and standard training program (C) according to the group they belonged. Participants in TJ completed a repetitive tuck jump, started in standing position with both feet hip-width apart. Then they jumped with knees raised toward the chest, then landed on both legs. After landing, they needed to complete the next tuck jump as quick as possible. Participants in CMJ were instructed to stand in upright position, with hands rest on the hips. They were then instructed to perform downward movement followed by a maximal effort of vertical jump as high as possible. After that, they should land in an upright position and to bend the knees following landing. While participants in C were assigned to regular training program.

The training was individualized for each subject or participant based on the results of maximal strength and power test. The training programs were conducted three times a week over six weeks on non-consecutive days as recommended by previous studies to provide time for regeneration, made it a total of 18 sessions. Each training session was preceded with 10 minutes of standardized warm up, then followed by the actual training performed in three sets. All trainings were performed in the same order with two minutes of resting period between each set. The intensity of each training was gradually increased every two weeks, starting from 60% to 80%. All sessions were thoroughly monitored and exercise logbook was recorded for each subject. The detail of training program was illustrated in Table 1.

Performance measurements were obtained before the first week (pretest) and after training period (posttest). Each participant was required to wear the same shirt and shoes during each performance measurement. Prior 24 hours before the training was performed, all participants did not engage in any heavy activity with respect to jumping. A baseline anthropometric measurement was taken following their arrival at the training site during the week 0 before first session. Standing height was measured at the nearest 0.1 cm using portable stadiometer (Seca 213, Seca Ltd.), and body-weight were measured using digital bathroom scale at the nearest 0.1 kg.

Strength was assessed using Back Leg Dynamometer that has been calibrated. Participants were asked to lift the handle vertically by providing continuous isometric contraction of the lower back, hips, and knee extensors while holding the handle. They were asked to rise the pull gradually and reach maximum strength in three seconds, while maintaining this pull for two seconds. Each participant was given three attempts, with a 30 seconds rest period between attempts. The highest value (in kg) between three measurements was used for further analysis.

Table 1. The Details of Training Program for TJ, CMJ, and C Group

Week	Session	Day	Intensity	Repetition	Rest
1 st	1	Sunday	60%	3	2 min
	2	Wednesday	60%	3	2 min
	3	Friday	60%	3	2 min
2 nd	4	Sunday	60%	3	2 min
	5	Wednesday	60%	3	2 min
	6	Friday	60%	3	2 min
3 rd	7	Sunday	70%	3	2 min
	8	Wednesday	70%	3	2 min
	9	Friday	70%	3	2 min
4 th	10	Sunday	70%	3	2 min
	11	Wednesday	70%	3	2 min
	12	Friday	70%	3	2 min
5 th	13	Sunday	80%	3	2 min
	14	Wednesday	80%	3	2 min
	15	Friday	80%	3	2 min
6 th	16	Sunday	80%	3	2 min
	17	Wednesday	80%	3	2 min
	18	Friday	80%	3	2 min

Vertical jump test was done using Jump Mat MD with belt to measure power of muscle leg. Participants were asked to stand in upright position on jump mat with feet shoulder width apart and hand placed on the hips to minimize the contribution of the arms during the jump. Afterward, they needed to move downward followed immediately by explosive upward vertical jump, then landed with both feet completely on the jump mat for the jump to count. Each participant was also provided with three attempts with 30 seconds of break was provided between jumps. The reading of the highest value (in joule) was used for analysis.

Statistical analysis

Means and standard deviations as descriptive statistic were calculated and presented for the measured variables. All variables were tested for normality using Saphiro-Wilk test. Further analysed using paired t-test to compare the difference before and after plyometric training completed. One-way Anova was used to evaluate potential group differences between TJ, CMJ, and C. Confirmatory analysis was conducted using Least Significant Different (LSD) to find out which pairs were different. In all instance, p-value less than 0.05 was set to establish statistical significance. Data analysis and all statistical evaluations were performed using SPSS 21 for Windows.

Results

All participants have completed their respective training programs. There were no significant muscle soreness or any injury of the spine or lower limb, and no drop outs reported during the six weeks of experimental period. Participants

Table 2. Baseline Characteristic of Participants (n = 30)

Characteristic	Groups			sig.
	TJ	CMJ	C	
Age (year)	14.80 ± 0.64	14.30 ± 0.88	15.30 ± 0.41	0.060
Weight (kg)	46.5 ± 2.04	45.40 ± 5.86	47.30 ± 3.36	0.053
Height (cm)	151.40 ± 3.23	154.40 ± 8.43	154.80 ± 5.45	0.218
Body mass index (kg/m ²)	19.40 ± 0.85	19.10 ± 0.55	19.08 ± 0.70	0.195

TJ = tuck jump; CMJ = countermovement jump; C = Control group. Data were presented as mean ± SD

were very enthusiastic and actively followed every instruction in the exercise program that has been scheduled.

Table 2 shows the descriptive values of participants' characteristics in each group. Participants in CMJ had the lowest average of age and weight, which were 14.30 ± 0.88 years and 45.40 ± 5.86 kg, respectively. Control group had the highest average of height (154.80 ± 5.45 cm). The overall body mass index between group was ranging from 19.08 ± 0.70 to 19.40 ± 0.85 kg/m², which was categorized as normal according to cut-off of growth reference for 5-19 years (WHO, 2007). We found no statistical difference between groups with regard to baseline characteristics (p>0.05), so we learnt that the baseline data of all groups were equally homogeneous.

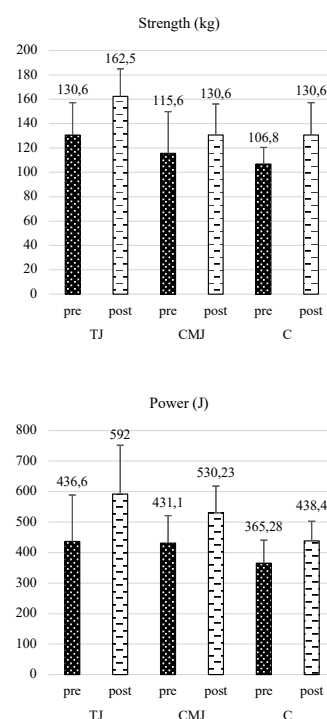


Fig. 1. The changes in strength (left) and power (right) before and after 6-weeks of plyometric training

Table 3 revealed the comparison results in strength and power before and after training programs were performed for six weeks. Significant improvement in strength were found in all groups, with p=0.000, p=0.005, and p=0.001

Table 3. Paired Sample Analysis of Change in Strength and Power of Muscle Leg over Six Weeks of Plyometric Training (Mean $\pm$ SD)

Group		Strength (kg)		sig.	Power (J)		sig.
		T score	Mean $\pm$ SD		T score	Mean $\pm$ SD	
TJ	pre	10.55	130.60 $\pm$ 26.59	0.000*	10.03	436.6 $\pm$ 152.1	0.000*
	post		162.50 $\pm$ 22.49			592.0 $\pm$ 160.0	
CMJ	pre	3.63	115.60 $\pm$ 34.25	0.005*	7.51	431.1 $\pm$ 90.32	0.000*
	post		130.60 $\pm$ 25.53			530.23 $\pm$ 87.94	
C	pre	5.22	106.80 $\pm$ 13.64	0.001*	5.18	365.28 $\pm$ 75.49	0.001*
	post		130.60 $\pm$ 26.59			438.4 $\pm$ 64.26	

TJ = tuck jump; CMJ = countermovement jump; C = Control group. *significant at $\alpha = 0.05$ *

Table 4. Between Group Differences in Delta Strength and Power

Group	Δ Strength (kg)	%	Sig.	Δ Power (J)	%	sig.
TJ	31.90 $\pm$ 10.55	24.4	0.000*	155.37 $\pm$ 10.03	35.6	0.017*
CMJ	15.00 $\pm$ 3.63	13.0		99.13 $\pm$ 7.51	23.0	
C	10.20 $\pm$ 5.22	22.8		73.18 $\pm$ 5.18	20.0	

TJ = tuck jump; CMJ = countermovement jump; C = Control group. Data were presented as mean $\pm$ SD. *significant at $\alpha = 0.05$

Table 5. Post-hoc Analysis of Significant Different in Strength

Pairwise Group		sig.	
		Strength	Power
TJ	CMJ	0.001*	0.010*
	C	0.000*	0.000*
CMJ	C	0.293	0.210

TJ = tuck jump; CMJ = countermovement jump; C = Control

*significant at $\alpha = 0.05$

respectively. Significant differences were also observed in explosive power where training programs that were performed for six weeks increase the power in both PT group or control group. The highest improvement in strength was found in TJ, which increased from 130.60 $\pm$ 26.59 to 162.50 $\pm$ 22.49 kg ($\Delta = 24.4\%$). Similar result was also showed in another variable, where TJ group exhibited the greatest increase in power from 436.6 $\pm$ 152.1 to 592.0 $\pm$ 160.0 joule ($\Delta = 35.6\%$). Meanwhile, CMJ had the lowest increase of strength among all groups, which was 13.0%, and control group had the lowest increase of power, which was 20.0%. Overall, one-way Anova revealed that the significant differences were found in Δ strength and Δ power, with $p = 0.000$ and $p = 0.0017$, respectively (Table 4).

Post-hoc test using LSD was performed for further analysis to examine pairwise differences. The results of the test disclosed that strength was found to be significantly different between TJ and CMJ ($p=0.001$), as well as between TJ and C group ($p=0.000$). Regarding power, it was revealed that TJ and CMJ group were significantly different ($p=0.010$), as well as between TJ and C group ($p=0.000$). Meanwhile, the significant differences were not found in strength and power between CMJ and C pairwise (Table 5).

Discussion

Present study demonstrated that plyometric training was effective to increase the measured variables, particularly strength and power of muscle legs. We also hypothesized that higher gains would occur in PT group compared to C group was clearly supported, as the given plyometric trainings (TJ) resulted in a significantly larger improvement in strength by the sixth week. The greatest increase was found in TJ group, where a change of 24.4% indicated that significant adaptation in strength was occurred.

Plyometric training relies on SSC mechanism, which consists of a quick eccentric and concentric phase of the muscle (Davies et al., 2015). Because of this continuous mechanism, it has been clarified that PT is able to induce greater performance improvement in fatigue-free state (Kobal et al., 2017). Hirayama et al. (2012) in their research showed that one session of plyometric exercise was able to change muscle-tendon characteristics by modulating neuromuscular activity with the lengthening and shortening of tendon occurred more frequently than fascicles. Unlike the acute effects of other exercises, plyometric training will enhance the performance of SSC exercises differently, with muscle tendon unit (MTU) behavior changes in a favorable way, adjusting to the altered muscle strength and tendon stiffness (Fouré et al., 2010; Hirayama et al., 2017; Wu et al., 2010). Tuck jump and countermovement jump that were assigned to experimental groups were able to shorten the change of eccentric phase to concentric phase, where this condition will also improves the ability to jump, supported by muscle ability to perform explosive moves which lead to the gain of strength and power in leg muscle (Louder et al., 2015).

In the context of physical fitness, countermovement jump (CMJ), squat jump (SJ), tuck jump (TJ), and depth jump (DJ) are one of vertical jump (VJ) tests widely used

to measure strength and power of lower muscle limb (Hi-rayama et al., 2017; Mirzaei et al., 2014; Petrigna et al., 2019; Ruffieux et al., 2020). However, the present study found that countermovement jump appeared to be less effective in improving strength and power compared to tuck jump. It was contradictory with other finding which revealed that countermovement jumps was found to be more effective than other vertical jump test used, ie. drop jump (Ruffieux et al., 2020). But, the findings of present study confirm previous randomized control trial study conducted by Muthukumar and Sokkanathan (2014) where significant difference in muscle strength was found between control group and plyometric training group. Elnaggar et. al. (2019) also observed similar results where subjects in plyometric training group had significant improvement in quadriceps and hamstring muscle strength compared to their peers in non-plyometric group. Some possible explanations beside SSC that can elucidate how PT can produce strength is that PT requires an adequate level of joint coordination as well as muscle strength, which later it augments the contraction of inter- and intra-muscle capacity, which finally produces force (de Villareal et al., 2010). However, higher increase in strength performance may be gained when plyometric is combined by various exercise to maximize the utilization of SSC. This may be explained by the fact that the combination of exercise will facilitate mechanical and neural mechanisms that increase performance in activity of maximal force (de Villareal et al., 2010).

Significant improvement in power was also found in all groups. In this study, high school students were trained at 60% to 80% 1 RM throughout six weeks, which is considered as high intensity training. Previous study reported that muscle power capacity could be transiently improved after high intensity training regimes (Kobal et al., 2017). For example, Smilios et al. (2005) reported an acute increase in CMJ height following 1 and 2 sets of half-squat exercise with intensity set at 60% 1 RM. Several studies have mentioned the effectiveness of PT in increasing strength and vertical jump performance, with one study suggested that the increase muscular power of lower limb, was again, might be due to the force variable in CMJ (SSC mechanism), coupled with the production of high velocity during vertical jump take off (Ben Ayed et al., 2020). In addition to that, plyometric training is able to enhance coordination (de Villarreal et al., 2009), therefore it induces a neuromuscular adaptation that improve power production (Chelly et al., 2010).

Some studies have demonstrated that the improvement in maximum strength would be accompanied by the improvement in power and vertical jump ability (Loturco et al., 2013, 2015). The finding of present study revealed that explosive power increased after six weeks of plyometric training. Three times a week over six weeks of exercise that were used in this study appeared to have good impact on increasing power in high school students. This finding supported previous study that used PT with similar duration where small but significant improvement (5.8%) was observed in vertical jump among collegiate female athletes (Chimera et al., 2004). Another study revealed the significant increase in vertical jump (Rubley et al., 2011), supported the notion that plyometric training increase vertical jump ability, thus increasing the power of lower limb.

Conclusion

Plyometric training has been becoming a popular training method that is extensively used by sport professionals and strength-conditioning specialists in improving sport-specific performance. Based on this research, it can be concluded that six-week plyometrics significantly increases the strength and power of muscle leg in high school students. A limitation of this study is the specific sample in which students may limit the applicability of these findings to a more diverse population. Longer training duration (>6 weeks) might show different results. Additionally, further studies must also consider the intensity, form or type of plyometrics exercise that is carried out, and whether PT will be combined with other training, as a combination of various exercises leads to greater improvement in physical performance.

Conflict of interest

The authors declare no conflict of interest.

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ВПЛИВ ШЕСТИТИЖНЕВИХ ПЛІОМЕТРИЧНИХ ТРЕНУВАНЬ НА ПОКРАЩЕННЯ СПОРТИВНИХ ПОКАЗНИКІВ УЧНІВ ПІДЛІТКОВОГО ТА ЮНАЦЬКОГО ВІКУ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 5 табл., 1 рис., 46 джерел.

Численними дослідженнями документально зафіксовано, що пліометричні тренування є ефективним методом покращення спортивних показників.

Метою цього дослідження було порівняння впливів шеститижневих пліометричних тренувань на показники міцності, швидкості та сили.

Матеріали та методи. Було проведено експериментальне дослідження за планом попереднього та підсумкового тестування з використанням контрольної групи на 30 спортсменах школи бойових мистецтв «Перісай Дірі» (Індонезія). Методом випадкового відбору учасників розподілили на три групи: група, яка виконувала пліометричні

вертикальні стрибки «ноги разом – ноги нарізно» з положення стоячи (JJ), група, яка виконувала вертикальні стрибки з початковим присіданням (CMJ), і група, яка виконувала вертикальні стрибки з групуванням у повітрі (TJ). Потім учасникам груп TJ та CMJ був призначений шеститижневий курс вправ, які склалися з трьох комплексів вправ на кожне тренувальне заняття (загалом 18 тренувальних занять), під час виконання яких рівень інтенсивності коливався в межах від 60% до 80%. Для одержання даних про показники міцності та вибухової сили були проведені попереднє та підсумкове тестування. Дані були проаналізовані з використанням ПЗ SPSS версії 21 та представлені у формі середнього та стандартного відхилення. Для порівняння відмінностей між групами до та після пройдених тренувань використовували t-критерій Стьюдента для парних вибірок. Для аналізу множинних порівнянь збільшення показників міцності та вибухової сили між групами використовували однофакторний дисперсійний аналіз.

Результати. Результати показали, що за шість тижнів показники міцності та вибухової сили учнів в усіх групах статистично значуще ($p < 0,05$) зросли. Відмінності між групами були виявлені в показниках міцності ($p = 0,000$), що було встановлено між парою TJ-CMJ ($p = 0,001$) та парою TJ-C (контрольна) ($p = 0,000$). Міжгрупові відмінності також були виявлені в показниках сили ($p = 0,017$), що було встановлено між парами TJ-CMJ та TJ-C (контрольна) ($p < 0,05$).

Висновки. На підставі одержаних результатів було зроблено висновок, що пліометричні тренування змогли покращити показники міцності та сили м'язів ніг нетренованих осіб.

Ключові слова: вертикальний стрибок із початковим присіданням (CMJ), пліометричні тренування, сила, вертикальний стрибок із групуванням у повітрі (TJ), міцність, цикл розтягання-скорочення (SSC) м'язів, учень.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF 12-WEEK CALISTHENICS EXERCISE ON PHYSICAL FITNESS AMONG OBESE FEMALE STUDENTS

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Abstract

Study purpose. The main purpose of this study was to determine the effect of calisthenics exercise on physical fitness. Materials and methods. 28 obese female students aged 20–30 with a BMI ranging between 30 kg/m² and 35 kg/m² were involved in this study. Participants were randomly divided into three groups which comprised a calisthenics exercise group, an aerobic calisthenics exercise and a control group. Sit and reach test (flexibility), sit up test (muscular endurance) and 20-meter shuttle run test (cardiovascular endurance) were measured as physical fitness parameters. All the tests were conducted before and after a 12-week intervention training program.

Results. The results of this study indicate that the calisthenics and aerobic calisthenics groups had significant ($p < 0.05$) improvement in the sit and reach test performance compared to the control group. The aerobic calisthenics group also showed significant ($p < 0.05$) improvement in the sit up and 20-metre shuttle run test performance compared to the calisthenics and control groups.

Conclusions. In conclusion, these study findings demonstrated that calisthenics exercise when combined with aerobic exercise was more effective to improve flexibility, muscular endurance and cardiovascular endurance among obese female students compared to calisthenics exercise only. Therefore, it is suggested that fitness trainers should consider combining calisthenics exercise with aerobics in the training program to improve flexibility, muscular and cardiovascular endurance.

Keywords: physical fitness, obesity, calisthenics exercise.

Introduction

Obesity can be defined as the accumulation of excess fat in the body. In Asian countries, Malaysia is one of the countries with the highest level of obesity (Ruiz Estrada et al., 2019). According to Mohd-Sidik et al. (2021), an obesity study based on demographic factors that have been conducted in Malaysia shows that demographic factors such as gender, marital status, age and level of education can affect the obesity level. Based on that study, obesity was higher among women than men. The rate of obesity was also higher among the married compared to the singles. In addition, middle-

aged adults have a higher obesity problem than other age groups and those with lower education (primary or secondary school) are more likely to show higher levels of obesity than those with higher levels of education (university).

Another a study by Wan Mohamed Radzi et al. (2019) found that the main factors contributing to the increase in obesity among university students in Malaysia were due to unbalanced dietary factors such as regular fast food and junk food intake, lack of involvement in physical activity and mental health issues such as stress. In the study by Tee et al. (2018), similar contributing factors (meal consumption, low level of physical activity and poor sleep quality) have also been stated as the main cause of the increasing obesity trend in Malaysian adolescents. Another study related to obesity knowledge by Ghazi et al. (2018) showed low knowledge regarding obesity among private university students in Malaysia. This indicates that the increase in obesity among

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university students may also be due to poor knowledge related to obesity.

Even though obesity problems can occur in all age groups such as the elderly, adolescents, adults and children. Increasing levels of obesity in a country especially among the young generation including university students can create a burden to the healthcare system and economy. Obesity has become one of the most severe health concerns worldwide because it can increase the risk of other chronic diseases such as diabetes, heart attack, cancer and hypertension (Smith et al., 2020), indirectly imposes a large burden on the health care system (Deng et al., 2016). In addition, excessive obesity can cause an individual's movement to be limited and reduce the quality of life, in turn leading to an increase in the unemployment rate and social disadvantages. These factors can lead to a reduction in socioeconomic productivity (Blüher, 2019). It is very important to overcome the problem of obesity among the young population such as university students.

Numerous studies have been conducted to identify the causes of obesity and it is well known that the best way to resolve the obesity problem is through a healthy diet and regular physical activity (Zouhal et al., 2020). The effectiveness of various types of exercise on obese populations has been demonstrated in past studies via weight training (Dias et al., 2015; Strasser & Schobersberger, 2011; Villareal et al., 2017), Circuit training (Kang et al., 2018; Kim et al., 2018; Seo et al., 2019), Aerobic training (Al Saif & Alsenany, 2015; Luo & Zheng, 2019; Shenbagavalli & Mary, 2008) and high-intensity interval training (Maillard et al., 2018; Wewege et al., 2017).

Other than that, calisthenics training is one of the effective training alternatives to increase the body's metabolism. The calisthenics training is an exercise that involves a variety of basic movements and can be performed by using bodyweight without the use of any equipment (Chaves et al., 2020). Based on the previous study, calisthenic training has been shown to be effective to improve fitness components such as reducing fat mass and increasing body mass (Cigerci & Genc, 2020), increasing aerobic capacity (Alsairawan et al., 2019), improved muscle strength (Kotarsky et al., 2018). However, most of these studies were conducted on athletes and the healthy population with normal weight. There is a lack of studies on the effect of calisthenic exercise among the obese population. Therefore, the purpose of this study was to investigate the effect of calisthenic exercise and aerobic calisthenic on physical fitness among obese female university students.

Methods and Materials

Participants

28 obese female university students were involved in this study voluntarily and have been informed that they were free to withdraw from the study at any time. Before the study was conducted, participants had completed the Physical Activity Readiness Questionnaire (PAR-Q) and informed consent. The selection criteria of participants for this study include; i) female students aged between 20 to 30 years, ii) BMI range between $30 \text{ kg}\cdot\text{m}^{-2}$ to $35 \text{ kg}\cdot\text{m}^{-2}$ and iii) did not have any history of chronic diseases. All participants were randomly divided into three groups, consisting of the aerobic calisthenic

group ($n = 9$), calisthenic group ($n = 9$) and control group ($n = 10$). Ethical approval for this study was obtained from the Committee of Sultan Idris Education University (Reference number: 2019-0034-01)

Instrument and Procedures

Participants in both aerobic calisthenics and calisthenics groups received the intervention for 12 weeks, which is 3 times of training per week. Pre- and post-tests were conducted to compare the effectiveness of both exercises on physical fitness levels among obese female students.

Measurements of Physical Fitness

Physical fitness parameters measured in this study during the pre-and post-tests for all participants in the three groups (aerobic calisthenic, calisthenic and control groups) were flexibility (sit and reach), muscular endurance (sit up) and cardiovascular endurance (20-meter shuttle run test).

For the sit and reach test, participants were asked to sit on the floor with straight legs without shoes and soles close to the sliding reach board (Trident, USA) with a scale marked at 23 cm. Participants' legs were apart and parallel to the shoulders and the hands were placed on top of the other hand. The position of the fingers will be the same on both hands. The participants were then instructed to slowly push forward on the scale marked with hands position facing down and legs remaining straight. 3 trials were given to each participant and the farthest distance would be taken for data analysis.

In the sit-up test, participants were instructed to lie on an exercise mattress with knees bent at 90° . The heels and feet were touching the floor and the feet were shoulder-width apart. The participant's hands are crossed on the chest and the palms hug the shoulders opposite. Participants sat up until they touched their knees on both elbows and then returned to the starting position. Participants were instructed to performed as many sit up repetitions as possible for 1 minute. The total number of correct completed sit up were counted and recorded for data analysis.

In the 20-meter shuttle run test, participants were instructed to continue running between the two lines, and turning when signalled by the recorded beeps. Participants have to cross a distance of 20 meters and wait until the "beep" sound to continue the run to and fro. A warning was given if the participants do not reach the line before the beep sounds for the first time, and were eliminated after the second warning. Participant's final score is the last level and shuttles they completed before missing a beep.

Training Programs

For the 12-week intervention training program, calisthenics training consists of eight exercise stations (high knee run, burpees, mountain climbers, planks, jumping jacks, Russian twits, squats and lunges) for one set. Each exercise was performed for 20 seconds (exercise training) with a 10 seconds rest between stations. The duration for 1 set of calisthenic exercises was 4 minutes.

For calisthenics training combined with the aerobic exercise group, the participants performed the same exercises

as the calisthenics group. However, after the 10 second rest period, the participants were required to perform the aerobic exercise (step box) for 60 seconds at each station. For the aerobic exercise, the participants need to step up where one foot on the top of box with one foot on the ground. The weight should be shifted into the heel of the foot that is on the box. Driving through that front heel, extend the leg completely straight before bringing the opposite foot onto the box. Repeat until the end of 1 minute. The duration of 1 set of aerobic calisthenic exercises was 12 minutes.

From week 1 to week 4, participants in both intervention groups performed 3 sets of the exercise, followed by 4 sets from week 5 to week 8 and lastly 5 sets from week 9 to week 12. Meanwhile, the control group did not receive any training intervention for 12 weeks and were only required to perform pre-and post-tests.

Data and statistical analyses

Mixed design MANOVA was used to compare physical fitness profiles (sit and reach, sit-up, 20-meter shuttle run test) between groups (aerobic calisthenic, calisthenic, control) during pre and post-tests among the obese students in UPSI. Table 1 shows the demographic and physical characteristics of the participants such as age, height and weight for all participants in the three groups.

Results

Table 1. Participants' demographic and physical characteristics

Category	Group	Mean±SD
Age (year)	Aerobic calisthenic	23.2±3.4
	Calisthenic	22.4±1.8
	Control	22.1±1.2
Height (cm)	Aerobic calisthenic	154.5±4.9
	Calisthenic	157.1±4.4
	Control	156.1±4.7
Weight (kg)	Aerobic calisthenic	73.2±10.2
	Calisthenic	77.7±6.2
	Control	83.6±9.4

Table 2. Multivariate values for physical fitness tests between a group

Effect	Wilks' Lambda value	F	Hypothesis df	Error df	Sig.	Partial Eta squared
Group	0.06	10.87	12	40	0.00	0.77

*Significant value was set at the level of $p < 0.05$

Result of the multivariate analysis in Table 2 showed there was significant main effect for group $F_{(12, 40)} = 10.87$, Wilk's $\lambda = 0.06$, $p = 0.00$, $\eta_p^2 = 0.7$.

Table 3 showed statistics descriptive of physical fitness scores between groups (aerobic calisthenic, calisthenic, and control) during pre and post-test.

Table 3. showed statistics descriptive of physical fitness scores between groups (aerobic calisthenic, calisthenic, and control) during pre and post-test.

Physical Fitness	Test	Aerobic calisthenic	Calisthenic	Control
Sit and Reach (cm)	Pre Test	25.1±4.9	27.8±4.5	22.2±4.7
	Post test	29.6±5.1c	29.6±4.6c	23.7±4.7ab
Sit up (repetitions)	Pre Test	18.9±2.2	16.0±3.3	16.2±3.3
	Post test	26.3±2.1bc	18.7±3.4a	16.4±3.4a
20-meter shuttle run test (Laps)	Pre Test	2.5±0.3	2.3±0.1	2.4±0.4
	Post test	3.4±0.2bc	2.6±0.2a	2.3±0.4a

a = significantly difference from aerobic calisthenic, $p < 0.05$; b = significantly difference from calisthenic, $p < 0.05$; c = significantly difference from control, $p < 0.05$

Table 4. Post hoc test for sit and reach score

	Test	Sum of Squares	df	Mean Square	F	Sig.
Sit and reach (cm)	Group	Pre	144.51	2	72.26	3.18
		Post	209.29	2	104.65	4.42
	Error	Pre	567.34	25	22.69	
		Post	591.96	25	23.68	

*Significant value was set at the level of $p < 0.05$

Table 4 showed, that there was significant interaction for sit and reach test $F_{(2,25)} = 4.42$, $p = 0.02$ between-group during post-test. Results of the Bonferroni Post hoc test showed, no significant difference ($p = 1.00$) between the aerobic calisthenic and calisthenic groups. However, both group aerobic calisthenic ($p = 0.05$) and calisthenic ($p = 0.05$) were significantly improve sit and reach scores compared to the control group during post-test as shown in Table 3.

Table 5. Post hoc test for sit up score

	Test	Sum of Squares	df	Mean Square	F	Sig.
Sit up (repetitions)	Group	Pre	50.22	2	25.11	2.77
		Post	509.84	2	254.92	27.72
	Error	Pre	226.46	25	9.06	
		Post	229.88	25	9.20	

*Significant value was set at the level of $p < 0.05$

Table 5 showed, that there was significant interaction for sit-up test $F_{(2,25)} = 22.72$, $p = 0.00$ between-group during post-test. The result of the Bonferroni Post hoc test showed there was a significant difference between aerobic calisthenic with calisthenic ($p = 0.00$) and the control group ($p = 0.00$) as shown in Table 3. There was no significant difference ($p = 0.35$) between the calisthenic and control groups. This finding proved that aerobic calisthenic was effective to improve the 1-minute sit-up repetition score, compared to calisthenic and control groups.

Table 6 showed, there was significant interaction for 20-meter shuttle run test $F_{(2, 25)} = 33.5$, $p = 0.00$ between-

Table 6. Post hoc test 20-meter shuttle run (Laps)

	Test	Sum of Squares	df	Mean Square	F	Sig.
20-meter shuttle run test (Laps)	Group Pre	0.16	2	0.08	0.77	0.47
	Post	6.41	2	3.21	33.05	0.00
	Error Pre	2.66	25	0.11		
	Post	2.43	25	0.10		

*Significant value was set at the level of $p < 0.05$

group during post-test. The result of the Bonferroni Post hoc test showed there was a significant difference between aerobic calisthenic with calisthenic ($p = 0.00$) and the control groups ($p = 0.00$) as shown in Table 3. There was no significant difference ($p = 0.16$) between the calisthenic and control groups. This finding showed that aerobic calisthenic was successful to improve the 20-meter shuttle run test, compared to the calisthenic and control group.

Discussion

The purpose of this study was to compare the effect of calisthenic and aerobic calisthenic exercise on physical fitness among obese female students. The results of this study showed that the training program for both aerobic calisthenics and calisthenics for 12 weeks improved the flexibility fitness component compared to the control group. However, only the aerobic calisthenics group showed improvements in muscular endurance and cardiovascular endurance performance compared to the calisthenic and control group.

In previous studies, calisthenics training has been shown to successfully improve fitness components such as flexibility in various ages and populations. Bayrakdar et al. (2019) found that 8-week calisthenics training improved flexibility among swimming athletes. Bayrakdar et al. (2019) also found that 8-week of calisthenics training was significantly increased the level of flexibility among junior high school boys. Similar to the effectiveness of calisthenics training in increasing flexibility among athletes as well as the general population, calisthenics and aerobic calisthenic training have also been shown in this study to be effective in increasing flexibility among obese peoples.

Other than that, this study found that muscular endurance and cardiovascular endurance in the calisthenic aerobic group were significantly better than in the calisthenic and control groups. This finding indicates that the combination of calisthenics with aerobics causes the training intensity to be higher following by increased the maximum oxygen uptake as most studies showing improvement in cardiovascular endurance performance after receiving high-intensity training (HIT) training (Türk et al., 2017). It is assumed that the calisthenics training group only induce training intensity at moderate or low level, thus it was insufficient to elicit significant increase in cardiovascular and muscular endurance performance.

Shaw et al. (2021), demonstrated that calisthenic training for 6 weeks improved lung capacity through peak expiratory flow (PEF) and maximal expiratory flow (MEF) test. In that study, the calisthenics training intervention provided aerobic exercise in the first 3 weeks followed by resistance training in the next three weeks. Thus, It was in line with

this study that included an aerobic element to increase the effectiveness of calisthenics training.

Kotarsky et al. (2018) indicated that calisthenic training was able to improve muscular strength. Thus, their finding it was contrary to the findings of this study that showed only aerobic calisthenic was able to increase muscle strength, but not in the calisthenic group. This result may be due to the limitations of this research which did not set the number of repetitions during calisthenic training. The participants in this study were only instructed to perform as many repetitions as possible in each type of exercise based on a pre-determined time. Therefore, it is likely that participants in the calisthenics group did not push themselves to perform the exercise with maximum effort, compared to the aerobic calisthenics group who may be able to perform more repetitions due to increased cardiovascular endurance.

Conclusion

In conclusion, combining calisthenics with aerobic exercise is more effective than calisthenics alone to increase the level of physical fitness such as flexibility, muscular endurance and cardiovascular endurance among female students with obesity problems. Therefore, it was recommended for fitness trainers to combine calisthenics with aerobic exercise in their training program.

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ВПЛИВ 12-ТИЖНЕВИХ ВІЛЬНИХ ГІМНАСТИЧНИХ ВПРАВ НА ФІЗИЧНУ ПІДГОТОВЛЕНІСТЬ СТУДЕНТОК З ОЖИРІННЯМ

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Мета дослідження. Основною метою цього дослідження було визначення впливу гімнастичних вправ на фізичну підготовленість.

Матеріали та методи. Учасницями цього дослідження стали 28 студенток з ожирінням віком від 20 до 30 років, у яких ІМТ коливався від 30 кг/м² до 35 кг/м². Учасниць розподілили методом випадкового відбору на три групи: група гімнастичних вправ, група аеробних гімнастичних вправ і контрольна група. Як параметри фізичної підготовки вимірювали показники тестів «Нахили тулуба вперед із положення сидячи» (гнучкість), «Піднімання тулуба з положення лежачи» (м'язова витривалість) та «Човниковий біг на 20 метрів» (серцево-судинна витривалість). Усі ці тести проводили до та після 12-тижневої експериментальної програми тренувань.

Результати. Результати цього дослідження вказують на те, що в групах гімнастичних вправ та аеробних гімнастичних вправ спостерігалось статистично значуще ($p < 0,05$) покращення показників виконання тесту «Нахили тулуба вперед із положення сидячи», порівняно з контрольною групою. У групі аеробних гімнастичних вправ також спостерігалось статистично значуще ($p < 0,05$) покращення показників виконання тестів «Піднімання тулуба з положення лежачи» та «Човниковий біг на 20 метрів», порівняно з групою гімнастичних вправ і контрольною групою.

Висновки. Отже, зазначені результати дослідження підтвердили, що гімнастичні вправи в поєднанні з аеробними вправами є ефективнішими для покращення показників гнучкості, м'язової витривалості та серцево-судинної витривалості у студенток з ожирінням, порівняно з лише гімнастичними вправами. Отже, тренерам із загальнофізичної підготовки рекомендується взяти до уваги можливість поєднання гімнастичних вправ та аеробіки в програмі тренувань для покращення показників гнучкості, м'язової та серцево-судинної витривалості.

Ключові слова: фізична підготовка, ожиріння, гімнастичні вправи.

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PATTERN OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION (ACLR) AMONG ATHLETES IN MALAYSIA BETWEEN 2015 AND 2020

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Abstract

Background. Individual involvement in sports activity is rising and thus increases the risk of knee injury. Anterior Cruciate Ligament (ACL) rupture is the most common knee injury requiring ACL reconstruction (ACLR). However, limited evidence is available to date on ACLR characteristics in Malaysia for comparison with Western countries.

This study aims to describe the epidemiological characteristic of ACLR surgery and the trend of pre-operative physiotherapy (pre-habilitation).

Materials and methods. ACLR cases recorded in a tertiary hospital database between January 2015 and December 2020 were extracted and reviewed. This retrospective study was approved by the hospital's Research Ethics Committee (UKMPPI/111/8/JEP-2020-500). All ACLR cases involving sports injuries were included with the exclusion of non-sports related injuries. Yearly ACLR cases were retrieved using an Injury Information form containing variables namely age, gender, type of ACL tear, accompanying meniscus injury, duration from injury to surgery and pre-habilitation details. Descriptive statistics were used to summarize the sample data.

Results. A total of 131 ACLR cases were reported between 2015 and 2020 (Male, n = 122; Female, n = 25). The number of ACLR cases fluctuated during the observed years, with a maximum of 30 cases reported in a year and 98% of the cases were represented by the youth age group (15 – 47 years old). The average age at time of surgery was 27.1 (± 7.79). On an average, 80% of athletes stated no history of previous knee injury. The most common type of ACL injury was a complete tear (88%), followed by partial tear (9%), and re-rupture (3%). A meniscus injury was noted in 61% of cases. The time from injury to surgery was 15 weeks. The study found low percentage of the ACLR patients who received pre-habilitation prior to surgery (<20%).

Conclusions. ACLR cases are showing a fluctuating trend every year. Despite the majority of the ACL cases being a complete tear, the participants waited more than four months to undergo ACLR, with only a quarter of them had pre-habilitation prior to surgery. The reasons for these situations require investigation. Future research inclusive of a larger database is also desirable to develop a better insight into ACL injury pattern.

Keywords: ACL reconstruction, descriptive epidemiology, pre-operative physiotherapy, knee injury.

Introduction

Anterior Cruciate Ligament (ACL) injury is among the most common knee injury associated with individuals who

are actively participating in sports activity. The annual occurrence of ACL isolated injuries is 68.6 per 100,000 person per year, and the incidence of ACL with concomitant injury is higher than isolated injury. The current systematic literature review reported one in 29 female athletes and one in 50 male athletes ruptured their ACL, with amateur female athletes remained at a higher risk of ACL compared to their male counterparts. However, in the general population, the incidence of ACL injuries were significantly higher in males

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than in females (81.7 vs 55.3 per 100,000 person per year). In addition, the rate of performed ACLR surgery also increased significantly over time in all age groups (Rowntree, 1942). Due to the increase rate of ACL injury, the injury pattern in active general population needs to be examined. Moreover, until now it is indistinct if the profiles of ACLR cases which comprises gender, age, injury, surgery and rehabilitation history among the Malaysian population is parallel to that reported in previous literatures.

ACLR surgery is a common medical management following ACL injury, aiming to restore the knee function, minimising the symptoms and therefore improving patients' quality of life (Dhillon, 2014). Usually, the ACLR surgery is recommended for patients who have recurrent knee instability during activities of daily living and sports which involved pivoting movements. However, various secondary issues may arise following the surgical procedure including requirement for long term rehabilitation and subsequent revision surgeries, financial burden, and the occurrence of post-traumatic early osteoarthritis (PTOA) (Rothrauff et al., 2020). In addition, the ACLR surgery generally does not guarantee a return to sports (RTS) activity to the pre-injury level. Literature has established that the success of RTS among ACLR patients depends on numerous factors such as the patient's psychological state, muscle strength, score of functional test, and score of self-reported knee function. It was also reported that ACLR patients with short waiting time from the initial injury to surgery and those received preoperative physiotherapy are more likely to achieve better functional outcomes and early RTS activity (Giesche et al., 2020; King et al., 2020). However, these factors are still under-reported in the Asian populations and general ACLR epidemiological literature. Moreover, most ACLR epidemiological studies were conducted based on the previously developed ACLR registries.

The identification of ACLR cases using ACL registries provide a mechanism for prospective surveillance of targeted population. This facilitates for long term follow-up of patients, provides continuous feedbacks to surgeons and therapists for patient safety and the improvement of patients' quality of life (Rothrauff et al., 2020). Besides, the ACLR registries offers identification of best clinical practices and trends over time. This subsequently enables the evaluation of patients' characteristics, injury profiles, surgery techniques, the risk affecting the clinical and functional outcomes following ACLR surgeries which includes the RTS outcome and the presence of secondary complications. Although many western countries have reported ACLR profiles based on their developed ACLR registry, the generalisability of their findings to the eastern populations is not possible due to the differences in population lifestyle, and surgical and rehabilitation approaches (Prentice et al., 2018). While there are few studies which reported the occurrence of ACLR surgeries in Malaysia, none of them explored the waiting time from initial injury to surgery, the preoperative physiotherapy data and their influence on functional outcome including return to sport. In addition, epidemiological data on ACLR related injuries are still lacking in the Asian region (Tabben et al., 2022).

Literature documented that the ACLR rate in the Asian countries is generally higher compared to the European regions. In Malaysia, a study reported a dramatic increase in

ACLR surgical procedures, and further investigations for epidemiological data on ACLR surgery were required (Dhillon, 2014). Therefore, the main purpose of this research is to describe the epidemiological characteristics of ACLR surgery in the country. This study also aims to evaluate the time factor for ACLR surgery and preoperative physiotherapy in order for comparison with previous studies.

Materials and methods

Study Design and Sampling Frame

A descriptive retrospective epidemiological survey was utilized for this research. This study adhered to the guideline of the Declaration of Helsinki and the study protocol was reviewed and approved by the Research Ethics Committee of the National University of Malaysia (UKM PPI/111/8/JEP-2020-500). All information regarding ACLR patients were treated as confidential to preserve patient privacy. The ACLR surgery cases were identified from the registry of patients from a tertiary public hospital for the period beginning January 2015 until December 2020. Patients' characteristics, injury and surgical details, time from injury to surgery, and their pre-operative physiotherapy information were retrieved and summarised. Each reviewed ACLR case was documented into a proforma designed for this study.

Variables Definition

This study used variables definition based on definitions described from a previous study (Rothrauff et al., 2020). These include: 1) ipsilateral operation: any non-revision procedure on the injured knee; 2) contralateral ACLR knee: any procedure performed on the contralateral side following primary ACLR; 3) the revision ACLR: a procedure in which the graft has been replaced; 4) recreational athletes: general population who are active in sports activity; and 5) the ACLR patient: patient who ruptured their ACL while playing sports for recreational or high performance purpose. The injury to the cartilage involved in this study considered all severity levels without any grade classification. The age categorisation followed the World Health Organization (WHO) guideline which indicated the age between 5-17 years old as children and adolescent, 18-64 years old as adult and 65 years old and above as elderly. There was a small difference noted between the age categorisation of WHO (2020) and Department Statistic of Malaysia.

Study Procedure

Upon identification of potential ACLR cases from the registry, a request to review the patients' medical record was submitted to the medical records department of the hospital. Selection of cases was then made by a trained therapist based on specified inclusion criteria, namely: (1) all age groups and gender; (2) Malaysian citizens; (3) ACL injuries due to any involvement in physical or sports activity; (4) Both types of injuries either contact or non-contact; (5) having concomitant meniscal tears and chondral lesions; and (6) ACLR surgery done between 1st January 2015 and 31 December 2020. The exclusion criteria were: (1) ACL injury due to motor vehicle accident (MVA) or (2) non-sports activities. Medi-

cal records of eligible cases were reviewed comprehensively and essential data were retrieved through the utilization of a proforma. Collected data included patients' demographic details, injury details, surgical information and preoperative physiotherapy management.

Statistical analysis

In this research, descriptive statistics (frequency, percentage, mean & standard deviation) were used to describe each variables of interest. The statistical analysis for the study was executed using the SPSS software. The level of significance value was pre-set at $p < 0.05$.

Results

Patients Characteristics

The primary cases search from the hospital registry determined that a total of 181 elective ACLR surgeries were performed between the year 2015 to 2020. However, only 150 medical records were able to be retrieved. The remaining 31 records were not found possibly due to several reasons such as records in use at others specialties at the time of retrieval; staffs unable to locate; or the files have been transferred to different facility. Second attempt for records retrieval for the remaining 31 records were done again to ensure maximum record availability before decisions of exclusion were made. After excluding 19 cases of ACL injury due to non-sports activities, a total 131 cases were reviewed and analysed which included 17 ACLR cases of national athletes. Generally, the mean age of the patients at the time of surgery was 27.1 years (± 7.79), with 109 of them were male (83.21%) and 22 were female patients (16.79%). Twelve cases (9.2%) represent ACLR among children and adolescent age (5-17 years old), and 119 cases (90.8%) involving adults (18-64 years old), while there was no case involving elderlies (65 years and above) (WHO,2020; <https://www.dosm.gov.my>). The distribution of ACLR cases according to age and performance category are as in Fig. 1.

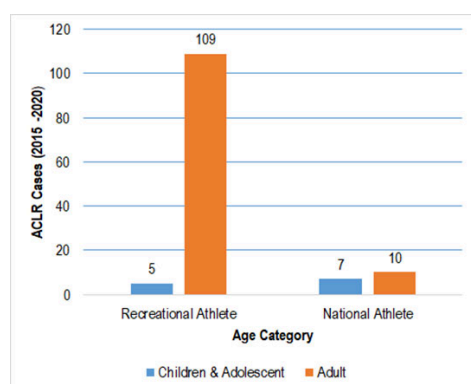


Fig. 1. Frequency of ACLR cases in recreational and national athletes group according to age category of children and adolescent (5-17 year old) and adult (18-64 year old), N=131

The frequency of ACLR cases reported fluctuated every year but presented a trend of increment among adult (Fig. 2).

The total sample distribution based on the type of graft used for ACLR surgery was hamstring in 93 (71.0%) proce-

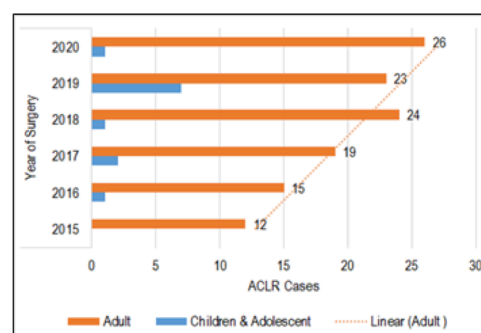


Fig. 2. frequency of reported Anterior Cruciate Ligament Reconstruction (ACLR) cases according to age categorisation from 2015 - 2020

dures, and BPTB used in 30 (22.9%) procedures. The other types of graft used includes 1 (0.8%) peroneus longus and 3 (2.3%) for Tendon Achilles (TA), while 4 (3.1%) cases have not reported on this. All ACLR cases was performed using anatomical ACLR. The ACLR injury and surgery details for overall cases and national athletes are presented in Table 1.

Time from Injury to ACLR Surgery

In 114 recreational athletes, the waiting time for ACLR surgery ranged between 1 week and 192 weeks, with the median waiting time being 15 weeks. Further classification of time from injury to ACLR surgery revealed that a total of 76 (66.7%) ACLR procedures were conducted within 6 months and 22 (19.3%) procedures were conducted after 6 months. Only 9 (7.9%) ACLR procedures were conducted after 1 year post-injury and the remaining 7 (6.1%) ACLR cases were performed more than 2 years post-injury. However, among the 17 national athletes, the ACLR procedures were mostly conducted within 6 months post-injury (16 ACLR cases, 94.1%) and only one case was performed after 6 months of injury. Overall, the national athletes received ACLR procedure within 7.59 ± 6.69 weeks (Table 2).

Pre-operative Physiotherapy (Prehabilitation)

Among the 114 recreational athletes who underwent ACLR procedures, only 24 (21.1%) of them received pre-operative physiotherapy and the remaining 90 (78.9%) athletes did not receive pre-operative physiotherapy prior to ACLR surgery. All national athletes (17 ACLR cases) received pre-operative physiotherapy following the ACLR reconstruction surgery (Fig. 3).

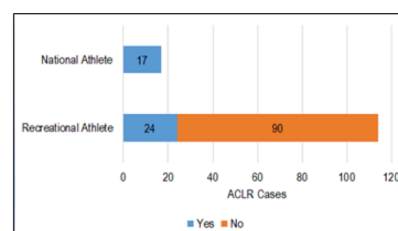


Fig. 3. The frequency of ACLR cases that receive pre-operative physiotherapy management prior to ACLR surgery

Table 1. Demographics and Profiles of Anterior Cruciate Ligament Reconstruction (ACLR), 2015-2020 in all cases (n=131)

Variables	n (% of Total ACLR Cases)
No. of tears, n	131
Recreational / National Athletes	114/17
Age, mean $\pm$ SD (years)	27.1 $\pm$ 7.79
Sex	
Male / Female	109 (83.21)/ 22 (16.79)
Age Group (years)	
Child and Adolescent (5-18)	12 (9.16)
Adult (18-64)	119 (90.84)
Elderly (≥ 64)	0 (0)
History of Previous Knee Injury	
Yes / No	26 (19.8) / 105 (80.2)
ACLR Knee	
Right / Left	70 (53.4) / 61 (46.6)
Confirmatory of ACL Tear (Surgical Record)	
Partial Tear	12 (9.2)
Complete Tear	115 (87.8)
Re-rupture Tear	4 (3.1)
Type of ACL Tear	
Isolated ACL	29 (22.1)
ACL with concomitant injury	102 (77.9)
Tear Occurrence	
Primary injury	112 (85.5)
Secondary (Ipsilateral)	12 (9.2)
Secondary (Contralateral)	7 (5.3)
Duration (week) from injury to surgery, mean $\pm$SD	
(Minimum 1 week – Maximum 192 weeks)	23.02 $\pm$ 31.77
Meniscus Injury	
Yes / No	80(61.1) / 51 (38.9)
Meniscus Injury Location	
Lateral	30 (22.9)
Medial	33 (25.2)
Lateral and Medial	17 (13.0)
Not Related	51 (38.9)
Other Concomitant Injuries	
Yes / No	52 (39.7) / 79 (60.3)
Bone Injuries	
Yes / No	4 (3.1) / 127 (96.9)

* Values are expressed as n (%) unless otherwise specified.

Discussion

The findings of this research emphasize the profile and trend of ACLR surgeries performed in the recent years. A total of 131 ACLR surgeries were performed between the year of 2015 to 2020 which was related to sports activity, with an increasing trend in the number of surgery performed every year. This data is consistent with the results of earlier studies which documented the increasing occurrence of ACLR every year (Costa et al., 2018; Mall et al., 2014; Sanders et al., 2016). This study showed that ACLR surgeries were performed mainly among males than female patients

Table 2. Demographics and Profiles of Anterior Cruciate Ligament Reconstruction (ACLR), 2015-2020 among National Athletes (n=17)

Variables	n (% of Total ACLR Cases)
No. of tears, n	17
Recreational / National Athletes	19.41 $\pm$ 4.19
Age, mean $\pm$ SD (years)	12 (70.6)/5(29.4)
Sex	
Male / Female	12 (70.6)/5(29.4)
Age Group (years)	
Child and Adolescent (5-18)	7 (41.18)
Adult (18-64)	10 (58.82)
Elderly (≥ 64)	0 (0)
History of Previous Knee Injury	
Yes / No	3 (17.7) / 14 (82.4)
ACLR Knee	
Right / Left	9 (52.9) / 8 (47.1)
Confirmatory of ACL Tear (Surgical Record)	
Partial Tear	3 (17.6)
Complete Tear	13 (76.5)
Re-rupture Tear	1 (5.9)
Type of ACL Tear	
Isolated ACL	4 (23.5)
ACL with concomitant injury	13 (76.5)
Tear Occurrence	
Primary injury	15 (88.2)
Secondary (Ipsilateral)	1 (5.9)
Secondary (Contralateral)	1 (5.9)
Duration (week) from injury to surgery, mean $\pm$SD	
(Minimum 1 week – Maximum 192 weeks)	23.02 $\pm$ 31.77
Meniscus Injury	
Yes / No	11(64.7) / 6 (35.3)
Meniscus Injury Location	
Lateral	4 (23.5)
Medial	7 (41.2)
Lateral and Medial	0 (13.0)
Not Related	6 (35.3)
Other Concomitant Injuries	
Yes / No	4 (23.5) / 13 (76.5)
Bone Injuries	
Yes / No	0 (0) / 17 (100)

and is parallel with that reported in ACLR literatures which stated the cases were likely related to higher sports involvement among male athletes than their female counterparts in Malaysia. Besides, the occurrence of ACL injuries are also higher in males than females as well in the context of general population who are active in sports activity (Prentice et al., 2018; Sanders et al., 2016). In this study, the average age of patients undergoing ACLR surgery is 27 years old, with the higher percentages of individuals being under 47 years old. This finding is similar with literature by Mall et al. (2014). This is reasoned due to the higher level of physical activities to remain socially active, either during high school, college years and early working years and the higher needs to live a

healthy lifestyle. Sanders et al. (2016) also reported a peak incidence of ACL tear at the age of 19 to 25 years in male patients. Although there was inconclusive evidence of history of knee injury as predictor for ACL injury, interestingly in this study, 19% of ACLR cases reported a history of previous knee injury before ACL tear. Further research using a national ACL database will be necessary to determine the trend of ACLR incidence in Malaysia in order to better comprehend the ACLR epidemiology.

In this study, the confirmations of ACL tear were taken from surgical records as a mean of confirming the pathology of knee injury. More than 75% of patients in this study experienced a complete ACL tear, with less than 10% of cases experienced a partial tear. The inclusion of this ACL partial tear for reconstructive surgery was decided by a surgeon to facilitate ligament healing ability and increase post-injury knee function. Another important finding in this study was about the meniscal lesion that was identified in more than 60% of ACLR patients. This percentage is considered higher when compared to certain previous studies (Costa et al., 2018) but similar to the study by Church and Keating, (2005) which reported 71% of meniscal tear incidence among ACLR patients undergoing reconstruction after 12 months of injury. The high occurrence of meniscal tear in the current study is highly likely due to the longer time taken from injury to surgery which exceeded 12 months in this study. Literatures documented that any ACL injuries that are related with meniscal or any condral injury has been associated with an increase in risk in developing early post-traumatic osteoarthritis (PTOA) (Spahn et al., 2016). In this study 77% of ACLR cases with concomitant injuries have higher risk of developing PTOA later in life within 5 to 10 years following reconstruction surgery. There are several risk factors associated with meniscus injury which has been identified in the literature such as time to surgery, male gender, age below 30 years old, revision ACLR, chronic injuries, pre-operative side to side laxity > 6mm and the presence of concomitant tear at the lateral meniscus region (Sonnery-Cottet et al., 2018).

Injury to surgery time interval has been associated with expectation of successful return to sports (RTS) activity. The time interval from injury to ACLR surgery can also be classified according to acute ACLR reconstruction (≤ 16 weeks) or delayed ACLR surgery (≥ 16 weeks). Based on a systematic review study by Fabricant et al. (2016), they found 78% -100% of returning rate to baseline pre-injury level for athletic participation among young athletes who received acute ACLR reconstruction, with some incidence of graft rupture. As established in this study, almost all of the national athletes received acute ACLR surgeries (below than 6 months). This is due to their average age which were relatively younger compared to the recreational athletes. Also, the expectation of return to sports activity among them will be higher which is within 1 year following complete ACLR post-operative rehabilitations (Fabricant et al., 2016). A recent systematic review with meta-analysis which involved 2093 patients documented that there were no difference in clinical and functional outcomes between those receiving early or delayed (3 and 6 weeks cut-off) ACLR surgery for isolated ACL injury (Vermeijden et al., 2022). However, despite this report, the question on the success of return to sports remains unanswered. Unfortunately, this study could not fur-

ther clarify on this issue. The lack of available published data for Malaysian recreational athletes and high performance athletes warrants more studies to address this concern in the near future.

It is recommended to conduct ACLR reconstruction within the first year from injury incidence (Kennedy et al., 2010). This is in order to minimise the risk of further damage to the meniscus and thus lead to early joint degenerative changes (Church & Keating, 2005). Studies have also shown that the time from injury to ACLR reconstruction is associated with a better objective performance and functional outcomes (Bieri et al., 2017). As ACLR injuries are commonly linked with a meniscus tear, a study by Yeo, Suhaimi and Parker (2019) reported that good patient-reported outcome measures (PROMs) can be obtained and failure rates after arthroscopic meniscal repair can be reduced when the patient received treatment within 3 months following the initial ACL injury involving meniscus tear. In this study, more than 60% of ACLR cases were treated less than 6 months and approximately 20% were done after more than 6 month but within a year following the injury. The practice of early ACLR surgery timing lead to a better knee function, reduced knee laxity and better scoring in subjective knee evaluation with improved early return to sports activity (Kennedy et al., 2010). In addition, early ACLR surgery is also beneficial in reducing the individual physiology inactivity among the ACLR patients (Bieri et al., 2017; Fabricant et al., 2016; Grindem et al., 2015). However, data in this study also presented that fewer than 10% of ACLR cases had their surgeries after more than 1 year (Kennedy et al., 2010). This group of patients could have preferred conservative management and only decided to undergo surgery when failed to achieve satisfactory knee outcomes and functional performance. The ACLR surgeries among national athletes were performed less than 6 months of post-injury. The practice of early ACLR surgery timing among this group of patients follows the practice as suggested in literature and this will aid in faster recovery and early return to sports (Yeo et al., 2019). Contrary to this, Fabricant et al. (2016) reported that acute or delayed surgeries produce an equal rate of return to sports, although with a varying degree of time of recovery for each individuals. It is recommended that future researches should consider to include the time to surgery and time to return to sports activity as appropriate predictor and outcome variables. Recent literature also suggested an acute ACLR surgery (received ACLR surgery within 16 week prior to time of injury) may be performed safely without the increased risk in developing arthrofibrosis. This could also prevent secondary injury associated with meniscus and cartilage lesions, in which the patients' age and sports activity level are key factors to review when considering timing for surgery (von Essen et al., 2020).

The significance of preoperative physiotherapy management (prehabilitation) prior to ACLR surgery cannot be questioned. In the orthopaedic field, the concept of prehabilitation has gained attention as it has been found to improve the outcome following surgery (Gränicher & Scherr, 2021). The benefits of prehabilitation has been explained previously (Giesche et al., 2020; Gränicher & Scherr, 2021) and comprises reduced post-operative pain, length of stay in the hospital, and post-operative complications, while it increases knee functions and have early return to sports rate. Better ACLR rehabilitation results can be attained by a struc-

tured preoperative physiotherapy management (Grindem et al., 2015). In this study, the percentage of ACLR patients receiving preoperative physiotherapy prior to surgery is low in both recreational and national athletes. This scenario needs to be explored since the benefits of prehabilitation in orthopaedic surgery has been well accepted and documented since 1942 (Rowntree, 1942).

A survey by Carter, Webster, and Smith (Carter et al., 2021) among 122 physiotherapists worldwide established that 84% of the respondents reported many ACLR patients who were waiting for ACLR did not receive prehabilitation. However, this study did not report the reasons on why preoperative physiotherapy was omitted. A systematic review found little variation in the content of prehabilitation and in general, the protocol consist of exercises including muscle control and co-contraction of the knee muscle specifically the quadriceps and hamstring (Giesche et al., 2020). Previous studies recommended that prehabilitation protocols should consist of strengthening and stretching exercises of the lower limb (4 to 6 weeks with 2 to 4 times per week) with considerations to include advanced neuromuscular (perturbation, balance, stability, proprioceptive exercises) and plyometric exercises (Carter et al., 2021; Wilk & Arrigo, 2016). As recent literature highlights that there is no specific evidence-based guidelines for strength and neuromuscular training in the early stage after ACL injury (Giesche et al., 2020), further research exploration in this area is recommended. Although this study found a very low percentage of patients who received prehabilitation, the prehabilitation protocol in standard of care for ACLR patient is recommended to be increased to maximize the functional outcome following surgery (Ebrahimi Atri & Taghizadeh, 2021). Additionally, it is predicted that with progressive structured prehabilitation, it will provide a better functional outcome following surgery and increase the chance of early and safe return to sports activity at pre-injury level. While the effects of prehabilitation prior to ACLR surgery seem beneficial in improving the ACLR recovery rate, more research are also required here to identify the correct exercises dosage (duration, intensity, frequency) and optimal exercise protocol (Carter et al., 2021; Ebrahimi Atri & Taghizadeh, 2021; von Essen et al., 2020).

There are a few limitations in this study. Firstly, the data were collected from a single hospital representing the central region of Malaysia. In future, inclusion of ACLR registry from each region in Malaysia will be necessary to enable better understanding on the outcome of surgery including return to sports. This include long term monitoring of the status of HR-QOL, secondary complications such as post-traumatic osteoarthritis and level of physical activity. In addition, as no standard online registry system was available, the reporting on ACLR outcome following surgery were varied across surgeons. Also, essential information may be missed out and less documented. Future research initiatives should be taken on developing the standard ACLR registry system for better monitoring of ACLR outcome.

Conclusion

Anterior cruciate ligament reconstruction (ACLR) is the most common procedure conducted in sports injury field. This study reports the rise of ACLR procedures performed annually in Malaysia with low number of ACLR patient re-

ceiving preoperative physiotherapy. Further studies should emphasis on larger samples and assess the consequences of preoperative physiotherapy management on functional outcomes post ACLR surgery.

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КАРТИНА ВИПАДКІВ ХІРУРГІЧНОГО ВІДНОВЛЕННЯ ПЕРЕДНЬОЇ ХРЕСТОПОДІБНОЇ ЗВ'ЯЗКИ У СПОРТСМЕНІВ: 2015–2020 У МАЛАЙЗІЇ

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Історія питання. Рівень особистого прилучення до занять спортом зростає, тим самим підвищуючи ризик травмування колін. Розрив передньої хрестоподібної зв'язки (ПХЗ) є найпоширенішою травмою коліна, яка

потребує хірургічного відновлення ПХЗ (ХВПХЗ). Однак на сьогодні існує обмежена кількість документальних фактів про характеристики ХВПХЗ в Малайзії для порівняння з країнами Заходу. Метою цього дослідження є опис епідеміологічних характеристик ХВПХЗ та загального напрямку передопераційної фізіотерапії (передопераційної реабілітації).

Матеріали та методи. Було зроблено витяги та проведено аналіз випадків ХВПХЗ, зареєстрованих у базі даних закладу третинної медичної допомоги в період від січня 2015 року до грудня 2020 року. Це ретроспективне дослідження було схвалене Комітетом з етики наукових досліджень при цьому медичному закладі (дозвіл UKMR-PI/111/8/JEP-2020-500). До розгляду були включені всі випадки ХВПХЗ, пов'язані зі спортивними травмами, крім травм, не пов'язаних зі спортом. Вибірку випадків ХВПХЗ з розподілом за роками здійснювали за допомогою форми «Інформація про травми», яка містить такі змінні, як вік, стать, тип розриву ПХЗ, супутня травма меніска, тривалість періоду від моменту травмування до проведення операції та докладний опис передопераційної реабілітації. Для узагальнення даних вибірок використовували описову статистику.

Результати. У період 2015-2020 рр. було зареєстровано загалом 131 випадок ХВПХЗ (чоловіки, $n = 122$; жінки, $n = 25$). Протягом спостережуваних років кількість випадків ХВПХЗ коливалася, при цьому за один рік було зареєстровано максимум 30 випадків, а 98% випадків були представлені молодіжною віковою групою (віком 15–47 років). Середній вік на момент операції становив $27,1 (\pm 7,79)$ року. У середньому 80% спортсменів заявили про відсутність попередніх травм колін у минулому. Найпоширенішим типом травми ПХЗ був повний розрив (88%), за яким ідуть частковий розрив (9%) і повторний розрив (3%). Травму меніска було констатовано в 61% випадків. Тривалість періоду від моменту травмування до проведення операції становила 15 тижнів. За результатами дослідження було встановлено низький відсоток пацієнтів із ХВПХЗ, які отримували передопераційну реабілітацію до операції (<20%).

Висновки. Випадки ХВПХЗ щороку показують мінливу тенденцію. Незважаючи на те, що більшість випадків ПХЗ становила повний розрив, учасники очікували на проведення ХВПХЗ понад чотири місяці, причому лише чверть із них отримувала передопераційну реабілітацію до операції. Причини таких ситуацій потребують розслідування. Також вважається доцільним проведення подальшого дослідження з використанням більшої бази даних для поглиблення розуміння картини травм ПХЗ.

Ключові слова: хірургічне відновлення ПХЗ, описова епідеміологія, передопераційна фізіотерапія, травма коліна.

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SMALL-SIDED GAMES IN BUILDING FEMALE STUDENTS' MOTIVATION FOR PRACTISING FOOTBALL IN PHYSICAL EDUCATION

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Abstract

Study purpose. This study aimed to analyze the effect of a small-sided games (SSGs) cooperative learning model on female students' motivation to participate in practical football learning.

Materials and methods. The one-group pretest-posttest design was used to identify the change in motivation on twenty female eleventh grade students selected as research subjects by random sampling techniques. Data on their motivation were collected before and after the small-sided games practice. Data analysis was carried out by using descriptive techniques and the dependent t-test.

Results. The results indicated a pretest value of 134.30 with 15.97 as the mean value. Meanwhile, the posttest resulted in a value of 152.60 with 15.73 as the mean value, which yields a difference of 18.3 in the mean values. It indicates an increase in motivation by 13.63%. The dependent t-test resulted in 6.654 as t-count value at 0.05 significance level. These results indicated that small-sided games cooperative learning model in physical education had a significant effect on improving female students' motivation to actively participate in football. Examining the implementation of football SSGs in school physical education courses and its effect on the motivation of female students to participate in practical football playing was the focus and novelty of this study.

Conclusions. This study findings will be useful resources for sports instructors and stakeholders in physical education to give more consideration to innovations such as SSGs in increasing awareness and participation of students in sports and physical activities, especially football, to improve their physical health, and as one of the determinants of achieving success in students' studies.

Keywords: female students, football, motivation, physical education, small-sided games.

Introduction

It has been a challenge to engage female students in the field of Physical Education for teachers/instructors (Azza-rito, Solmon, & Harrison, 2006; Enright & O'Sullivan, 2010; Slater & Tiggemann, 2010). One of the existing variables which contributes to the learning outcome of female students in Physical Education teaching and learning process is motivation. To construct students' activities, student motivation is the main aspect that should be achieved in the early phase of learning process (Darmawan, Ridwan, & Herdyanto, 2019). However, students' motivation to study physical education is experiencing a downward trend with increasing student school levels (Ha et al., 2018).

Sports research and physical education research have shown an intrinsic relationship of positive motivation with reduced boredom in students, increased enthusiasm, and determination to participate in physical activities. Many teaching innovations have been created by educators in teaching sports to high school students, one of which is Small-Sided Games (SSGs). Small-sided games (SSGs) are learning methods that involve physical sports in a minimized area, often using modified rules and involving fewer players than common sports. Halouani et al. (2017) focused their research on the need to test the optimal periodic strategy of SSGs training for the long-term development of physiological capacity, technical skills, and tactical abilities, and minimize the risk of injury to players. In addition, Trajkovic et al. (2017) studied SSGs vs instructional training to improve the accuracy of skills in young female volleyball players which proved that SSGs are more effective in increasing accuracy in young female

volleyball players. Furthermore, Jastrzębski and Radzimiński (2015) compared time-motion analysis and physiological responses that produce intensity in SSGs football players of all genders in 4 vs 4 SSGs and noted similarities.

Previous studies that discuss the implementation of small-sided games in football by women players abound, however, research that connects small-sided games as a method of learning football to increase the motivation and participation of female players (students) has not yet been conducted. This study's findings will be useful resources for sports instructors and stakeholders in physical education to give more consideration to innovations such as SSGs in increasing awareness and participation of students in sports and physical activities, especially football, to improve their physical health, and as one of the determinants of achieving success in student's studies. The purpose of this study is to analyze the influence of SSGs cooperative learning model on female students' motivation to participate in practical football learning.

Physical education influence on student learning outcome

Physical education (PE) gives a significant contribution to human resources development. According to that condition, physical education hopefully can make students healthier and have good physical fitness by applied teaching and learning processes based on a curriculum that can increase student competencies. Trost (2007) added that "... children who are physically active and fit tend to perform better in the classroom, and that daily physical education does not adversely affect academic performance, schools can provide outstanding learning environments while improving children's health through physical educations". However, there is discrimination between females and males in physical education during the teaching and learning process and they should actively make good teamwork and contribute to each other (Ulstad et al., 2016).

Female participation in football course

Nowadays, football is not only played by male but also female as well as give more opportunity for a female to join the competition and get the achievement as a professional football player. According to the International Federation of Association Football (FIFA), there are approximately 270 million people directly involved with football of which 840,000 are referees and assistant referees. Ninety-four percent are men and 6% are women (Orta, 2014). Murphy et al. (2014) supported this fact by mentioned that only about 6-7% of female students are interested in playing football. Therefore, his study suggested effective and innovative teaching methods for enhancing female students' engagement in physical education, especially football.

Small-sided games (SSGs)

SSGs exercise intensity is usually increased with the concurrent reduction in player number and increase in relative pitch area per player. A small number of influential SSGs players will be more effective in increasing the intensity of the game so that all players in SSGs show greater and more intense participation compared to SSGs with a large number of players. Furthermore, pitch area is the main factor that

has a strong influence on psychological stress in SSGs, the impact of which makes SSGs an effective sports teaching method for physical training/education. Direct coach supervision during SSGs has been shown to increase compliance with training programs, increase training intensity, and increase performance measures in various training modes. The physiological response to SSGs is significantly higher during situations with coach encouragement compared to no encouragement during all SSGs formats. The presence of the goalkeeper can also affect the intensity of the SSGs. In a study of Bujalance-Moreno et al. (2019), it was found that there was a positive influence of the goalkeeper on the intensity in SSGs format (4 vs 4). To date, only one study has explored the effect of game duration on physiological responses in SSGs football (Fanchini et al., 2011). There was a significant increase in HR response (expressed in percentage HRmax) between game duration 2 and 4 minutes (82, respectively, 4 vs 85.9%) and a decrease between the duration of games 4 and 6 minutes (85.9 vs 85.6%, respectively). There is only one study that explores energy expenditure and enjoyment during SSGs badminton games in boys who are overweight (reference). In this study, the finding indicates that it might be better to play SSGs in a larger court when space is available.

Materials and methods

General background and participants

This study used the quasi-experiment research design. The research design used was a one-group pre-test (before being given treatment/applying SSGs) and post-test (after being given treatment/applying SSGs). The population in this study comprised of twenty female eleventh grade students studying sciences from SMAN 11 Surabaya. The sample used in this study were female students due to several reasons. Many women were afraid of football because football had a lot of body contact or touch between bodies. Many women did not like football. In addition, the field for studying physical education in schools was still limited. The random sampling technique was applied using cluster random sampling to select the population of the study.

SSGs procedure

In this study, SSGs used a small playing field with a short duration of play. The number of students was determined constantly (4 vs 4) and three small pitch sizes were 10×15 (150 m^2), medium: 15×20 (300 m^2), and large: $20 \times 25 \text{ m}$ (500 m^2). The pitch ratio per player (pitch area divided by several players) was 1:19 m^2 , 1: 37.5 m^2 , and 1: 62.5 m^2 respectively for small, medium, and large pitch areas. Duration of the game, students do a 4×4 -minute game with a 2 minute recovery period in between. During the recovery period, the players were instructed to stop the ball and rest it under the sole in a zone 1 meter before the finish line of the playing field. Stopping the ball allows the player to determine a way to enter the "destination zone".

Data collection and analysis

The data collection instrument used was the questionnaire with items designed to follow football learning and

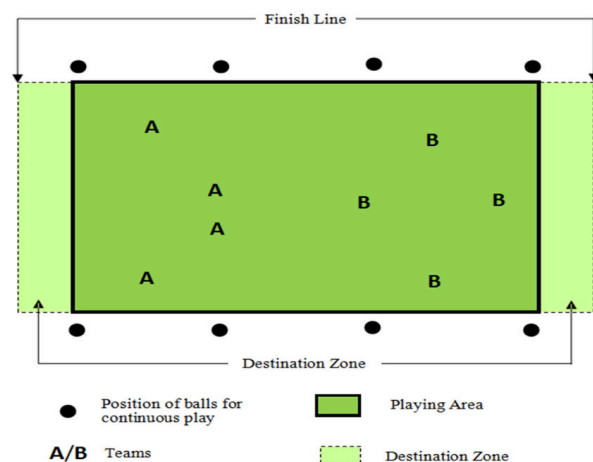


Fig. 1. SSG layout (football)

consisting of 40 items. The item validity test results = 0.323 - 0.789 ($n = 41$, r -table 0.2542) and the reliability test = 0.952. The pre-test was carried out during the first meeting by giving a motivational questionnaire to students which revealed the motivation that consists of perceived competence, task orientation, and motivational climate variables in learning football courses. The treatment phase was conducted in 2-4 football meetings with the subject focused on passing the lesson. In this phase, the students are formed into four groups. Meanwhile, the post-test was conducted at the 4th meeting of the small-sided games.

The data analysis was descriptive statistics. Tests were conducted to test the effect of independent variables (SSGs) on the dependent variable (motivation) and its difference in pre-test and post-post using the t-test with a significance level of 0.05. Data analysis was performed using Cronbach's alpha to determine its reliability. The study design was an unequal control group design and manipulation checks were carried out on the pre-test to check for any major differences in motivation. Analysis of variance (ANOVA) was performed to compare the differences between the two educational conditions on motivation with t-tests conducted to show a significant analysis.

Result

Small-sided games used as the treatment in four meetings showed significant impacts on female students' motivation in practicing football. Table 1 described the results of descriptive analysis of female students' motivation. The pre-test of perceived competence obtained an average value of 134.30, with a standard deviation value of 15.97, the lowest value of 112.00, and the highest value of 165.00. While the post-test obtained an average value of 152.60, with a standard deviation value of 15.73, the lowest value is 129.00, and the largest value is 179.00. Likewise, the value of task orientation and motivational climate is greater at post-test, so it can be concluded that SSGs are effective in increasing competence, orientation towards tasks, and motivational climate in teams. Furthermore, a normality test was conducted to continue the parametric statistical analysis to test the effect of the small-sided games on the motivation of female students in participating in the football course.

Meanwhile, Table 2 presented normality test of the form of motivation data distribution between pre-test and post-test. Based on the results of the normality test the distribution of motivational data indicated a normal distribution, so the parametric statistical analysis using the t-dependent test was conducted (Table 3). In addition to knowing the effect of small-sided games on the motivation of female students in participating in learning football, a large increase in motivation was calculated before using small-sided games and after using small-sided games.

Also, the results of the analysis of the influence of small-sided games on female student motivation are explained in Table 3. Different tests of normality in this study also used parametric statistical analysis, namely the paired sample t-test. Whereas to find out the magnitude of the effect of applying the small-sided games model, it was calculated using the difference between the results of the pre-test and post-test that was divided by the average pre-test results multiplied by 100%, and the following results were obtained. It was found that student motivation has an average pretest of 134.30 and a posttest average of 152.60 with a difference of 18.3, a t-value of 6.654 with a significance of 0.000 < 0.05, so there is an increase of 13.62%.

Table 1. Descriptive statistics

Variable	N	Test	Mean	SD	Min.	Max.
Perceived competence	20	Pre-test	134.30	15.97	112.00	165.00
		Post-test	152.60	15.73	129.00	179.00
Task-orientation	20	Pre-test	133.50	15.60	113.00	162.00
		Post-test	154.00	14.80	124.00	174.00
Motivational climate	20	Pre-test	130.26	14.70	114.00	151.00
		Post-test	151.80	15.30	121.00	168.00

Table 2. Normality test result

Variable	N	Test	Z	Sig.
Perceived competence	20	Pre-test	0.140	0.200
		Post-test	0.186	0.068
Task-orientation	20	Pre-test	0.139	0.019
		Post-test	0.187	0.069

Table 3. T-test dependent results

Variable	N	Test	Mean	Diff.	Gain (%)	t	Sig
Perceived competence	20	Pre-test	134.3	18.3	13.62	6.654	0.00
		Post-test	152.6				
Task-orientation	20	Pre-test	135.6	18.4	13.56	6.656	0.00
		Post-test	154.0				
Motivational climate	20	Pre-test	136.8	19.00	13.88	6.705	0.00
		Post-test	155.8				

Discussion

This research results indicate a significant decrease in orientation in traditional conditions before the post-test. The motivational climate did not show any significant changes

under the conditions of sports education but has shown a significant decrease in scores under traditional conditions for motivational climate. These results support previous research on teacher understanding of sports education having a positive effect on student motivation in physical education (Alexander & Luckman, 2001; Grant, 1992). Furthermore, Hastie (1998) has shown that insisting on sports education planning can improve student skills and tactical development.

There is a significant difference between sports education and traditional conditions based on perceptions of competence, task orientation, and motivational climate with the size decreasing from pre-test to post-test under traditional conditions compared to the conditions of sports education. Previous studies of sports education models have shown that these results can be linked to student excitement, engagement, and participation (Wallhead & O'sullivan, 2005). A motivational climate that is perceived to be more oriented towards competitiveness prevails more in sports education, which can be attributed to task orientation and positive motivation (Castro-Sánchez et al., 2019).

This research findings can be utilized in learning physical education because football is included in the material must be implemented starting from elementary school to high school. The state of the school in Indonesia, which on average does not have a standard football field and has become an open secret that more female students are passive in physical education lessons, especially in football. For this, small-sided games are suitable to be applied in such a situation so that they can be interesting student interest as well as the enthusiasm of students in participating in football learning and students will get new experiences in football games that have not been obtained before. With the facilities and infrastructure available at school, given the application of small-sided games conducted by researchers can stimulate students to be more active, have an enthusiastic play, and have high motivation in participating in football learning, which at first was not enthusiastic when given it conducted on hot weather conditions.

Conclusion

As this research findings showed that SSGs positively affected female students' motivation in practicing football through the aspects the strategy covered, SSGs can be continuously used by trainers in developing players' skills specialized skills, in addition to increasing their perseverance. The aspects need closer attention to implement SSGs to get optimum effect on students' motivation were number of players, pitch areas, coach encouragement, the involvement of goalkeeper, game duration, and exploration of energy expenditure and enjoyment.

Further research is needed to gain more insight into the SSGs' core interactions the best way to use them to improve student's physical education. Recommendations to physical education teachers when teaching sports lessons are to endeavor to alter team setups and vary the intensity of exercise during SSGs. More to that, effective sports teacher encouragement is vital in intensifying exercises, as well as giving comments.

Acknowledgement

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Conflict of interest

The authors declare that there are no conflicts of interest.

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РОЛЬ ІГОР НЕПОВНИМИ СКЛАДАМИ В ПОБУДОВІ МОТИВАЦІЇ ШКОЛЯРОК ДО ПРАКТИЧНОГО НАВЧАННЯ ГРИ У ФУТБОЛ НА ЗАНЯТТЯХ ІЗ ФІЗИЧНОГО ВИХОВАННЯ

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Реферат. Стаття: 5 с., 3 табл., 1 рис., 19 джерел.

Мета дослідження. Метою цього дослідження було проведення аналізу впливу моделі колективного навчання з використанням ігор неповними складами (ІНС) на мотивацію школярок до участі в практичному навчанні футболу.

Матеріали та методи. Дослідження проводили за планом попереднього та підсумкового тестування на одній групі для визначення зміни мотивації двадцяти одинадцятикласниць, відібраних учасницями дослідження методами випадкової вибірки. Дані про їхню мотивацію збирали до та після практичних занять з ігор неповними складами. Аналіз даних проводили з використанням описових методів і t-критерію Стюдента для залежних вибірок.

Результати. Результати показали значення попереднього тестування 134,30 із середнім значенням 15,97. Тоді як підсумкове тестування дало в результаті значення 152,60 із середнім значенням 15,73, що дає різницю середніх значень 18,3. Це означає зростання мотивації на 13,63%. За результатами застосування t-критерію Стюдента було отримано значення 6,654 за рівня значущості 0,05. Ці результати показали, що модель колективного навчання з використанням ігор неповними складами на заняттях із фізичного виховання статистично значущо впливали на підвищення мотивації школярок до активної участі у грі у футбол. Основна мета й новизна цього дослідження полягали у вивченні реалізації ІНС у футбол на шкільних заняттях із фізичного виховання та її впливу на мотивацію школярок до участі в практичній грі у футбол.

Висновки. Результати цього дослідження будуть корисними джерелами інформації для вчителів фізичного виховання та зацікавлених осіб у галузі фізичного виховання, які приділятимуть більшу увагу ролі таких інновацій, як ІНС, у підвищенні обізнаності та участі учнів у спорті та фізичній діяльності, особливо у футболі, для покращення їхнього фізичного здоров'я, і розглядатимуть такі інновації як один із вирішальних чинників досягнення успіху в навчанні учнів.

Ключові слова: школярки, футбол, мотивація, фізичне виховання, ігри неповними складами.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTS OF INDIVIDUALIZED TRAINING AND RESPIRATORY MUSCLE TRAINING ON PULMONARY FUNCTION AMONG COLLEGIATE SWIMMERS: AN EXPERIMENTAL STUDY

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Abstract

The study aimed to examine the effect of individualized (IT) and respiratory muscle training (RMT) on pulmonary function among collegiate swimmers.

Materials and methods. The study recruited 43 healthy collegiate swimmers aged 18 to 25, and they were freestyle non-elite swimmers who swam at least three days a week. The participants were divided into three groups of Usual training (Control Group A), Respiratory muscle training (Experimental Group B) and Combination of respiratory muscle training and individualized training (Experimental Group C). The repeated measures two-way ANOVA was used to evaluate the differences within and between (time x group) the groups upon completion of the four-week intervention.

Results. Both experimental groups (Group B and C) showed significant improvement within the groups. Whereas in between-group comparison, Group C (RMT and IT) showed tremendous improvement with significant differences in FVC value, predicted FVC value (percent), FEV1, FEV (percent), and predicted MVV, with the exception of the FEV1/FVC predicted ratio percent.

Conclusions. When RMT and IT are used combined, swimmers' performance increases more than when RMT and usual training are used separately. The findings suggest that training instructors may adapt RMT and IT techniques to fit the individual demands of swimmers in order to increase progress and performance efficiency, especially among competitive swimmers.

Keywords: individualized training, respiratory muscle training, pulmonary function, collegiate swimmers, swimming performance.

Introduction

Freestyle swimming is the common stroke technique used by participants at various sports levels. Swimming is a dynamic exercise controlled by multiple stroke techniques, muscle and lung physiology, as well as related anthropometry (Cohen et al., 2015). Swimming has a variety of effects on lung functions, such as increased lung capacity and endurance over a period of time (Pareek & Modak, 2013).

Despite this, swimming is a physically challenging sport that demands the diaphragm and respiratory muscles to function in order to counteract chest wall expansions and to tolerate the amount of stress throughout the breathing cycle caused by immersion in water pressures (Cunha et al 2019, Sable et al 2012). Water pressure in the thorax impairs respiratory function, resulting in fatigue and an alteration of the respiratory muscle metaboreflex (Hess & Hostler, 2018). Respiratory muscle activity is required not just for proper breathing but also for physical movements. Some research indicates that professional swimmers are more likely to experience exercise-induced respiratory symptoms and are more susceptible to exercise-induced bronchoconstriction

even in the absence of asthma (Bougault & Boulet, 2012). Thus, swimmers in need of an excellent respiratory muscle strength and high aerobic capacity to overcome the challenges faced under the water (HajGhanbari et al., 2013).

Many studies have been conducted on training for the respiratory muscles in order to increase swimming performance (Lemaitre et al., 2013; Wells et al., 2005; Witt et al., 2007; Wylegala et al., 2007). One of the exercises that has been popularized is respiratory muscle training (RMT), a technique that aims to improve lung functions, reduce the development of respiratory muscle fatigue metaboreflex occurrences through specific exercises (Bağiran et al., 2019; Espinosa-Mendez et al., 2021; Ren-Jay Shei, 2018; Wilson et al., 2014). The RMT technique of high-force, low-velocity contractions improves respiratory muscle strength as well as pressure generation capacity in the inspiratory and expiratory muscles against a closed glottis (Illi et al., 2012). Further, the RMT would improve adaptations in muscle fibre structures and improve cross-section muscle strength and functional adaptations like endurance and inspiratory flow (Menezes et al., 2016). In addition, the individualized training (IT) combined with RMT has shown significant improvement in respiratory functions (Kim et al., 2014; Muthusamy et al., 2021). Evidently, IT enhances sports-related performances in a various of sporting specialties as the respiratory muscle strength improves significantly under dynamic conditions (HajGhanbari et al., 2013; Illi et al., 2012).

Although numerous studies have been published on the effectiveness of RMT and IT, there is a scarcity of research on the effectiveness of the exercises on swimming performance in terms of pulmonary function. Thus, the purpose of this study was to examine the effect of IT and RMT on pulmonary function among collegiate swimmers. The study hypothesized that there would be no difference in the swimmers' pulmonary functions following IT and RMT intervention.

Materials and methods

Study participants

An experimental study with forty-three collegiate swimmers (Age = 19.53 ± 1.12) were recruited in the current study. All the recruited participants were assessed based on the predefined criteria by a blinded assessor. The inclusion criteria were healthy swimmers aged 18 to 25, freestyle non-elite swimmers, and swims at least three days a week. The study excluded swimmers with recent infections in lungs, congenital pulmonary problems, known history of respiratory problems like asthma, COPD, etc., recent injuries to the lower limbs or upper limbs, BMI greater than 24 kg/m^2 and those participating in any other research. All swimmers were explained on the study and informed consent was obtained prior to the experiment. The current study obtained ethical approval from Department of Physical Education and Health Sciences, Alagappa University, India.

Study organization

Selected swimmers were divided randomly into three group; Group A: Usual training (control group), Group B: Respiratory muscle training (experimental group) and

Group C: Combination of respiratory muscle training and individualized training (experimental group). Measurements of swimming performance were taken before and after the four weeks of intervention period for the respective groups. Prior to the intervention, the baseline measurement of the swimmers such as time taken to complete 100m distance, max HR, FVC, FEV1, FEV1/FVC, and MVV were obtained.

Participants in Group A (Usual training) had regular training sessions were given a standard exercise load and a standard land-based training regimen. Cardiovascular exercises such as jogging, cycling (both static and non-static), and light resistance training with an emphasis on freestyle swimming's major muscles were emphasized in the training session. Group B (RMT) received respiratory muscle training throughout the training session prior to warm-up and cool-down, followed by their normal routine activities (Cunha et al., 2019; Lemaitre et al., 2013). The RMT intensity ranged from a low level to a moderate level (Based on the medium resistance power breathe trainer) (Cunha et al., 2019). Group C's (RMT + IT) training intensity was prescribed based on each participant's resting heart rate, maximum heart rate ($220 - \text{Age}$) and Borg's scale of 10 points (Grant, 2017; Sadowski et al., 2012). In the first week of training, exercise intensity was set at 75% and progressively increased depending on the swimmer's capacity, with RMT incorporated into the training sessions. Participants in all three groups were assigned to five-day weekly practice sessions with sufficient rest in between. An expert swimming coach kept track of the training sessions and progression, while an expert cardiorespiratory physiotherapist advised the RMT training and levels. The study procedure has been explained in Figure 1.

The Garmin Forerunner 935 watch was used to measure the swimmers' distance and monitor their heart rates. The data was recorded using the Garmin app on the smart phone. The Garmin watch was strapped to the chest with a sensor that connected to the watch, and it was worn throughout the 100-meter

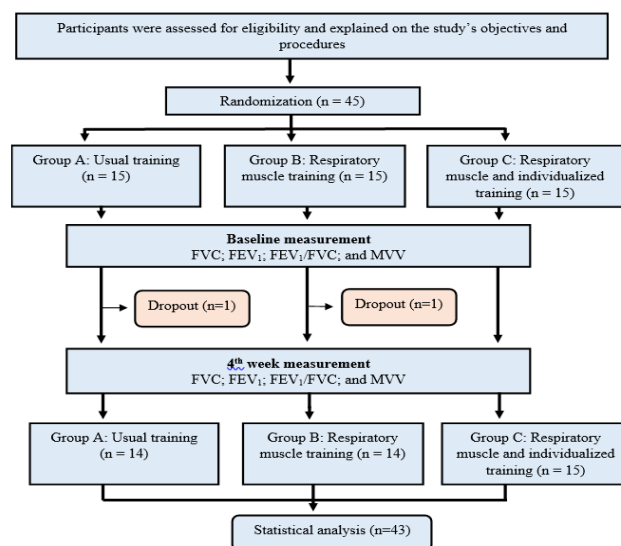


Fig. 1. Study flow chart.

Note. Forced Vital Capacity (FVC), Forced Expiratory Volume In 1 S (FEV1), Forced Expiratory Volume In 1s (FEV1), and Maximum Voluntary Ventilation (MVV)

swim to accurately measure the heart rate. Precautions were taken to ensure that the participant's breathing was not restricted or that any discomfort was avoided during the swim.

The respiratory muscles were trained with a medium-resistance trainer, Power breathe® device (Gaiam Ltd; Southam, Warwickshire, UK) (Nepomuceno Júnior et al., 2016). Before using the power breathe, all participants were given clear instructions and a practical demonstration. The resistance settings on this trainer range from level 0 to level 9 (Amaro et al., 2017). The resistance can be increased or decreased using an adjustable knob at the bottom of the device. The higher the level, the greater the resistance. Levels 2 to 8 were prescribed for different groups with different exercise sessions in the current study.

The UBREATH® Pro Spirometer System PF680 (e-Link-Care Meditech Co., Ltd, Manchester, United Kingdom) was used to measure pulmonary function among the swimmers. The data of three expiratory maneuvers with 1-min intervals were measured and collected using the best values obtained for forced vital capacity (FVC) [L], forced expiratory volume in 1 s (FEV1) [L], forced expiratory volume in 1s (FEV1)/FVC [L], and maximum voluntary ventilation (MVV) [L].

Statistical analysis

IBM SPSS version 24.0 software (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Continuous descriptive data was represented by mean and standard deviation, while categorical descriptive data was represented by frequency and percentages. A repeated measure two-way ANOVA (group x time) was conducted to examine the effects and interaction of within and between control group (Group A), respiratory muscle training (Group B) and respiratory muscle training combined with individualized training (Group C) during the four weeks of intervention. For repeated measure tests, the Shapiro-Wilk test revealed that normality was not violated, and Mauchly's test revealed that the assumptions of sphericity were not violated. The α level was set at 0.05.

Results

Forty-three collegiate swimmers were recruited in the current. The baseline demographic characteristic of the subjects was shown accordingly in Table 1.

The differences of usual training were evaluated pre and post 4 weeks intervention among fourteen swimmers. The predicted FVC value (%), FEV1, FEV (%) showed a significant improvement ($p < 0.05$) following 4 weeks training as shown in Table 2.

The differences of respiratory muscle training were evaluated pre and post 4 weeks intervention among fourteen swimmers. The FVC value, predicted FVC value (%), FEV1, FEV (%) and predicted MVV showed a significant improvement ($p < 0.05$) following 4 weeks training as shown in Table 3.

The differences of respiratory muscle and individualized training were evaluated pre and post 4 weeks intervention among fourteen swimmers. The FVC value, predicted FVC value (%), FEV1, FEV (%) and predicted MVV showed a significant improvement ($p < 0.05$) following 4 weeks training as shown in Table 4.

A repeated measure two-way ANOVA (group x time) was conducted to examine the effects and interaction of control group, respiratory muscle training and respiratory muscle training combined with individualized training. The Shapiro-Wilk test indicated that normality was not violated and Mauchly's test showed that the assumptions of sphericity was not violated for repeated measure tests.

In the FVC [L] value, no significant differences between groups $F_{(2,26)} = 1.307$, $p = 0.288$, small effect size. There is a significant difference in improvement of four weeks of intervention of the training, $F_{(1,13)} = 179.09$, $p = 0.000$, large

Table 1. Baseline characteristics of the participants

Variables	Group A (n=14)	Group B (n=14)	Group C (n=15)
Gender (n/%)			
Male	8 (57.14)	7 (50.0)	7 (46.67)
Female	6 (42.86)	7 (50.0)	8 (53.33)
Age	19.50 $\pm$ 1.092	19.50 $\pm$ 1.225	19.60 $\pm$ 1.121
Time taken for 100m distance	3.42 $\pm$ 0.40	3.54 $\pm$ 0.35	3.66 $\pm$ 0.30
Max HR	166.93 $\pm$ 9.19	165.29 $\pm$ 14.24	161.00 $\pm$ 12.49
BMI	14.90 $\pm$ 4.00	13.56 $\pm$ 3.03	22.18 $\pm$ 1.49

All the data presented in mean $\pm$ standard deviation except gender presented in frequencies (percentage), HR – Heart rate

Table 2. Comparison before and after four weeks of usual training protocol (Group A)

Variables	Pre-training (Mean $\pm$ SD)	Post-training (Mean $\pm$ SD)	Mean differences	95% CI for the Mean (Lower to Upper)	t (df)	P value
FVC	4.22 $\pm$ 0.27	4.25 $\pm$ 0.26	0.002	-0.045 to 0.000	2.132 (13)	0.053
FVC Predicted (%)	82.40 $\pm$ 1.95	82.85 $\pm$ 2.27	0.045	-0.889 to -0.001	2.168 (13)	0.049
FEV1 (L)	3.45 $\pm$ 0.23	3.47 $\pm$ 0.23	0.022	-0.004 to -0.008	3.429 (13)	0.004
FEV1 (%)	84.09 $\pm$ 3.00	84.64 $\pm$ 2.95	0.561	-0.903 to -0.218	3.537 (13)	0.004
FEV1/FVC Ratio Predicted (%)	81.82 $\pm$ 3.24	81.93 $\pm$ 3.05	0.106	-0.586 to 0.375	0.475 (13)	0.643
MVV Predicted (%)	80.14 $\pm$ 2.03	81.14 $\pm$ 2.69	1.000	-2.109 to 0.109	1.947 (13)	0.073

Forced Vital Capacity (FVC), Forced Expiratory Volume In 1 S (FEV1), Forced Expiratory Volume In 1s (FEV1), and Maximum Voluntary Ventilation (MVV)

Table 3. Comparison before and after four weeks of respiratory muscle training group (Group B)

Variables	Pre-training (Mean ± SD)	Post-training (Mean ± SD)	Mean differences	95% CI for the Mean (Lower to Upper)	t (df)	P value
FVC	4.23 ± 0.24	4.44 ± 0.28	0.211	-0.026 to -0.166	10.034 (13)	0.000
FVC Predicted (%)	82.72 ± 2.27	86.82 ± 2.51	4.103	-4.920 to -3.286	10.854 (13)	0.000
FEV1 (L)	3.36 ± 0.16	3.90 ± 0.22	0.543	-0.227 to -0.132	8.112 (13)	0.000
FEV1 (%)	86.14 ± 1.38	90.75 ± 2.20	4.611	-5.857 to -3.365	7.995 (13)	0.000
FEV1/FVC Ratio Predicted (%)	79.49 ± 2.67	79.820 ± 3.74	0.325	-1.507 to 0.856	0.595 (13)	0.562
MVV Predicted (%)	80.00 ± 1.96	93.43 ± 5.32	13.429	-16.245 to -10.612	10.299 (13)	0.000

Forced Vital Capacity (FVC), Forced Expiratory Volume In 1 S (FEV1), Forced Expiratory Volume In 1s (FEV1), and Maximum Voluntary Ventilation (MVV)

Table 4. Comparison before and after four weeks of respiratory muscle training group (Group B)

Variables	Pre-training (Mean ± SD)	Post-training (Mean ± SD)	Mean differences	95% CI for the Mean (Lower to Upper)	t (df)	P value
FVC	4.22 ± 0.256	4.25 ± 0.252	0.024	-0.045 to -0.003	2.437 (14)	0.029
FVC Predicted (%)	82.42 ± 1.88	82.90 ± 2.19	0.481	-0.898 to -0.064	2.472 (14)	0.027
FEV1 (L)	3.44 ± 0.23	3.47 ± 0.22	0.024	-0.038 to -0.010	3.804 (14)	0.002
FEV1 (%)	83.80 ± 3.11	84.39 ± 3.01	0.587	0.910 to -0.266	3.917 (14)	0.002
FEV1/FVC Ratio Predicted (%)	81.59 ± 3.26	81.69 ± 3.09	0.099	-0.544 to 0.344	0.483 (14)	0.637
MVV Predicted (%)	82.27 ± 2.99	101.20 ± 3.91	18.933	-20.588 to -17.279	24.547 (14)	0.000

Forced Vital Capacity (FVC), Forced Expiratory Volume In 1 S (FEV1), Forced Expiratory Volume In 1s (FEV1), and Maximum Voluntary Ventilation (MVV)

effect size. Besides, the interaction of the group x time also showed significant differences with $F_{(2,26)} = 45.163$, $p = 0.000$, large effect size.

The FVC [L] predicted (%) showed significant changes between groups, $F_{(2,26)} = 3.871$, $p < 0.05$, large effect size; within the groups over the four weeks intervention, $F_{(1,13)} = 216.55$, $p = 0.000$, large effect size; and a significant difference in the interaction between group x time, $F_{(2,26)} = 47.97$, $p = 0.000$, large effect size.

The FEV1 (L) showed significant changes between groups, $F_{(2,26)} = 14.093$, $p = 0.000$, large effect size. Significant differences were also seen within the groups over the four weeks intervention, $F_{(1,13)} = 383.48$, $p = 0.000$, large effect size; and a significant difference in the interaction between group x time, $F_{(2,26)} = 171.34$, $p = 0.000$, large effect size.

Whereas in the FEV1 [L] (%), all the interaction showed a significant difference between the groups, $F_{(2,26)} = 2303.72$, $p = 0.000$, large effect size, within the groups, $F_{(1,13)} = 6871.93$, $p = 0.000$, large effect size and between group x time, $F_{(2,26)} = 6685.49$, $p = 0.000$, large effect size.

The FEV1/FVC [L] ratio showed significant difference between the groups, $F_{(2,26)} = 5.114$, $p < 0.05$, large effect size were seen. The improvement over four weeks also showed a significant difference with $F_{(1,13)} = 23.329$, $p < 0.05$, large effect size and the interaction between group x time, $F_{(2,26)} = 16.616$, $p < 0.05$, large effect size.

The final variables, MVV [L] Predicted (%) also showed a significant difference in the analysis. There was a significant

difference between the groups, $F_{(2,26)} = 74.618$, $p = 0.000$, large effect size. Significant differences were also reported within the group over the four weeks of intervention, $F_{(1,13)} = 360.85$, $p = 0.000$, large effect size and the interaction between group x time, $F_{(2,26)} = 103.99$, $p = 0.000$, large effect size.

Discussion

The purpose of the study was to examine the effect of individualized training and respiratory muscle training on pulmonary function among forty-three healthy collegiate swimmers.

The comparison within the group in RMT and RMT + IT demonstrated a significant improvement over the four weeks intervention in the FVC value, predicted FVC value (%), FEV1, FEV (%) and predicted MVV except the FEV1/FVC predicted ratio % in the current study. The current study's findings are consistent with previous studies that found RMT to have a positive impact on swimmers' performance (Vašíčková et al., 2017; Kilding et al., 2010; Wylegala et al., 2007). Under normocapnic hyperpnoea conditions, (RMT) is proven to improve respiratory muscle strength and enhance pulmonary function (Szczezan et al., 2020). Researchers found that RMT has a number of positive physiological adaptations, including diaphragm hypertrophy and increased nitric oxide concentration in airways, as well as a change in muscle fibre contraction efficiency, advancement in nervous control and economy of respiratory muscle work

and reduced dyspnoea, as well as enhanced pulmonary function that led to decreased ratings of perceived breathlessness or exertion (Szczepan et al., 2020; Held and Pendergast, 2014; Ren-Jay Shei, 2018; Wylegala et al., 2007).

Despite the improvement within the RMT groups, the analysis between the groups (group x time), RMT + IT showed significant differences in comparison to RMT and usual training over the four weeks of intervention. Our results were supported by previous research that stated that athletes frequently train excessively hard during recovery sessions, impairing their ability to achieve the desired intensity during more challenging training sessions (Wallace et al., 2008). By adopting an individualized training approach, coaches perhaps would be able to measure the intensity of each training session using the RPE approach, enabling increased intensity during high-intensity training and better recovery periods (Wallace et al., 2008). Furthermore, a comparable study on collegiate swimmers found a considerable improvement with RMT and IT combination approach on perceived effort, VO₂ max, and a sharp increase in the swimmers' performance (Muthusamy et al., 2021).

To our knowledge, there has been no study on the use of RMT in combination with IT in swimming, despite the fact that it has been widely employed in other sports. The current study shown that by combining the RMT and IT methods, the pulmonary functions (FVC, FEV₁, FEV₁/FVC, and MVV) of swimmers may be significantly improved. The current study has some limitations, including a focus on solely recreational collegiate swimmers, an emphasis only on pulmonary functions rather than swimming performances or general fitness, and a short duration of intervention (four weeks). Future research should be undertaken over a longer period of time to assess the long-term effects of RMT and IT on swimming performance and among competitive swimmers.

Conclusions

The current study's findings demonstrate that when RMT and IT are combined, the swimmers' performance improves more than when RMT and usual training are used alone. The findings imply that training instructors can adjust RMT and IT approaches to their training to meet the specific demands of swimmers in order to improve development and performance even among the athletic swimmers.

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Conflict of interest

No potential conflict of interest was reported by the author(s).

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ВПЛИВ ІНДИВІДУАЛІЗОВАНИХ ТРЕНУВАНЬ І ТРЕНУВАНЬ ДИХАЛЬНИХ М'ЯЗІВ НА ФУНКЦІЮ ЛЕГЕНЬ У ПЛАВЦІВ-СТУДЕНТІВ КОЛЕДЖУ

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Метою дослідження було вивчення впливу індивідуалізованих тренувань (ІТ) і тренувань дихальних м'язів (ТДМ) на функцію легень у плавців-студентів коледжу.

Матеріали та методи. Для участі в дослідженні було відібрано 43 фізично здорових плавців-студенти коледжу віком від 18 до 25 років, які були непрофесійними плавцями вільним стилем і займалися плаванням принаймні три дні на тиждень. Учасників розподілили на три групи: «Звичайні тренування» (Контрольна група А), «Тренування дихальних м'язів» (Експериментальна група В) та «Комбінація тренувань дихальних м'язів та індивідуалізованих тренувань» (Експериментальна група С). Для оцінки відмінностей у групах і між групами (час х група) після завершення чотиритижневої інтервенції використовували двофакторний дисперсійний аналіз повторних вимірювань.

Результати. Обидві експериментальні групи (групи В та С) показали статистично значуще покращення показників у цих групах. Тоді як у міжгруповому порівнянні група С (ТДМ та ІТ) показала величезне покращення показників зі статистично значущими різницями значення форсованої життєвої ємності легень ФЖЄЛ, прогнозованого значення ФЖЄЛ (відсоток), значення об'єму форсованого видиху за першу секунду ОФВ1, значення ОФВ (відсоток) і прогнозованого значення максимальної довільної вентиляції МДВ, за винятком прогнозованого значення відсоткового співвідношення ОФВ1/ФЖЄЛ.

Висновки. У разі комбінованого використання ТДМ та ІТ показники плавців підвищуються більше, ніж у разі окремого використання ТДМ та звичайних тренувань. Одержані результати означають, що тренери можуть адаптувати методи ТДМ та ІТ відповідно до індивідуальних вимог плавців із метою покращення показників професійного розвитку та продуктивності, особливо серед спортсменів-плавців.

Ключові слова: індивідуалізовані тренування, тренування дихальних м'язів, функція легень, плавці-студенти коледжу, показники в плаванні.

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EFFECT OF PLYOMETRIC EXERCISE AND LEG MUSCLE ENDURANCE ON THE AGILITY AND VO_{2max} OF BADMINTON ATHLETES

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Abstract

Study purpose. This study aimed to determine: (1) the difference in the effect of plyometric ladder drill and hurdle drill exercises on agility and VO_{2max} , (2) the difference in the effect of badminton athletes' high and low leg muscle endurance on agility and VO_{2max} , (3) interaction between plyometric ladder drill and hurdle drill exercises with high and low leg muscle endurance on agility and VO_{2max} .

Materials and methods. This research was an experimental study with a 2×2 factorial design. The study sample was badminton athletes, totaling 24 people who were randomly selected from a population of 45 people. The instrument to measure agility was the T Drill Test, and that to measure VO_{2max} was the Multistage Fitness Test (MFT). The data analysis technique used was the two-way ANOVA at a significance level of 0.05.

Results. The study findings are as follows: (1) there is a significant difference in the effect of ladder drill and hurdle drill exercises on the agility of badminton athletes, whereas ladder drill and hurdle drill exercises have an equally good effect on increasing VO_{2max} ; (2) there is a significant difference in effect of badminton athletes' high and low leg muscle endurance on agility and VO_{2max} ; (3) there is a significant interaction between ladder drill and hurdle drill exercises and high and low leg muscle endurance on agility, whereas both exercises are equally well used to provide VO_{2max} improvement.

Conclusions. Based on the results of the study and the results of the data analysis that was carried out, it was concluded that there is a significant difference in the effect of plyometric ladder drill and hurdle drill exercises on the agility of badminton athletes.

Keywords: ladder drill, hurdle drill, agility, VO_{2max} , badminton.

Introduction

Badminton is a well-known sport all over the world. According to expert opinion, badminton is the most widely practiced sport in the world (Abián, Bravo, & Abián, 2021). In badminton, physical condition is very important. According to the findings of the literature review, badminton requires a combination of technique and physical fitness (Bozdoğan & Kizilet, 2017). Flexibility, strength, coordination, power, endurance, and agility are the most important

physical components in badminton (Nugroho et al., 2021). According to a review of several literatures, the purpose of training is to develop team and individual competence, as well as to achieve peak performance (Yudhistira et al., 2021). According to the preceding viewpoint, the preparation of an exercise program has become the responsibility of a coach; additionally, the exercises prepared by the coach are in accordance with the characteristics of motion in badminton (Sukendro et al. 2021). According to the findings of the literature review, there are actions with a relatively short and fast duration of about 10 seconds, followed by short breaks of about 25 seconds and a duration of 40 minutes in badminton matches (Ozmen & Aydogmus, 2017). Researchers discovered that badminton athletes' movements were comprehensive, in the sense that they were complex; logically,

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when the athlete lacked agility, the movements carried out could not change direction quickly. Furthermore, when action movements are performed for an extended period of time, athletes require not only agility, but also aerobic and anaerobic endurance (Nasrulloh et al., 2021).

Endurance has evolved into a necessary physical component for badminton (Ilham et al., 2021). To become a national level badminton player, the average VO_2max required is a minimum of 55 ml/minute/body weight for male athletes and 50 ml/minute/body weight for female athletes, but the field says otherwise (Lu et al., 2022). This was clearly seen when researchers observed badminton athletes based on the needs analysis with the test of badminton athletes aged 17-18 years still not entering the criteria, namely the acquisition of a VO_2max value of 40.80-47.80ml/minute/body weight for male badminton athletes (Saifu et al., 2021). Consecutive smashes cause excessive fatigue, which affects technique and concentration (Listyarini et al., 2021). Experts agree that endurance plays a significant role in winning matches (Ramírez-de la Cruz, et al., 2022).

There are numerous training methods to develop aerobic agility and endurance, but developing a good training program can be difficult (Hastuti et al., 2021). It can be seen in the setting of training doses, training targets in one session, intervals, recovery, individuality principles and the principle of progressive overload which are not appropriate when the researchers made observations with 13 trainers through a questionnaire with questions related to setting exercise doses, including: intensity settings according to the target of endurance training, the trainer answered 66.7% no, 33.3% yes. The intensity setting according to the agility training target of the trainer answered 83.3% yes, 16.7% no. Setting intervals in the application of physical exercise, the trainer answered 77.8% yes, 22.2% no. Recovery settings in the application of physical exercise, the trainer answered 66.7% yes, 33.3% no. Agility is needed in badminton to perform various movements, the coach answered 77.8% yes, 22.2% no. Endurance plays an important role when badminton players make fast movements but for a long duration the coach answered 66.7% yes, 33.3% no. Ladder drill and hurdle drill are means to help improve the physical condition of agility. The trainer answered 61.1% yes, 38.9% no. Plyometrics is an ideal method to improve the physical condition of badminton. The trainers answered 77.8% yes, 22.2% no.

Based on the needs analysis, it can be explained that there are problems regarding the setting of the exercise dose, as well as the exercise method. This study is reinforced by previous research that a good exercise is one that follows guidelines such as the principle of loading, individuality and level of regularity (Gronwald et al., 2020). The study explains that the exercise setting or exercise dose is similar to a drug dose when someone consumes it, because the exercise dose here plays an important role in improving an athlete's physique (Gasim, Cengizel, & Günay, 2022). This empirical evidence can already be the basis of the problem which is immediately given a solution. As a result, it is necessary to find a solution to increase agility and endurance, one of which is to provide plyometric training methods. Plyometric exercises are distinguished by a muscle lengthening process that is quickly followed by a muscle shortening process, also known as the stretch shortening cycle (SSC) (Fernandez-Fernandez et al., 2022). The lengthening and shortening cycle signifi-

cantly improves the tendons' and muscles' ability to generate maximum strength in the shortest amount of time.

The ladder drill and hurdle drill are two of the most commonly used tools and equipment for practicing plyometrics. Ladder drills and hurdle drills are training tools that can be used in gyms to improve the physical components of badminton players. The rationale for selecting the ladder drill and hurdle drill as a means of improving physical components in badminton is that the ladder and hurdle can be varied with various training models, the hurdle is jumping, when the athlete jumps quickly with almost no jump pauses, this falls under the plyometrics category, so the authors assume that ladder drills and hurdles can be used to improve physical conditions, particularly agility and endurance.

Previous studies defined that ladder drill for 8 weeks with a frequency of three times was able to increase speed, agility and quickness in badminton players (Guo et al., 2021). In addition, training with a combination of speed, agility, quickness and plyometrics hurdle box jump exercises for 3 alternative days for 8 weeks with three sets per exercise and per session 60%-80% with progressive increases showed a significant increase in physiological variables such as vital capacity to withstand breath compared to the control group (Kanagasabai, Manikandan & Lakshmanan, 2018). Furthermore, research on high leg muscle endurance with low leg muscle endurance for increasing VO_2max capacity and the result is that there is a difference and the better one is the group that has high leg muscle endurance (Chua et al., 2021). Based on the literature review that has been explained that ideally agility and endurance training that is in accordance with the characteristics of badminton is to use the plyometrics method, therefore researchers will develop a plyometrics program using ladder drills and using hurdle drills, where both of these tools are needed to practice agility and accumulation of skills. Exercise can also affect aerobic endurance.

The remainder of this paper is organized as follows. Section 2 presents the compound set method and the data analysis technique, Section 3 presents the results, Section 4 discusses the results, and finally Section 5 concludes the paper.

Materials and methods

Study participants

The research population was a badminton club in Yogyakarta City, amounting to 45 athletes. Research sampling was based on the simple random sampling technique. The division of groups was based on a ranking system using a percentage taken is the high group of 27% and the low group 27% (Wartika et al., 2014). Based on this result, 24 samples were found, then this stage would be separated or divided by match subject ordinal pairing (MSOP) which is divided into 4 high and low groups with 1 group containing 6 athletes who are given ladder drill and hurdle drill exercises.

Study organization

This research method was an experimental method with a 2x2 factorial design. An instrument for measuring leg muscle endurance or often referred to as dynamic strength was a squat jump. Procedure: (a) ready stance, stood with legs slightly wide, (b) bent your knees and lower your but-

tocks, then jumped up, continued the movement as in the beginning, did it for 30 seconds, then took the record for the test results. Aerobic endurance test used a multistage fitness test (MFT), the procedure was as follows: (a) the test size was 20 meters with a cone marked, (b) the athlete placed 1 foot above the 20 meter marking line from each turn and test, (c) waited for the sound “beep” then continued, before the signal and the sound “beep” the athlete was not allowed to perform, (d) the athlete ran as long as possible, if the athlete failed 2 times or was late to the marking line then the athlete must stop and finished the test, (e) note the level and amount. While the agility test used the T drill test. The test procedure was as follows: (a) ran to the center cone, (b) stepped to the left 5 meters, (c) then stepped to the right side 10 meters, (d) stepped left side 5 meters to the middle (e) then ran 10 meters back (f) took the records for the time.

The half squat jump test instrument was adopted from the research of Nursalam & Aziz (2020) so that the test instrument was valid and reliable, while the VO₂max test and t-test were adopted from Mackenzie’s book (2005) “Performance Evaluation Test”, so that the test was standard and of course it was valid and reliable. Validity and Reliability T-Test (agility) with a significance level of ($\alpha = 0.05$) obtained a validity value of 0.795, while the reliability value of 0.692. The validity and reliability of the Multi Stage Fitness (endurance) test with a significance level of ($\alpha = 0.05$) obtained a validity value of 0.744, while the reliability value was 0.697. The validity and reliability of the Squad jump test with a significance level of ($\alpha = 0.05$) obtained a validity value of 0.97, while the reliability value was 0.98.

Statistical analysis

Data analysis technique using prerequisite test includes normality test and homogeneity test, then after the data could be said to be normal and homogeneous proceeded to the next stage or hypothesis testing. The hypothesis test was

a two-way ANOVA. Hypothesis testing was assisted by using statistical product and service solutions with a significant level of $=0.05(5\%)$.

Results

The results of plyometric exercises with ladder drills and hurdle drills on agility and VO₂max in terms of high and low leg muscle endurance in badminton athletes are described in table 1.

Based on the data in table 1, the Pre-test and Post-test of Agility and VO₂max in terms of leg muscle endurance in badminton athletes can be presented in the figure 1.

This normality test uses the Kolmogorov-Smirnov analysis technique and the calculation of the normality test using SPSS 25 software. The data is said to be normally distributed if Sig > 0.05. The results of the normality test show that all research variables have a significance value greater than 0.05, so it can be concluded that all variables are normally distributed. The results of the homogeneity test in the study were carried out using the SPSS 25 application. Based on the statistical analysis of the homogeneity test, the pretest group obtained a significance value of >0.05, so this means that the data group has a homogeneous variance. Likewise, the results of the calculation on the posttest obtained a significance value of > 0.05, this means that the data group has a homogeneous variance.

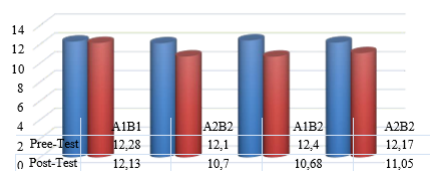
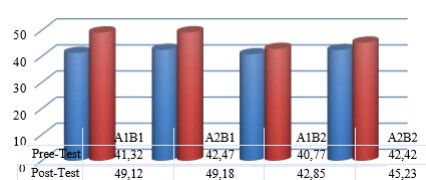
The research hypothesis was tested based on the results of data analysis and the interpretation of the two-way ANOVA analysis. Based on the processed research data, the results of hypothesis testing are as follows:

Agility

The first hypothesis tested in this study was that “there is a significant difference in the effect of plyometric ladder drill and hurdle drill exercises on the agility of badminton athletes”. The results of the analysis are described in table 2.

Table 1. Description for Agility Test and VO₂max

Agility Test					
Plyometric Exercise Treatment	Level of leg muscle endurance	Statistics	Pre-test	Post-test	Improvement
Ladder Drill	High	Average	12.28	12.13	0.15
	(A1B1)	SD	0.64828	0.56709	0.08115
	Low	Average	12.10	10.70	1.4
	(A1B2)	SD	0.50725	0.66211	-0.15486
Hurdle Drill	High	Average	12.40	10.68	1.72
	(A2B1)	SD	0.46911	0.20926	0.25985
	Low	Average	12.17	11.05	1.12
	(A2B2)	SD	0.56793	0.57424	-0.00631
VO ₂ max Test					
Plyometric Exercise Treatment	Level of leg muscle endurance	Statistics	Pre-test	Post-test	Improvement
Ladder Drill	High	Average	41.32	49.12	7.8
	(A1B1)	SD	1.45522	1.67412	0.2189
	Low	Average	40.77	42.85	2.08
	(A1B2)	SD	2.95138	6.54973	3.59835
Hurdle Drill	High	Average	42.47	49.18	6.71
	(A2B1)	SD	1.68008	2.16002	0.47994
	Low	Average	42.42	45.23	2.81
	(A2B2)	SD	2.75566	2.30362	-0.45204

Improvement of Agility**Improvement of VO₂Max****Fig. 1.** Average Score of Pre-test dan Post-test in the Agility and VO₂max Improvement Based on the Ladder Drill dan Hurdle Drill**Table 2.** ANOVA Result for the Difference of Plyometric Exercise with Ladder drill dan Hurdle drill on the agility

Source	Type III Sum Of Squares	df	Mean Square	F	Sig
Training Method	2.051	1	2.051	6.966	0.016

From the results of the ANOVA test, it can be seen that the significance value of p is 0.016 and the F value is 6.966. Since the significance value of p is $0.016 < 0.05$, thus there is a significant difference in the effect of ladder drill plyometric exercises and hurdle drills on the agility of badminton athletes. This means that the research hypothesis is proven that there is a significant difference in the effect of plyometric ladder drill and hurdle drill exercises on the agility of badminton athletes.

The second hypothesis tested in this study was that “there is a difference in the effect between badminton athletes who have high and low leg muscle endurance on agility”. The results of the study can be seen in the table 3.

Table 3. Results of ANOVA for the Difference of Athletes Having High and Low Leg Muscle Endurance on the Agility

Source	Type III Sum Of Squares	df	Mean Square	F	Sig
Leg Muscle Endurance	1.912	1	1.912	6.493	0.019

From the results of the ANOVA test in table 3, it can be seen that the significance value of p is 0.019 and the F value is 6.493. Since the significance value of p is $0.019 < 0.05$, thus there is a significant difference in the effect of badminton athletes who have high and low leg muscle endurance on agility. This means that the research hypothesis proves that there is a difference in the effect of badminton athletes who have high and low leg muscle endurance on agility.

The third hypothesis tested in this study was that “there is an interaction between ladder drill and hurdle drill plyometric exercises and leg muscle endurance (high and low) on the agility of badminton athletes”. The calculation results can be seen in the table 4.

Table 4. Result of ANOVA for the Interaction of Plyometric Exercise with Ladder Drill and Hurdle Drill and Leg Muscle Endurance on the Agility of Badminton Athletes

Source	Type III Sum Of Squares	df	Mean Square	F	Sig
Training Method *					
Leg Muscle Endurance	4.062	1	4.062	13.795	0.001

From the results of the ANOVA test in table 4, it can be seen that the significance value of p is at 0.001 and the F value is at 13.795. Since the significance value of p is $0.001 < 0.05$, so based on this it means that the hypothesis is proven that there is an interaction between plyometric exercises (ladder drill and hurdle drill) and leg muscle endurance (high and low) on the agility of badminton athletes. After testing the third hypothesis, there is an interaction between plyometric exercises (ladder drill and hurdle drill) and leg muscle endurance (high and low) on the agility of badminton athletes, it is necessary to carry out further tests using the Turkey test. Further test results can be seen in the table 5.

Tabel 5. Ringkasan Uji Post Hoc

Group	Interaction	Mean Difference	Std. Error	Sig.
A1B1	A1B2	1.4300*	0.31531	0.001
	A2B1	1.4583*	0.31531	0.001
	A2B2	1.0883*	0.31531	0.013
A1B2	A1B1	-1.4300*	0.31531	0.001
	A2B1	0.0283	0.31531	1.000
	A2B2	-0.3417	0.31531	0.703
A2B1	A1B1	-1.4583*	0.31531	0.001
	A1B2	0.0283	0.31531	1.000
	A2B2	-0.3700	0.31531	0.650
A2B2	A1B1	-1.0883*	0.31531	0.013
	A1B2	0.3417	0.31531	0.703
	A2B1	0.3700	0.31531	0.650

Based on table 5 the results of the Turkey test calculation on the asterisk sign (*) show that the pairs that have interactions or pairs that are significantly different are: (1) A1B2-A1B1, (2) A2B1-A1B1, (3) A2B2 -A1B1, while the other pairs stated that there was no difference in effect were: (1) A1B2-A2B1, (2) A1B2-A2B2, (3) A2B1-A2B2. The following is a group of pairs of pairs that have interactions:

The group that was trained plyometrically with ladder drill and had lower leg muscle endurance was better than those trained plyometrically with the ladder drill method and had high leg muscle endurance on agility, with $p < 0.05$.

The plyometric group trained with the hurdle drill method and had high leg muscle endurance was better than the group trained with the ladder drill plyometric method and had high leg muscle endurance for agility, with a p value of < 0.05 .

The group that was trained with the hurdle drill method and had lower leg muscle endurance was better than the group trained with the ladder drill method and had high leg muscle endurance for agility, with a p value of < 0.05 .

VO₂max

The hypothesis tested in this study was that “there is a significant difference in the effect of plyometric exercises with ladder drills and hurdle drills on the VO₂max of badminton athletes”. Results of the analysis are described in table 6.

Table 6. Results of ANOVA on the Difference of Ladder Drill and Hurdle Drill Effects on VO₂max

Source	Type III Sum Of Squares	df	Mean Square	F	Sig
Training Method	0.920	1	0.920	0.210	0.652

From the results of the ANOVA test in table 6, it can be seen that the significance value of p is at 0.652 and the F value is at 0.210. Since the significance value of p is 0.652 > 0.05, it can be concluded that there is no difference between the drill and hurdle drill training methods on VO₂max, meaning that the ladder drill training method has the same effect as the hurdle drill training method on VO₂max and ladder training methods. drill and hurdle drill have the same effect on VO₂max in badminton athletes.

The next hypothesis that was tested was that “there is a difference in the effect between badminton athletes who have high and low leg muscle endurance on VO₂max”. The results of the study can be seen in the table 7.

Table 7. Results of ANOVA on the Difference of Effect of Athletes Having High and Low Leg Muscle Endurance on VO₂max

Source	Type III Sum Of Squares	df	Mean Square	F	Sig
Leg Muscle Endurance	75.260	1	75.260	17.165	0.001

From the results of the ANOVA test, it can be seen that the significance value of p is at 0.001 and the F value is at 17.165. Since the significance value of p is 0.001 < 0.05, it can be concluded that there is a significant difference in the effect of badminton athletes who have high and low leg muscle endurance on VO₂max. Based on the results of the analysis, it turns out that high leg muscle endurance has a better effect than low leg muscle endurance on VO₂max in badminton athletes. This means that the research hypothesis proves that there is a difference in the effect of badminton athletes who have high and low leg muscle endurance on VO₂max.

The last hypothesis tested in this study was that “there is an interaction between plyometric ladder drill and hurdle drill exercises and leg muscle endurance (High and Low) on the VO₂max of Badminton Athletes”. The calculation results can be seen in the table 8.

Table 8. Results of ANOVA Tes ton the Interaction between Plyometric Ladder Drill and Hurdle Drill and Leg Muscle Endurance on VO₂max of the Badminton Athletes

Source	Type III Sum Of Squares	df	Mean Square	F	Sig
Training Method*					
Leg Muscle Endurance	1.000	1	1.000	0.228	0.638

From the results of the ANOVA test in the table above, it can be seen that the significance value of p is 0.638 and the F value is 0.228. Since the significance value of p is 0.638 > 0.05, it can be concluded that there is no interaction between the plyometric ladder drill and hurdle drill training methods with muscle endurance on badminton athletes' VO₂max.

Discussion

Based on the hypothesis testing, it is known that the ladder drill and hurdle drill exercises have a significant different effect on the agility of badminton athletes, accepted. This means that the hurdle drill and ladder drill training methods have a significant difference in influence on the agility of badminton athletes. Ladder drill and hurdle drill are forms of plyometric exercise. Plyometric exercises can improve agility in athletes (Kayantaş & Söyler, 2020; Padrón-Cabo et al., 2021).

Plyometrics is a type of physical exercise that emphasizes the formation of lower body power (Moran et al., 2021; Nasrulloh et al., 2022; Pratama et al., 2022). This type of exercise is effective when practiced in sports that require foot support (Almeida et al., 2021; Chen et al., 2017; Nopembri et al., 2022). Most researchers and practitioners have the same view that plyometric training is one approach in every field of sport that is often used by athletes, especially those who have Short-Shortening Cycle (SSC) (Shamshuddin et al., 2020; Adji et al., 2022; Sutapa et al., 2021). Previous studies have shown that plyometric training in every sport can improve athlete performance (Ramirez-Campillo et al., 2021; Jufriani et al., 2021). The selection of hurdle drill and ladder drill exercises was carried out based on the relevance of previous research which stated that there was an increase in agility in athletes who were given hurdle drill exercises (Ramirez-Campillo et al., 2021). This is in line with this study that based on data analysis on the calculation of the average value of the hurdle drill exercise is higher (good) compared to the ladder drill exercise on the agility of badminton athletes.

Ladder drill and hurdle drill exercises did not have a significant difference in the VO₂max of badminton athletes. Based on the results of the research data analysis, it is stated that the average calculation for ladder drill exercises is 45.98 and hurdle drill is 47.20 for the increase in VO₂max with a difference of 1.22. Because the results of the difference between the ladder drill and the hurdle drill are small, it means that the two exercises have the same effect on increasing the VO₂max capacity of badminton athletes. In this study, there was no significant difference between the two groups of ladder drill and hurdle drill exercises because both exercises were aimed at increasing the VO₂max of badminton athletes. The factor that distinguishes these two training methods is the stage of implementation. So, to train to increase VO₂max, you can choose these two training methods, on the basis of research that these two methods have the same effect on increasing VO₂max.

The results of the analysis show that badminton athletes who have high leg muscles are better than badminton athletes who have low leg muscles on agility and VO₂max. It is relevant to previous research that athletes who have high leg muscle endurance will have excellent agility and VO₂max capacity compared to athletes who have low leg muscle endurance, so their physical condition of agility and VO₂max is sufficient (Raymundo et al., 2018).

One of the important elements of physical fitness is endurance or leg muscle endurance (Junker & Stöggl, 2019). There-

fore, badminton requires a physical component of agility and an increase in VO_2max (Cinthuja et al., 2015). Athletes who have good endurance, the athlete's performance will remain optimal from time to time leading to long-term fatigue (Handaru et al., 2020). Physical endurance produces physiological and biochemical changes in muscles, so that endurance generally manifests through muscle endurance (Wee et al., 2016).

Conclusions

Based on the results of the research and the results of data analysis that has been carried out, it is concluded that there is a significant difference in the effect of plyometric ladder drill and hurdle drill exercises on the agility of badminton athletes. In addition, there is a significant difference between badminton athletes who have high and low leg muscle endurance on agility and VO_2max and there is a significant interaction between the ladder drill and hurdle drill training methods on agility and there is no significant interaction between ladder drill and hurdle drill exercises on VO_2max .

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Conflict of interest

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ВПЛИВ ПЛІОМЕТРИЧНИХ ВПРАВ І МІЦНОСТІ М'ЯЗІВ НІГ НА ПОКАЗНИКИ СПРИТНОСТІ ТА МАКСИМАЛЬНОГО СПОЖИВАННЯ КИСНЮ СПОРТСМЕНІВ-БАДМІНТОНІСТІВ

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Мета дослідження. Метою цього дослідження було визначення: (1) відмінності впливу пліометричних вправ із координаційною драбиною та з координаційними бар'єрами на показники спритності та максимального споживання кисню (МСК), (2) відмінності впливу високих і низьких показників міцності м'язів ніг спортсменів-бадмінтоністів на показники спритності та МСК, (3) взаємного впливу пліометричних вправ із координаційною драбиною та з координаційними бар'єрами за високих і низьких показників міцності м'язів ніг на показники спритності та МСК.

Матеріали та методи. Це дослідження було експериментальним дослідженням із факторним планом 2х2. Досліджуваною вибіркою були спортсмени-бадмінтоністи загальною кількістю 24 особи, випадковим чином відібрані з генеральної сукупності кількістю 45 осіб. Засобом вимірювання показників спритності слугував Т-тест на спритність і координацію (різноспрямований біг між 4 конусами, розташованими у формі літери «Т» з торканням кожного та поверненням у вихідне положення), для вимірювання показників МСК використовували тест «Човниковий біг на 20 метрів». Для аналізу даних використовували метод двофакторного дисперсійного аналізу за рівня значущості 0,05.

Результати. Результати дослідження наступні: (1) існує статистично значуща відмінність впливу вправ із координаційною драбиною та з координаційними бар'єрами на показники спритності спортсменів-бадмінтоністів, при цьому вправи з координаційною драбиною та з координаційними бар'єрами однаково гарно впливають на підвищення показника МСК; (2) існує статистично значуща відмінність впливу високих і низьких показників міцності м'язів ніг спортсменів-бадмінтоністів на показники спритності та МСК; (3) існує статистично значущий взаємний вплив вправ із координаційною драбиною та з координаційними бар'єрами за високих і низьких показників міцності м'язів ніг на показники спритності, при цьому обидва види вправ однаково гарно використовують для забезпечення підвищення показників МСК.

Висновки. На підставі результатів дослідження та результатів проведеного аналізу даних було зроблено висновок про наявність статистично значущої відмінності впливу пліометричних вправ із координаційною драбиною та з координаційними бар'єрами на показники спритності спортсменів-бадмінтоністів.

Ключові слова: вправи з координаційною драбиною, вправи з координаційними бар'єрами, спритність, максимальне споживання кисню (МСК), бадмінтон.

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EFFECTIVE LEARNING ENVIRONMENTS IN PHYSICAL EDUCATION

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Abstract

Background. Physical education (PE) has been acknowledged as important by scholars all across the world. As a result, they have been looking for techniques to improve PE teaching and learning. There are various ways that may be used to improve PE teaching and learning. The most effective way identified in the research, however, is the classroom management approach. Furthermore, because the learning atmosphere in the classroom is inappropriate, PE teachers have been unable to regulate the class and handle students' discipline problems.

Study purpose. As a result, the goal of this study is to explore the impact of classroom management practices on the learning environment.

Materials and methods. The Classroom Management Methods questionnaire and the Self-Evaluation of Teaching Effectiveness in PE questionnaire were used to collect data from 359 instructors in a high school in Indonesia.

Results. The findings demonstrated that preventative and corrective techniques have a considerable impact on the learning environment. Meanwhile, the supporting approach has no discernible effect on the learning environment. These findings can help school administrators, such as the principal and PE teacher, choose suitable classroom management strategies to deal with misconduct.

Conclusions. As a result, improving and sustaining a good learning environment in high schools also supports the teaching and learning process, hence increasing students' learning efficiency.

Keywords: classroom management, physical education, learning environment.

Introduction

Physical education (PE) is widely recognized and accepted across the world. This is due to the abundance of scientific research demonstrating that PE benefits pupils (Bevans et al., 2010; Botagariyev et al., 2016; Dyson, 2014). Recognizing the growing trends in research in this sector, Indonesia has been actively seeking methods to develop PE teaching and learning process to be more effective, which includes arranging classroom atmosphere to positive learning environment as well as approaches to managing misbehavior in classroom to enhance the teaching and learning process, which will increase students' learning (Beazidou et al., 2013; Bertills et al., 2018; Wilson, 2018). According to Botagariyev et al. (2016) classroom management in PE class should not only focus on placing chairs or tables in the square room, but

also on avoiding students' misconduct, helping students on the correct road, and dealing with difficulties that develop in the classroom.

Teachers can use a variety of tactics in the classroom to change and regulate students' conduct, such as preventative approaches, which are proactive measures for preventing students' unpleasant behavior. According to Larson, et al (2018), preventative tactics should be used before an issue arises to prevent the unforeseen problem and foster positive conduct in the classroom. A teacher who is not prevention-oriented, on the other hand, will be liable for producing student disciplinary issues in the classroom (Gareis & Grant, 2014). Furthermore, supporting measures are used to aid pupils in regaining control and getting back on track.

According to Chacon-Cuberos et al., (2020), supportive practices in the classroom are significant elements for student learning and progress. Furthermore, supporting tactics are those that assist students in re-energizing the class and effectively motivating them. Meanwhile, if the instructor did

not find preventative and supportive methods relevant in regulating specific behaviors of the students, there are additional ways such as corrective approaches to fix the students' behavior. Previous studies revealed that using punishment in PE class was the most effective correction strategy.

According to Yarmak et al. (2017), punishment should be used in the classroom to reduce undesirable behaviour. Similarly, Tekindal et al. (2017) states that punishment can either increase or lessen kids' problems in the classroom. As a result, either preventative, supporting, or corrective tactics impact classroom management practices. On the other side, Rahimi & Karkami (2015) demonstrated that a PE instructor may fail to manage a classroom because he is unable to supervise classrooms and students' discipline conduct.

Recently, academics have drawn attention to the importance of managing and keeping a positive learning environment in the classroom since it promotes and maintains a positive learning environment that assures support for students, which leads to dedication to their class. Lopes et al. (2017) discovered that when students are in an adequate and safe learning environment, they feel at ease, trustworthy, and motivated to study. On the other hand, if they encounter a dangerous atmosphere, such as classrooms with broken windows and tables and chairs that are falling apart, they lose interest in the subject (Larson et al., 2018). As a result, the classroom setting is important in generating a conducive learning environment.

According to Osborne et al. (2016) classroom organization is an important component in the learning environment since it aids the entire teaching and learning process. This is consistent with Hannah (2013) claim that if a classroom is not managed properly, it hinders learning progress or does not provide a healthy learning environment. Unfortunately, very few empirical evidences have been discovered that investigate the influence of classroom management practices on learning environment among Indonesia high school teachers. Thus, in order to build successful PE teachers and enhance the efficiency of students' learning in Indonesia, empirical research into the influence of classroom management techniques toward learning environment in PE class is required.

The purpose of this study was to investigate at the classroom management practices in PE class regarding the learning environment among high school teachers in Indonesia. The study will also focus on characteristics of classroom management techniques in numerous aspects, including preventative strategies, supporting strategies, and corrective strategies toward learning environment, to have a better understanding.

Materials and methods

Design

The quantitative research approach is used in this investigation. In order to meet the aims, the instrument utilized in this study contains two questionnaires for data collection.

Study participants

To gather data for this study, a questionnaire was administered in person. Physical Education instructors were

among those who responded. A total of 359 high school teachers from Indonesia were chosen to participate in the data gathering. All of the surveys were completed and returned, yielding a 100% response rate; 96.82 percent of the questions were complete (347 sets), while 3.18 percent had some missing data (12 sets). The response rate of the questionnaire in this study is shown in table 1.

Table 1: Questionnaire response rate

Response	Frequency	Percentage
Questionnaires were distributed.	359	100
Questionnaires returned	359	100
Questionnaire not returned	0	0
Questionnaires that are incomplete	0	0
Questionnaires that were returned	12	3.18
Questionnaires that were saved	347	96.82

Study organization

McCormark (1997) provided the classroom management techniques questionnaire (table 2). Meanwhile, Kyriridis et al. (2014) used the self-evaluation teaching effectiveness in Physical Education (SETEQ-PE) to gather data in the learning environment (table 3). Both questionnaire replies were graded on a five-point Likert scale: frequently (5), occasionally (4), infrequently (3), rarely (2), and never (1).

Table 2. Classroom Management Strategies Detail

No	Variables	Items
1	Preventive Strategies	Positive relationships
2		Effective communication
3		Active listening
4		Being genuine
5		Clear expectations
6		Clear directions
7		Effective movement management
8	Supportive Strategies	Praise and encouragement
9		Communicating understanding
10		Using logical consequences
11		Humors
12		Wittiness
13		Rules
14		Commands and orders
15		Proximity control
16		Desists
17		Contracts
18		Detention
19		Timeout/exclusion
20		Parent referrals

(Source: McCormark (1997))

Table 3. Learning Environment Detail

No	Items
1	Do you individualize your teaching so that each of your students improves emotionally and socially?
2	Do you individualize your teaching so that each of your students improves kinetically?
3	Do you individualize your teaching so that each of your students improves cognitively?
4	Is student safety (physical, emotional, social) guaranteed during your lesson?
5	Do you modify your lesson plan to ensure motivation, progress, and safety to students?

Source: Kyrgiridis et al (2014)

Statistical analysis

The data collected from those teachers was analyzed using two types of statistical software: Statistical Package for Social Sciences (SPSS) version 23 for preliminary data analysis and Partial Least Square-Structural Equation Modeling (PLS-SEM) version 3 for examining the formation of reflective measurement model and structural equation model.

Results

In order to evaluate a measurement model there are four processes to assess namely; examining individual item reliability, ascertaining internal consistency reliability, ascertaining convergent validity, and ascertaining discriminant validity.

Table 4. Frequency of Respondents

Profile	Factors	Frequency	Percentage
Gender	Male	242	67.5%
	Female	117	32.5%
Age	< 25	17	4.7%
	26-35	137	38.2%
	36-45	164	45.6%
	> 46	41	11.5%
Academic Bachelor's degree	PE	274	76.4%
	Sport sciences	64	17.7%
	Health Education	10	2.7%
	Elementary Education	11	3.2%
Teaching experience (years)	< 2	40	11.1%
	3-6	49	13.7
	7-10	116	32.4%
	11-14	78	21.5%
	>15	76	21.3%

The measurement model's results are shown in table 5; the composite reliability scores for the four constructs ranged from 0.759 to 0.857. According to Leguina (2015), the composite dependability value should be more than 0.7. The AVE ranged from 0.53 to 0.578. This is consistent with to Leguina (2015) recommendation for AVE, which should be

Table 5. Summary of Standardized Loading, Composite Reliability (CR), and Average Variance Extracted (AVE)

Constructs	Indicators	Loading	CR	AVE	Convergent validity
Preventive	cms1p	0.676	0.871	0.53	Yes
	cms4p	0.763			
	cms5p	0.723			
	cms6p	0.733			
	cms8p	0.721			
	cms9p	0.732			
Supportive	cms10p	0.762	0.825	0.531	Yes
	cms12p	0.783			
	cms13p	0.742			
	cms14p	0.673			
	cms15p	0.726			
Corrective	cms18p	0.671	0.759	0.531	Yes
	cms19p	0.743			
	cms20p	0.724			
	te21evm	0.812			
Learning Environment	te22evm	0.839	0.857	0.578	Yes
	te23evm	0.771			
	te24evm	0.625			
	te25evm	0.711			

at least 0.5 for each variable to be adequate. The current research items have loadings for indicators ranging from 0.625 to 0.839. According to Leguina (2015) proposed removing the loading for indicators with values less than 0.40. As a consequence, all of the results suggesting the model of this study met the needed requirements.

Table 6. The Fornell-Larcker Criterion Analysis

Indicators	Corrective	Learning Environment	Preventive	Supportive
Corrective	0.815			
Learning Environment	0.166	0.742		
Preventive	0.003	0.512	0.722	
Supportive	0.132	0.438	0.628	0.735

Table 6 shows that in the Fornell-Larcker measurement, the AVE square root values in the first order construct should be greater than the correlations among all the other variables (2016), as evidenced by the results showing that the AVE value is greater than the value of all the constructs below it.

The Heterotrait Monotrait criteria of correlation (HTMT) is shown in table 7, (HTMT). According to Hensel-

Table 7. The Heterotrait Monotrait (HTMT) Criterion

Indicators	Corrective	Learning Environment	Preventive	Supportive
Corrective	-			
Learning Environment	0.265	-		
Preventive	0.183	0.612	-	
Supportive	0.233	0.58	0.728	-

Table 8. PLS-SEM

Relationship	Std. Beta (b)	T Values	P Values	Finding
PS->learning environment	0.413	5.331	0.001	*significant
SS->learning environment	0.146	1.533	0.143	not significant
CS->learning environment	0.165	3.158	0.003	*significant

Note: *significant at $p < 0.05$

er et al. (2015), the HTMT value of correlation should not be greater than 0.85. The HTMT values in this study are less than 0.85.

Table 8 depicts the hypothesis evaluation using the bootstrapping PLS-SEM. The findings revealed a significant relationship between corrective strategies (CS) and learning environment ($b = 0.165$, $T = 3.158$, $P < 0.05$) and between preventative strategies and learning environment ($b = 0.413$, $T = 5.331$, $P < 0.05$). However, no relationship was discovered between support techniques and learning environment ($b = 0.146$, $T = 1.533$, $P > 0.05$).

Discussion

These findings provide empirical evidence for the current study's conclusion that there is a substantial relationship between classroom management practices and learning environment among high school teachers in Indonesia. These data show that preventative and corrective techniques contribute considerably and favorably to the learning environment among high school teachers in Indonesia, but supporting approaches have no significant influence on the learning environment.

The findings revealed a substantial relationship between preventative methods and learning environment among high school teachers in Indonesia. The possible cause of this effect is the respondents' teaching experience, which is evident from the demographics of the participants (see table 4). According to Ozben (2010), teachers with greater teaching experience can manage and establish a pleasant learning environment to reduce student misconduct. According to Kayani (2018), teaching experience is favorably associated to classroom management for reducing undesirable conduct. This is because teachers with greater teaching experience have different techniques to dealing with pupils' misconduct (Sprick, 2013).

Furthermore, the findings revealed a substantial relationship between corrective techniques and learning environment among high school teachers in Indonesia. These findings are consistent with the prior finding, which is connected to the instructors' experience. These findings are similar with the Lopez-Gonzalez et al. (2017). This is because those with extensive teaching and training experience may bring their knowledge to bear in managing their classrooms (Chu & Zhang, 2018; Ratten & Jones, 2018). As a result, it was proposed that the 40 of all responders be reduced to less than 11.1 percent in year terms.

Conclusions

Overall, the current study discovered that preventative and corrective measures have a considerable influence on the learning environment. On the other hand, supportive

techniques had no substantial effect on high school teachers in Indonesia. Yet, supportive approaches to the learning environment cannot be ignored; however, new techniques to assist the learning environment are required. As a result, this study can assist PE instructors understand how to choose classroom management approaches to tackle disobedience and to improve and maintain a healthy learning environment in high schools. The current study has several limitations because the data was obtained exclusively in the area of Indonesia.

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Conflict of interest

The authors declared no potential conflicts of interest.

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ЕФЕКТИВНІ НАВЧАЛЬНІ СЕРЕДОВИЩА У ФІЗИЧНОМУ ВИХОВАННІ

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Реферат. Стаття: 6 с., 8 табл., 1 рис., 26 джерел.

Історія питання. Фізичне виховання (ФВ) визнане важливим ученими в усьому світі. У цьому зв'язку вони шукали методи покращення викладання та навчання ФВ. Існують різні способи, які можна використовувати для покращення викладання та навчання ФВ. Однак найефективнішим способом, визначеним у процесі наукових досліджень, є підхід до управління роботою на уроці. Крім того, через неналежну навчальну атмосферу на уроці вчителі ФВ були не в змозі регулювати заняття та вирішувати проблеми з дисципліною учнів.

Мета дослідження. Таким чином, метою цього дослідження є вивчення впливу практичних підходів до управління роботою на уроці на навчальне середовище.

Матеріали та методи. Для збору даних було проведено опитування 359 вчителів старших класів середньої школи в Індонезії з використанням анкети «Методи управління роботою на уроці» та анкети «Самооцінка ефективності викладання на заняттях із ФВ».

Результати. Результати показали, що попереджувальні та коригувальні методи мають значний вплив на навчальне середовище. При цьому підтримувальний підхід не має помітного впливу на навчальне середовище. Ці результати можуть допомогти таким представникам шкільної адміністрації, як директор і вчитель ФВ, у виборі належних стратегій управління роботою на уроці для вирішення проблем із поганою поведінкою.

Висновки. Отже, покращення та підтримання належного навчального середовища в середніх школах також сприяє процесу викладання та навчання та, відповідно, підвищує ефективність навчання учнів.

Ключові слова: управління роботою на уроці, фізичне виховання, навчальне середовище.

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ORIGINAL SCIENTIFIC ARTICLE

INTEGRAL ASSESSMENT OF THE TECHNICAL AND TACTICAL ACTIVITY OF A HIGHLY QUALIFIED FOOTBALL TEAM

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Abstract

The study purpose was to carry out a comparative analysis of special indicators of the integral assessment of the technical and tactical football activity of the national team of Ukraine and national teams of various European countries.

Materials and methods. The study included pedagogical observation and video recording of the competitive activity of highly qualified football players of the national team of Ukraine and national teams of European countries within the framework of the 2021 (2020) European Football Championship. In total, the Ukrainian team played 5 matches at the European Championship. The integral assessment reflects the quantitative (coefficients of intensity, mobility, aggressiveness) and qualitative (coefficients of effectiveness, efficiency of single combat, creativity) indicators of the technical and tactical activity of the football team.

Results. In the course of the European Football Championship, the average value of the integral assessment of the technical and tactical activity of the Ukrainian team was 5.34 ± 0.24 points, which was not statistically different ($p=0.875$) from the indicator of the rival national teams, i.e. 5.36 ± 0.31 points. In the national team of Ukraine, in relation to the European champion of the national team of Italy, lower indicators were observed not only for the integral assessment – by 1.09 points (16.6%), but also for almost all specific indicators: for intensity coefficient – by 0.36 points (26.9%), for mobility coefficient – by 0.49 points (21.6%), for aggressiveness coefficient – by 0.14 points (15.5%), for effectiveness coefficient – by 0.02 points (2.3%), for creativity coefficient – by 0.12 points (25.0%).

Conclusions. The developed integrated assessment of the technical and tactical activity of a football team comprises six special coefficients: intensity coefficient, mobility coefficient, aggressiveness coefficient, effectiveness coefficient, coefficient of efficiency of single combat, and creativity coefficient. The established values of the specific coefficients of the integral assessment of the technical and tactical activity of the national football team of Ukraine can be considered as models and be the basis for correcting the training and competition processes.

Keywords: highly qualified football teams, European Football Championship, integral assessment of the technical and tactical activity.

Introduction

Intensification of competition among teams of different levels prompts the conduct of a large amount of scientific research aimed towards identification of the most significant

factors that determine the achievement of high sports results both on the national and international football arena. Due to this, control and analysis constitute integral components of the management of training and competitive activities of athletes as they are carried for the purpose of determining the effectiveness of the implementation of pedagogical influences planned by the coach (Bompa, Haff, 2009; Gerhard, 2009). Only on the basis of indicators of competitive activity, optimal corrections are introduced into the training process

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of athletes (Doroshenko, 2014; Doroshenko et al., 2019; Kostiukevych, Shchepotina, Vozniuk, 2020).

In team sports and namely in football, control and analysis of competitive activity has specific features, which, first of all, is due to the large volume of competitive actions and the multi-vector nature of the technical and tactical skill of athletes (Solovey et al., 2020; Oliinyk et al., 2021; Bezmylov et al., 2022). Therefore, there arises a problem of comprehensive analysis of the competitive activity of athletes in these sports. The analysis of special scientific literature made it possible to establish that the problem of control and analysis of competitive activity was studied by scientists in volleyball (Doroshenko, 2013; Shchepotina, 2015; Oliinyk et al., 2021), basketball (Mitova, Sidorenko, 2015; Vozniuk et al., 2020; Doroshenko et al., 2020), handball (Tyshchenko et al., 2019; Solovey et al., 2020), football (Bangsbo, Peitersen, 2000; Sarmiento et al., 2014; Kostiukevych, Lazarenko, Shchepotina, Poseletska et al., 2019), field hockey (White, MacFarlane, 2015; Kostyukevich, Konnov, 2021; Kostiukevych, Lazarenko, Shchepotina, Vozniuk et al., 2021) and in other sports.

One should note that general principles of control of competitive activity in team sports were developed by Mitova with co-authors (2015, 2019, 2020). One of the scientific and methodical approaches to control and analysis of the competitive activity of athletes in team sports is the integral assessment of the technical and tactical activity of both players and teams (Shchepotina, 2015; Vozniuk et al., 2020; Konnov, 2021). As for the determination of the integral assessment of the technical and tactical activity of athletes of team sports, the subject of scientific research of this problem was the research conducted by M. Bezmylov (2015), S. Konnov (2021), V. Kostiukevych with co-authors (2020, 2021).

Thus, taking into account the importance of determining the indicators that characterize the specificity and versatility of the game, reflect the quantitative and qualitative indicators of the technical and tactical activity of the players, the problem of analyzing the competitive activity of highly qualified athletes in football on the basis of an integral assessment, including in the overall team aspect, remains relevant.

Research hypothesis: it was assumed that the analysis of special indicators of the integral assessment of the technical and tactical activity of the national team of Ukraine and the national teams of various European countries will allow to determine the direction for correction of the training process of highly qualified football teams and will create prerequisites for effective management of training of players.

The purpose of the research was to carry out a comparative analysis of special indicators of the integral assessment of the technical and tactical football activity of the national team of Ukraine and the national teams of various European countries.

Material and methodology

Participants

The study included pedagogical observation and video recording of the competitive activity of highly qualified football players of the national team of Ukraine and national teams of European countries within the framework of the 2021 (2020) European Football Championship. In total, the Ukrainian team at the European Championship played

5 matches against the teams of the Netherlands (2:3), North Macedonia (2:1), Austria (0:1), England (0:4), Sweden (2:1). Such results allowed the Ukrainian team to become of the eight best teams in Europe. The study was approved by the ethics committee of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University and all procedures were in compliance with the Declaration of Helsinki.

Research organization

The study was conducted during the 2021 (2020) European Football Championship. The competitive activity of the national team of Ukraine and national teams of various European countries was analyzed based on the methodical approach of V.M. Kostiukevych (Kostiukevych, Shchepotina, Shynkaruk et al., 2020; Kostiukevych, Lazarenko, Shchepotina, Vozniuk et al., 2021). According to the outlined approach, in the process of pedagogical observation of filmed video materials of football matches, all technical and tactical actions (TTA) of the players were recorded on specially developed forms while taking into account the coordination complexity. In particular, the 1st mode of coordination complexity (MCC) included TTA performed on the spot or at a convenient speed of movement. TTA performed on the move with a limitation in space and time belonged to the 2nd MCC. Execution of TTA in conditions of active interference by the opponent (single combat) were registered as TTA of the 3rd MCC.

In addition, ball passes were regarded as holding, developing and aggravating ones. That is, they characterized the football team's tactical moves – possession of the ball, development of the attack, escalation of offensive actions.

The integral assessment reflects the quantitative and qualitative indicators of the technical and tactical activity of the football team, and the method of its determination is presented in detail in previous studies (Kostiukevych, Shchepotina, Shynkaruk et al., 2020; Kostiukevych, Lazarenko, Shchepotina, Vozniuk et al., 2021; Shchepotina et al., 2021). And namely, quantitative specific indicators: intensity coefficient (IC) reflects the active TTA of the team during the match; mobility coefficient (MC) characterizes the dynamics of the team's game, the tempo of the game; aggressiveness coefficient (AC) is an indicator of the team's participation in single combat, as well as final offensive actions. Qualitative specific indicators: effectiveness coefficient (EC) is an indicator of the effectiveness of all TTA of the team during the match (half); coefficient of efficiency of single combat (CESC) reflects the effectiveness of team players' participation in martial arts; creativity coefficient (CC) determines the level of creative TTA of the team (fig. 1).

Statistical analysis

Descriptive statistics were used for mathematical processing of research results. Indicators characterizing the sample of objects were determined – mean value (M), standard deviation (SD), coefficient of variation (V, %). The parametric Student's t-test was used to determine the statistical reliability of the difference between the studied indicators of football teams. The difference between indicators was considered reliable at the significance levels $p < 0.05$ and $p < 0.01$. The sample was previously checked for normal distribution

$$1. \text{ The intensity coefficient (IC): } IC = \frac{\sum_{i=1}^n TTA}{t}, (1)$$

where: $\sum_{i=1}^n TTA$ – total amount of technical and tactical actions;

$$2. \text{ The mobility coefficient (MC): } MC = \frac{\sum_{i=1}^n TTA(2nd \text{ MCC} + 3rd \text{ MCC})}{t} \times 2, (2)$$

where: $\sum_{i=1}^n TTA(2nd \text{ MCC} + 3rd \text{ MCC})$ – total amount of technical and tactical actions performed by players in the second and third modes of coordination complexity;

2 – indicator of coordination complexity.

$$3. \text{ The aggressiveness coefficient (AC): } AC = \frac{\sum_{i=1}^n TTA(3rd \text{ MCC})}{t} \times 3, (3)$$

where: $\sum_{i=1}^n TTA(3rd \text{ MCC})$ – total amount of technical and tactical actions performed by players in the third mode of coordination complexity;

3 – indicator of coordination complexity.

$$4. \text{ The effectiveness coefficient (EC): } EC = \frac{\sum_{i=1}^n preciseTTA}{\sum_{i=1}^n allTTA}, (4)$$

where: $\sum_{i=1}^n preciseTTA$ – total amount of precise technical and tactical actions performed by players;

$\sum_{i=1}^n allTTA$ – total amount of all technical and tactical actions performed by players.

5. The coefficient of efficiency of single combat (CESC):

$$CESC = \frac{\sum_{i=1}^n preciseTTA(stops, holds, tackings, dummies, performed in 3rd \text{ MCC})}{\sum_{i=1}^n allTTA(stops, holds, tackings, dummies, performed in 3rd \text{ MCC})}, (5)$$

where: $\sum_{i=1}^n preciseTTA(stops, holds, tackings, dummies, performed in 3rd \text{ MCC})$ – total amount of precise technical and tactical actions performed by players in the third mode of coordination complexity;

$\sum_{i=1}^n allTTA(stops, holds, tackings, dummies, performed in 3rd \text{ MCC})$ – total amount of all technical and tactical actions performed by players in the third mode of coordination complexity.

6. The creativity coefficient (CC):

$$CC = \frac{\sum_{i=1}^n preciseTTA(DP \times 1 + SP \times 2 + GP \times 5 + GK \times 5 + G \times 10)}{t}, (6)$$

where: DP – developing passes; SP – sharpening passes; GP – goal passes; GK – goal kicks; G – goals.

7. The integral assessment (IA) was determined by the sum of six specific indicators and was one of the criteria for creating an athletes' rating: $IA = IC + MC + AC + EC + CESC + CC$ (7)

Development of protocols for pedagogical observation of the competitive activity of players was carried out on the basis of mathematical statistics.

Fig. 1 Qualitative specific indicators: effectiveness coefficient (EC) is an indicator of the effectiveness of all TTA of the team during the match (half); coefficient of efficiency of single combat (CESC) reflects the effectiveness of team players' participation in martial arts; creativity coefficient (CC) determines the level of creative TTA of the team

of results using the Shapiro-Wilk test. Mathematical processing of the research results was carried out using the "Data Analysis" package of the MS Office Excel software as well as using the Statistica program (Albert et al., 2017; Lopatiev et al., 2017; Byshevets, Denysova et al., 2019; Kostiukevych, Shchepotina, Shynkaruk et al., 2020).

Results

In order to achieve the goal of the study, the indicators of the technical and tactical activity of the national team of Ukraine were determined and they were compared with the TTA indicators of other national teams at the 2021 (2020) European Football Championship.

The indicators and structure of the technical and tactical activity of the Ukrainian team at the 2020 (2021) European Football Championship are presented in the table 1.

The indicators of the technical and tactical activity of the national football team of Ukraine can be considered as a model for a high level of competition. In general, during the European Championship, the national team of Ukraine performed ($M \pm SD$) 901.0 ± 60.94 TTA with a coefficient of variation of 6.8 %.

A fairly low coefficient of variation fully characterizes the stable level of skill of the players of the national team of Ukraine. This is also evidenced by the performance indicator of TTA by the Ukrainian team – 0.85 ± 0.02 with a coefficient of variation of 2.5 %.

From the table 1, it can be seen that the greatest efficiency is observed when performing such technical techniques as stopping and holding passes of the ball in the 1st MCC – 1.0, dribbling the ball – 0.99 ± 0.02 , holding passes of the ball in the 2nd MCC – 0.99 ± 0.01 , developing passes of the ball in the 1st MCC – 0.96 ± 0.03 .

Table 1. Indicators and structure of technical and tactical actions of the national team of Ukraine at the 2020 (2021) European Football Championship (n=5)

Technical and tactical actions		Indicators										Distribution, % (quantity)	
		Quantity					Quality						
		M	SD	max	min	V, %	M	SD	max	min	V, %		
Stops	1 MCC	34.0	21.4	63	13	63.1	1.0	–	–	–	–	13.4	22.2 (254.2)
	2 MCC	180.0	35.19	222	140	19.6	0.99	0.01	0.99	0.98	0.43	70.8	
	3 MCC	40.2	0.75	56	32	1.8	0.74	0.09	0.84	0.63	12.2	15.8	
Ball passes	holding 1 MCC	19.0	12.01	35	7	63.2	1.0	–	–	–	–	16.8	113.0
	2 MCC	84.6	29.61	124	55	35.0	0.99	0.01	1.00	0.98	0.9	74.9	
	3 MCC	9.4	3.86	14	5	41.1	0.88	0.09	1.00	0.80	9.8	8.3	
	developing 1 MCC	35.8	15.87	55	18	44.4	0.96	0.03	1.00	0.92	0.1	13.3	44,8 (403.8)
	2 MCC	21.4	21.33	242	193	9.9	0.87	0.04	0.91	0.82	4.4	78.6	
	3 MCC	21.6	16.31	48	10	75.5	0.64	0.26	1.00	0.39	40.9	8.1	
	aggravating 1 MCC	4.0	2.57	7	1	64.4	0.69	0.26	1.00	0.40	37.3	18.2	(22.0)
	2 MCC	15.8	5.57	22	9	35.3	0.50	0.13	0.68	0.37	26.6	71.8	
	3 MCC	2.2	1.72	4	1	78.0	0.56	0.26	1.00	0.33	51.3	10.0	
Leading the ball		48.6	1.29	52	45	2.6	0.99	0.02	1.00	0.96	1.7	5.4	
Dribbling the ball		43.2	7.72	51	33	17.8	0.78	0.08	0.89	0.69	11.0	4.8	
Tackling the ball		66.2	15.88	82	45	23.9	0.46	0.04	0.51	0.42	8.4	7.5	
Interception	1 MCC	1.00	–	–	–	–	1.00	–	–	–	–	1.3	8.6 (77.4)
	2 MCC	42.8	4.72	55	34	11.0	0.70	0.03	0.89	0.83	3.6	55.3	
	3 MCC	33.6	11.59	48	21	34.4	0.52	0.17	0.69	0.29	33.0	43.4	
Shots on goal	From the game	64	3.43	10	2	53.6	0.54	0.28	1.00	0.33	53.2	84.2	0.7 (7.6)
	SP	1.2	–	–	–	–	0.60	–	–	–	–	15.8	
Number of TTA		901.0	60.94	951	809	68	0.85	0.02	0.88	0.83	2.5		
Single combat		218.2	45.49	273	167	20.8	0.57	0.04	0.65	0.55	75.5	24.2	
EC		–	–	–	–	0.85	0.02	0.88	0.83	0.83	2.5		
Specific indicators	IC	0.98	0.07	1.06	0.89	7.1							
	MC	1.78	0.13	1.90	1.59	7.3							
	AC	0.76	0.15	0.91	0.56	19.7							
	EC						0.85	0.02	0.88	0.83	2.5		
	CESC						0.61	0.04	0.65	0.55	6.6		
	CC						0.36	0.05	0.41	0.29	13.8		
	IA	5.34	0.24	5.60	5.03	4.2							

Notes: MCC – mode of coordination complexity; SP – standard provisions; TTA – technical and tactical actions; IC – intensity coefficient; MC – mobility coefficient; AC – aggressiveness coefficient; EC – effectiveness coefficient; CESC – coefficient of efficiency of single combat; CC – creativity coefficient; IA – integral assessment

Table 2. Indicators of integral assessment of technical and tactical activity (in one half) of the national team of Ukraine (n=10) and rival teams (n=10) at the 2021 (2020) European Football Championship

Specific indicators of technical and tactical activity	National team of Ukraine		National teams of Europe		ΔM (%)	t	p
	M	SD	M	SD			
Intensity coefficient, points	0.98	0.07	1.04	0.08	0.06 (5.8)	1.79	0.089
Mobility coefficient, points	1.78	0.13	1.74	0.32	0.04 (2.3)	0.36	0.722
Aggressiveness coefficient, points	0.76	0.15	0.55	0.16	0.21 (38.2)	3.03	0.007*
Effectiveness coefficient, points	0.85	0.02	0.91	0.03	0.06 (6.6)	9.00	0.000*
Coefficient of efficiency of single combat, points	0.61	0.04	0.74	0.03	0.13 (17.6)	8.22	0.000*
Creativity coefficient, points	0.36	0.05	0.38	0.04	0.02 (5.3)	1.00	0.329
Integral assessment, points	5.34	0.24	5.36	0.31	0.02 (0.4)	0.16	0.875

Notes: * – statistically significant difference at the level of significance $p < 0.01$

The lowest performance indicators of TTA were registered when hitting the goal from the game, i.e. 0.54 ± 0.28 , and from standard positions, i.e. 0.60, as well as when taking the ball, i.e. 0.46 ± 0.04 and aggravating passes of the ball in the 2nd MCC, i.e. 0.50 ± 0.13 , and in the 3rd MCC, i.e. 0.56 ± 0.26 .

The average value of the integral assessment (IA) of the national team of Ukraine at the 2020 (2021) European Football Championship was 5.34 ± 0.24 points. The structure of the integral assessment of the technical and tactical activity of the national team of Ukraine is presented in fig. 1. The highest values in the structure of the integral assessment of the TTA of the Ukrainian team were for MC – 33.5 % and IC – 19.0 %, the lowest – for CC – 6.6 %.

One of the tasks of the study was to compare the indicators of the integral assessment of the national team of Ukraine and rival teams (Table 2).

In the course of the European Football Championship, the average value of the IA TTA of the Ukrainian team was 5.34 ± 0.24 points, which was statistically not different ($p = 0.875$) from the average value of the IA of the TTA of the rival national teams, i.e. 5.36 ± 0.31 points.

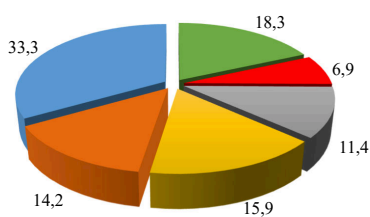


Fig. 1. The structure of the integral assessment of the technical and tactical activity of the national team of Ukraine at the 2021 (2020) European Football Championship, % was the following: ■ – intensity coefficient; ■ – mobility coefficient; ■ – aggressiveness coefficient; ■ – effectiveness coefficient; ■ – coefficient of efficiency of single combat; ■ – creativity coefficient

In the course of the European Football Championship, the average value of the IA of the TTA of the Ukrainian team was 5.34 ± 0.24 points, which was statistically not different ($p = 0.875$) from the average value of the IA of the TTA of the rival national teams, i.e. 5.36 ± 0.31 points.

It is always important to compare the values obtained in the study with the corresponding values of the champion. The national football team of Italy became the 2021 (2020) European football champion.

Table 3 represents the indicators of the IA of the TTA of the national team of Ukraine and the national team of Italy.

The national team of Italy has greater values not only for the integral assessment of the TTA by 1.09 points (16.6 %), but also for almost all specific indicators of the integral assessment. In particular, in the national team of Ukraine, in relation to the European champion of the national team of Italy, lower indicators are observed for IC – by 0.36 points (26.9 %), for MC – by 0.49 points (21.6 %), for AC – by 0.14 points (15.5 %), for EC – by 0.02 points (2.3 %), for CC – by 0.12 points (25.0 %). That is, in order for the national football team of Ukraine to reach the finals of the European

Table 3. Indicators of the integral assessment of the technical and tactical activity of the national team of Ukraine (average values) and the national team of Italy (final match) at the 2021 (2020) European Football Championship

National teams	Specific coefficients						
	IC	MC	AC	EC	CESC	CC	IA
Ukraine (n=5)	0.98	1.78	0.76	0.85	0.61	0.36	5.34
Italy	1.34	2.27	0.90	0.87	0.57	0.48	6.43

Notes: IC – intensity coefficient; MC – mobility coefficient; AC – aggressiveness coefficient; EC – effectiveness coefficient; CESC – coefficient of efficiency of single combat; CC – creativity coefficient; IA – integral assessment

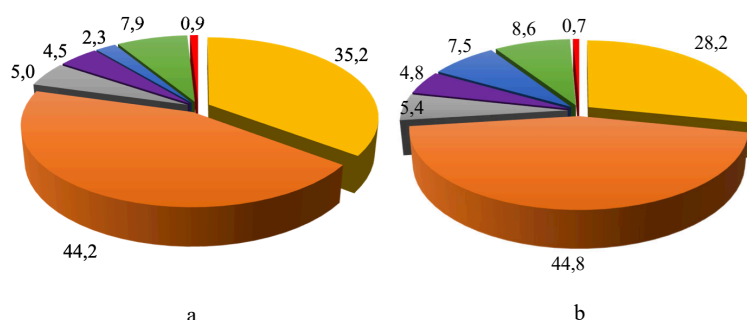


Fig. 2. The structure of the technical and tactical activity of the European national football teams: a – the Italian national team, b – the national team of Ukraine, %: ■ – stops; ■ – passes; ■ – leading; ■ – dribbling; ■ – tackles; ■ – interception; ■ – shots on goal

Championship, it is necessary to fully focus on the meaning of the IA of the TTA of the Italian national team.

If we consider the structure of the technical and tactical activity of the national teams of Italy (Fig. 2 a) and Ukraine (Fig. 2 b), then the advantage of the Italian national team over the national team of Ukraine in the execution of TTA which are performed in the ball possession phase is observed. In the Italian national team, passes, stops, leads, dribbles and shots on goal were 88.9 %. In the national team of Ukraine, these TTAs amounted to 84.0 %. Therefore, the game of the national team of Ukraine should be aimed at greater control of the ball.

It can be noted that focusing on the indicators of the Italian national team in one game cannot reflect the objective nature of the analysis.

Discussion

Summarizing the results of previous studies allows us to note that team management in competitive sports is one of the most difficult problems of coaching (Doroshenko, 2013; Mitova, Sidorenko, 2015; Tyshchenko et al., 2019). This is largely determined by the objective difficulties of operational control. At the same time, urgent objective information about the quantitative and qualitative characteristics of the players' competitive activity creates prerequisites for effective operational management of a football team.

Discussion matters in this article concern selected methods of scientific research as well as interpretation of the obtained results.

As for the methods of study of the outlined problem, it is worth noting that the analysis of the competitive activity of athletes of team game sports and football, in particular, based on the integral assessment of technical and tactical activity, is one of the most objective. First of all, this is due to taking into account not only all technical and tactical actions (stops, passes, dribbling, passing, tackles, interceptions, shots on goal) performed in the game, but also their coordination complexity. That is, the performance of each technical and tactical action is registered in three modes of coordination complexity. This allows form making objective adjustments to the structure and content of the training pro-

cess of athletes. For example, the predominant performance of technical and tactical exercises in the third mode of coordination complexity, especially aimed at improving such game techniques as passing, interception as well as tackles contributes to increasing the level of sportsmanship of football players. All these game techniques belong to the group of single combats, and, as a rule, a greater number of single combats won by the opposing team allows to achieve a winning result (Doroshenko, 2014; Kostiukevych, Shchepotina, Vozniuk, 2020).

The method of integral assessment of the competitive activity of athletes in team game sports was reflected in the results of previous studies and was tested in the practice of training teams in basketball (Vozniuk et al., 2020), volleyball (Shchepotina, 2015), field hockey (Kononov, 2021), mini-football (Leibo et al., 2021), where its objectivity was confirmed.

The disadvantage of this method of analyzing the competitive activity of football teams is the calculation of indicators of the motor activity of the players (Kostiukevych, Lazarenko, Shchepotina, Vozniuk et al., 2021). This is possible when using such specialized programs for monitoring competitive activity in sports games as Sports Code, GAME BREAKER Plus, Sports Code PRO, Sports Code ELITE, etc.

As for the interpretation of the obtained results, in general, in accordance with the formulated hypothesis of the study, it was assumed that the definition of an integral assessment of technical and tactical activity will allow to outline the directions of correction of the training process of highly qualified football teams.

The integral assessment reflects the technical and tactical preparedness of the players, therefore, the higher its value, the higher the team's sporting result can be. According to the indicator of the integral assessment of technical and tactical activity, the game of the national team of Ukraine corresponded to the development trends of European football (Bangsbo, Peitersen, 2000; Doroshenko, 2014). The greater value of the coefficient of aggressiveness of the national team of Ukraine in relation to rival teams can be viewed from a positive point of view. The negative difference between the values of the coefficient of effectiveness and the coefficient of efficiency of single combat determines the directions of

training work which should be aimed at increasing the level of performance of technical and tactical actions by the players of the national team of Ukraine.

Focus on the champion can be considered as a guide in the indicators of technical and tactical activity of national teams (Doroshenko et al., 2019; Solovey, Mitova, Solovey et al., 2020; Kostiukevych, Shchepotina, Vozniuk, 2020), including the national football team of Ukraine. There is an advantage of the 2021 (2020) European champion of the national team of Italy over the national team of Ukraine when performing technical and tactical actions performed in the ball possession phase. Therefore, the game of the national team of Ukraine should be aimed at greater control of the ball.

In general, the conducted study expanded the methodological approaches to the control of the competitive activity of athletes in team game sports (Doroshenko, 2013; Shchepotina, 2015; Oliinyk et al., 2021), including on the basis of an integral assessment of their technical and tactical activity (Vozniuk et al., 2020; Konnov, 2021; Kostiukevych, Lazarenko, Shchepotina, Vozniuk et al., 2021).

Conclusions

1. Control and analysis of competitive activity is a key link in the general system of training athletes. There is an integral assessment of technical and tactical activity for objective control of the competitive activity of athletes in team game sports.

2. The developed integrated assessment of technical and tactical activity consists of six special coefficients – intensity coefficient, mobility coefficient, aggressiveness coefficient, efficiency coefficient, coefficient of efficiency of single combat, creativity coefficient. Each of these coefficients reflects the main aspects of the football team's game.

3. The following indicators of the integral assessment of the technical and tactical activity of the national team of Ukraine at the 2021 (2020) European Football Championship were determined: intensity coefficient - 0.98 ± 0.07 points; mobility coefficient – 1.78 ± 0.13 points; aggressiveness coefficient – 0.76 ± 0.15 points; efficiency coefficient – 0.85 ± 0.02 points; coefficient of efficiency of single combat - 0.61 ± 0.04 points; creativity coefficient - 0.36 ± 0.05 points; integrated assessment – 5.34 ± 0.24 points. The established values of the specific coefficients of the integral assessment of the technical and tactical activity of the national football team of Ukraine can be considered as models and be the basis for correcting the training and competition processes.

The perspective of further studies of the specified problem will be determined by the development of models of technical and tactical activity of highly qualified football players of various playing roles based on an integral assessment of technical and tactical activity.

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Conflict of interests

The authors state that there is no conflict of interests.

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ІНТЕГРАЛЬНА ОЦІНКА ТЕХНІКО-ТАКТИЧНОЇ ДІЯЛЬНОСТІ ФУТБОЛЬНОЇ КОМАНДИ ВИСОКОЇ КВАЛІФІКАЦІЇ

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Реферат. Стаття: 9 с., 3 табл., 3 рис., 31 джерело.

Мета дослідження – здійснити порівняльний аналіз спеціальних показників інтегральної оцінки техніко-тактичної діяльності з футболу національної збірної команди України та національних збірних команд різних європейських країн.

Матеріал і методи. Дослідження передбачало педагогічне спостереження та відеозйомку змагальної діяльності футболістів високої кваліфікації національної збірної команди України та національних збірних команд європейських країн у рамках Чемпіонату Європи з футболу 2021 (2020) року. Усього команда України на чемпіонаті Європи провела 5 матчів. Інтегральна оцінка відображає кількісні (коефіцієнти інтенсивності, мобільності, агресивності) та якісні (коефіцієнти ефективності, ефективності однокористувачів, креативності) показники техніко-тактичної діяльності футбольної команди.

Результати. У процесі чемпіонату Європи з футболу середнє значення інтегральної оцінки техніко-тактичної діяльності команди України було $5,34 \pm 0,24$ бали, що статистично не відрізнялося ($p=0,875$) від показника збірних команд-суперників – $5,36 \pm 0,31$ бали. У збірній команді України по відношенню до чемпіона Європи збірної команди Італії спостерігаються нижчі показники не лише за загальною інтегральною оцінкою на 1,09 бала (16,6 %), а також майже за всіма специфічними показниками: за коефіцієнтом інтенсивності – на 0,36 бали (26,9 %), за коефіцієнтом мобільності – на 0,49 бали (21,6 %), за коефіцієнтом агресивності – на 0,14 бали (15,5 %), за коефіцієнтом ефективності – на 0,02 бали (2,3 %), за коефіцієнтом креативності – на 0,12 бали (25,0 %).

Висновки. Розроблена інтегральна оцінка техніко-тактичної діяльності футбольної команди складається з шести спеціальних коефіцієнтів – інтенсивності, мобільності, агресивності, ефективності, ефективності єдиноборств, креативності. Встановлені значення специфічних коефіцієнтів інтегральної оцінки техніко-тактичної діяльності національної збірної команди України з футболу можуть розглядатися як модельні і бути підґрунтям для корекції тренувального та змагального процесів.

Ключові слова: футбольні команди високої кваліфікації, чемпіонат Європи з футболу, інтегральна оцінка техніко-тактичної діяльності.

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ORIGINAL SCIENTIFIC ARTICLE

THE CORRELATION BETWEEN THE LEVEL OF HEALTH-IMPROVING AND RECREATIONAL PHYSICAL ACTIVITY AND FAMILY WELL-BEING

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Abstract

Study purpose. The purpose of the study was to assess the correlation between the level of health-improving and recreational physical activity and family well-being.

Materials and methods. Theoretical analysis of data from special scientific and methodological literature, generalization, systematization, sociological methods, and mathematical statistics. A research among parents was conducted using online surveying through completing an online questionnaire created with Google Forms. The study involved 106 married couples. The average age of the respondents was 35.1 ± 4.2 years. The vast majority of the studied families (95.1%) had up to two children (preschool and school age).

Results. The respondents were divided into two clusters according to their level of motor activity. Cluster 1 included families with a low level of physical activity, and cluster 2 included those with an average level of physical activity. Depending on the level of physical activity, statistically significant ($p < 0.05$) differences were found between the families in terms of the following parameters: motivations for engaging in active leisure, amount of leisure time, level of knowledge and skills in organizing active leisure, reasons preventing participation in active leisure, etc. The families differed significantly ($p < 0.05$) in 23 categorical parameters. It was found that the families with different levels of physical activity did not differ in their desire to engage in winter recreational activities. Reasons preventing participation in health-enhancing and recreational physical activity programs were identified. A comparative analysis of the current state of family well-being revealed statistically significant ($p < 0.05$) differences in all studied parameters between the families with different levels of physical activity, i.e. the families with a proper level of physical activity had higher scores of satisfaction, well-being, and quality of life. Low indicators of family well-being indicated the rationale for such families to engage in active recreation and increase their level of health-enhancing and recreational physical activity.

Conclusions. A relationship was identified between the level of health-enhancing and recreational physical activity and indicators of satisfaction, family well-being, and quality of life.

Keywords: active leisure, family satisfaction, quality of family life, winter recreation.

Introduction

One of the most important issues of the modern family is the organization of its leisure which includes active family leisure time (Currie, 2012). By leisure, scientists mean the

ability of an individual to satisfy their interests in the use of free time related to recreation, self-development, health-improving, education, communication, etc. Modern society is oriented towards organized leisure. The search for new approaches in working with families regarding the introduction of various health-improving and recreational technologies into the practice of family leisure is extremely relevant (Yelizarova et al., 2020a). Today in the world and Ukraine,

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in connection with the increase in the need for the organization of active leisure, the industry of entertainment and recreation is developing at a rapid pace (Ustian, 2019). The entertainment industry has become one of the most important areas of society's everyday life. A significant number of scientists have devoted their research to the issue of the development of the entertainment and recreation industry using the means of health-improving and recreational physical activity (HRPA) (Bakiko et al., 2022; Grygus, 2017; Krutsevich et al., 2019). The results of modern scientific research demonstrate numerous advantages of using active leisure for the integral development of the emotional, cognitive, physical, and social abilities of young people (Freire, 2018; Rodríguez, 2018). It has been confirmed that organized leisure brings more benefits than unorganized one (Monteagudo et al., 2017). The impact of active family leisure on the level of satisfaction and quality of life has been revealed (De Neve et al., 2013; Zabriskie et al., 2018). It has been confirmed that the family is a privileged environment for the development of children's leisure (Stodolska et al., 2020; Valdemoros et al., 2014). Joint family leisure time benefits family functioning (Agate et al., 2009; Sanz et al., 2018). Scientists have established that active family leisure significantly affects the psychological climate, as well as the emotional background and social activity of the family (Burns et al., 2022). The scientific interest of modern researchers is focused on establishing the connection between psychological well-being and the state of physical health, level of material well-being, education, social status, age, gender, etc (Mandolesi et al., 2018; Taylor et al., 2012). Numerous researches demonstrate that internal factors of the psychological well-being of a person (e.g., contentment, joy, and desire to be active) are associated with maintaining an appropriate level of physical activity (Bogantes et al., 2021; Mahlovany et al., 2021). Thus, it is noted that the level of life satisfaction was higher among the students who took part in health-improving activities for a longer period and more often than others. Researchers have identified a positive correlation between family leisure and family outcomes (solidarity, adaptability, family functioning, and satisfaction with family life) in a multinational sampling. At the same time, the assessment of the connection between the level of HRP and family well-being has not been the subject of scientific research which determines the relevance of the research in this direction.

Material & methods

Study participants

The research involved 106 families; most of them had been married for more than 12 years. The average age of parents was 35.1 ± 4.2 years. 95.3% of surveyed families had 1 or 2 children. All participants of the survey were informed in detail about the purpose and tasks of the research and indicated their voluntary consent to participate in the research.

Study organization

The research among parents was conducted using online surveying through completing an online questionnaire created with Google forms. The link to the questionnaire was distributed through social networks (Facebook, Instagram) and other available online resources (Viber, Telegram mes-

sengers). In total, the questionnaire contained 74 questions, among which 38 questions suggested receiving textual information, and the rest – numeric data.

Statistical analysis

To analyze the reliability of the questionnaire «Family leisure» offered to the participants, the Cronbach's alpha was used, the basis of which is the ratio of the variances of each individual question to the variance of the total scale. If not the real value but the random error in the answers to the questions is measured, then the variance of the sum will be the same as the sum of the variances of the individual items, so the value of the coefficient will approach zero. Cronbach's alpha was 0.92, and the standardized coefficient was 0.898, that is, it was close to 1 which indicates the high reliability of the questionnaire. The questions that suggested receiving answers in text form were considered separately. In order to assess the representativeness of the sample, the entire set of responses was randomly divided into equal parts, after which Kendall's τ coefficient was calculated. It should be noted that the aforementioned correlation coefficient was calculated for the questions suggesting receiving unambiguous answers. The calculations showed that for all questions the coefficient approached one ($\tau > 0.64$) and was statistically significant ($p < 0.05$). A comparative analysis between categorical variables was carried out using the Pearson's chi-squared test χ^2 . Regarding continuous variables, F-test was used for a comparative analysis. For a comparative analysis of indicators of the current state of well-being of families, depending on the cluster, average ranks of indicators r were calculated and Kruskal–Wallis H test was used. The figure $\alpha = 0.05$ was taken as the level of statistical significance. At the same time, the article gives the exact values of the p-level, and in the case when its value was less than 0.0001, it was noted that $p < 0.01$. Statistical processing of raw data was carried out with the use of the computer program Statistica 10.0 and its additional module Data Mining. In the course of the research clustering was implemented through the use of Data Mining, with the help of which families with children were divided into clusters via the k-means clustering. Data Mining is an intellectual analysis of data, with the help of which artificial intelligence means based on the processing of input data reveal hidden patterns. Moreover, in this module the division of the set of input data into clusters was carried out automatically, and the decision on the number of clusters was taken using cross-validation, in particular V-fold cross-validation which allows selecting and evaluating the best solutions to the problem of clustering mission automatically. Therefore, having analyzed continuous and categorical variables (a total of 74 indicators, 36 of which are categorical variables), the respondents were divided into two clusters. Depending on the type of question, respondents were asked to choose one of the answers, several answers, or to rank the suggested answers in order of their importance. Data mining allows to analyze text data. This approach was used to analyze the answers to the questionnaire without prior coding.

Results

A comparative analysis of parents' answers using k-means clustering showed that the families that partici-

pated in the research were divided into two clusters. The centroids for clustering are presented in the figure (Fig. 1).

At the same time, 62.3% ($n = 66$) of families were included into Cluster 1 (families with a low level of physical activity), and the remaining 37.7% ($n = 40$) formed Cluster 2 (families with a medium level of physical activity). The responding families differ statistically significantly ($p < 0.05$) in terms of the age of the children, overweight of parents, lifestyle, sports activities in childhood, previous physical activity experience, the systematic character of health-improving physical activities together with their child/children, the awareness of how active family leisure affects the well-being of the family, the desire to devote more time to active rest, unhealthy habits of parents – in total, according to 23 categorical indicators. Depending on the cluster, parents prefer different types of active family leisure, have different skills to organize active family rest based on health-improving and recreational technologies, devote different amounts of time to active family rest, etc. (Table 1).

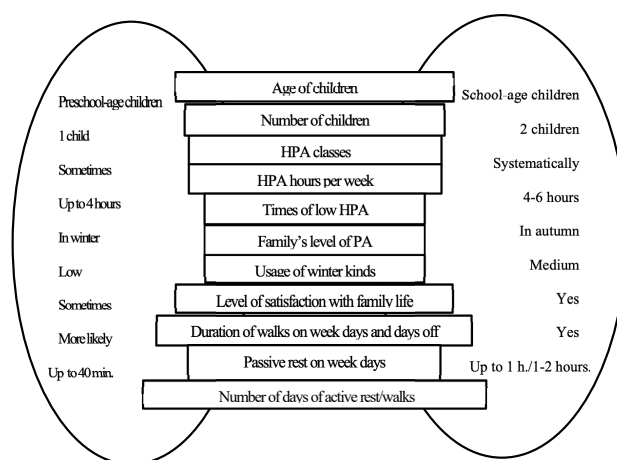


Fig. 1. The centroids for clustering respondents using k-means clustering

Table 1. A comparative analysis of parents' answers (nominal measurement scale), $n=106$

No.	Questionnaire questions supposing receiving text information	Statistical calculations		
		df	χ^2	p-level
1	Specify the period of your family life	2	4,36	0,1132
2	How many children do you have?	2	4,14	0,1259
3	What is the age of your children?	3	35,78*	0,0000
4	Do you have any chronic diseases?	3	9,88*	0,0196
5	Are you overweight?	3	4,98	0,1731
6	How can you describe the lifestyle of your family?	2	13,14*	0,0014
7	Did you go in for sports in your childhood?	3	12,12*	0,0070
8	Is your professional activity related to physical education and sports?	3	2,38	0,4976
9	Do you regularly engage in health-improving physical activities together with your child/children?	2	6,85*	0,0326
10	How much time per week do you usually devote to active family rest?	3	42,02*	0,0000
11	Do you know how to organize active family rest based on health-improving and recreational technologies?	2	0,71	0,6997
12	Do you know how active family rest impacts the family well-being?	2	2,31	0,3154
13	What kinds of active family leisure do you prefer?	43	81,48*	0,0004
14	What period during the year does your family have less active leisure?	3	35,19*	0,0000
15	Do you care about the state of health of your family members?	1	9,56*	0,0020
16	What measures do you take to preserve the health of your family members?	38	72,82*	0,0006
17	What prevents you from engaging in health-improving and recreational activities?	14	35,67*	0,0012
18	How do you assess the level of family well-being?	3	18,61*	0,0003
19	How do you assess the level of physical activity of your family members?	3	34,22*	0,0000
20	Would you like to expand your knowledge on organizing active leisure?	3	0,50	0,9188
21	How do you assess the level of satisfaction with your family leisure?	3	22,89*	0,0000
22	Do you use winter types of recreation in the organization of active leisure?	2	39,30*	0,0000
23	Would you like to use winter types of recreation in the organization of active leisure?	2	11,45*	0,0033
24	Would you like to devote more time to active recreation?	3	5,21	0,1572
25	Thinking about your family life do you feel satisfied?	3	7,17	0,0666
26	How much time do you usually devote to active family leisure on weekdays?	4	4,65	0,3256
27	How much time do you usually devote to active family leisure on days off?	4	13,81*	0,0079
28	How satisfied are you with the availability of places for active family leisure?	2	6,59*	0,0371
29	How important is joint active family leisure for your family?	2	2,66	0,2640
30	Do you have any unhealthy habits?	3	2,42	0,4906
31	How long do your walks usually last on working days?	4	12,74*	0,0126
32	How long do your walks usually last on days off?	4	18,49*	0,0010
33	How much time do your children usually spend passively resting on working days?	4	20,16*	0,0005
34	How much time do your children usually spend passively resting on days off?	4	6,00	0,1993
35	How do you usually spend time with your children?	50	95,12*	0,0001
36	Do you have children of school age?	1	8,15*	0,0043

Note. * – in the case of proven statistically significant difference between indicators at $p < 0.05$ where $df=n-1$ is the degrees of freedom, which are the number of answer options provided for a question in the questionnaire; χ^2 is the Pearson's chi-squared test, used for the analysis of contingency tables; p-value is the achieved significance level

Dividing families by the duration of recreational activities on days off made it possible to make sure that the majority of families of Cluster 2 (whose share was 87.5%) are involved in health-improving and recreational activities for more than 2 hours. At that time, Cluster 1 included 54.5% of such families. There have been revealed differences in dividing by the duration of family walks on weekdays with regard to clusters. Among the families of Cluster 1, there are 13.2% more those who do not take walks at all and 6.4% less of those who take walks for more than 2 hours on weekdays. At the same time, among them, 20.4% more families take walks with a duration of up to 40 minutes, and 23.8% less of those who walk in the fresh air on weekdays for over 40 minutes up to 1 hour. A comparative analysis of the dividing families by the duration of walks on days off showed that Cluster 1 included 27.2% more families that either do not take walks on days off at all, or their walks last up to 40 minutes. Among the families of Cluster 2, no family indicated that they do not have walks on days off or that their walks are short. In the course of the research, dividing of families according to the duration of passive recreation of their children was studied. It was found that Cluster 2 included the families in which 9.5% more children do not use passive recreation. Among the families of Cluster 1, there are 30.0% more families whose children have passive rest for 1-2 hours and 12.7% more of those whose passive rest lasts for more than 2 hours (Fig. 2).

The respondents differed in terms of separate evaluations of the motives for engaging in active leisure and the reasons that prevent them from it; evaluations of motives for engaging in winter recreation and the reasons limiting their opportunities; evaluations of the state of their families in the current period; the number of days per week when they engage in recreational activities on weekdays and days off, as well as the number of days per week when they engage in health-improving physical activity and take walks together with their children. It is worth emphasizing that regardless of the cluster, the ranks of motives for engaging in winter recreation of the families do not differ among themselves (Table 2). The research allowed establishing that, according to the cluster to which the family was assigned, there were found statistically significant ($p < 0.05$) differences between them in the following ranks: hardening, moving games and joint performance of physical exercise complexes as motives for engaging in active leisure time, lack of time, lack of interesting offers, a low level of quality of services provided by entertainment centers, limited budget, lack of knowledge and skills in organizing active leisure, and lack of desire to systematically engage in health-improving and recreational physical activity as reasons that prevent from engaging in active leisure, the results of ranking of reasons that prevent from engaging in winter recreation activities, self-assessment of the current state of the family according to all the studied indicators, as well as the number of days when the family was engaged in family recreation activities during the previous week and the number of days when the family went for a walk during the previous week.

The degree of family well-being was assessed with the selected parameters that reflect the family condition in the current period using a 10-point scale, where 0 is the worst condition and 10 is the highest degree of satisfaction. A comparative analysis of the current state of family well-being

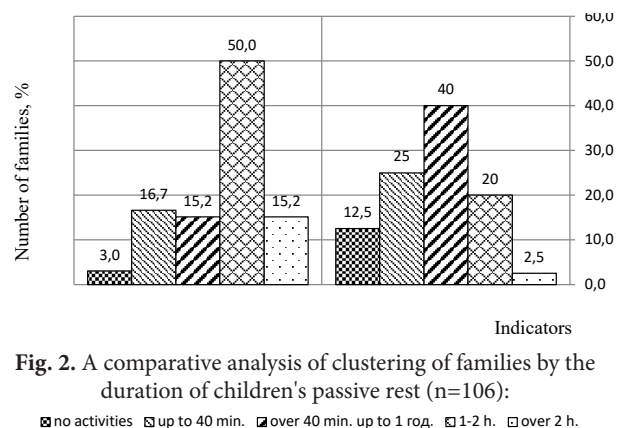


Fig. 2. A comparative analysis of clustering of families by the duration of children's passive rest (n=106):

no activities up to 40 min. over 40 min. up to 1 h. 1-2 h. over 2 h.

made it possible to establish that according to all studied indicators statistically significant ($p < 0.05$) differences can be observed in the families, and the families of Cluster 2 have higher evaluations of indicators (Table 3). Dividing families according to the level of family well-being showed that Cluster 2 included all families with a high level of current family well-being, and Cluster 1 consisted of families, among which 47.0% have high, 37.8% – medium, and 15.2% – low level. Obviously, families assigned to Cluster 1 have untapped potential for achieving family well-being through the use of active forms of leisure, in particular means of health-improving and recreational physical activity.

Discussion

The analysis of literature on the subject shows that despite the interest of scientists in increasing the level of family well-being and the search for the latest technologies to improve it, there are some contradictions between the complexity of properly organizing active family leisure and the lack of clearly defined connections with the components of family well-being; the urgent need to increase the levels of physical activity and family well-being and a lack of understanding of the factors affecting them (Agate et al., 2009; Alonso et al., 2019; Taylor et al., 2012). Rational planning of family leisure, taking into account the interests of all family members while choosing the kind of family leisure contribute to a high-grade rest and interesting spending of free time. Active rest associated with various health-improving and recreational activities is one of the constructive, socially approved, and personally useful types of leisure activities and recreation (Andrieieva et al., 2019; Galan et al., 2019, 2021; Yelizarova et al., 2020b). The importance of increasing the level of HRP in various population groups is indicated in the works of numerous authors (Drozdovska et al., 2020; Kashuba et al., 2021a,b). Besides, the value of using means of HRP to improve the quality and satisfaction with life is emphasized (Alonso et al., 2019; Hakman et al., 2020; Krutsevich et al., 2021). We have confirmed and expanded the results of the research on the correlation between family functioning and life satisfaction (Hodge et al., 2018; Williamson et al., 2019). Another result of this research was an increase in the level of family well-being and life satisfaction in the group with a higher level of participation in family health-improving and recreational activities. In the course of the research, families were divided according to the levels

Table 2. Comparative analysis of parents' answers (rank measurement scale), n=106

No.	Questionnaire questions supposing receiving numeric data (rank)	Statistical calculations			
		Intergroup variance (df=1)	Total variance (df=104)	F	p-level
1	regular health-improving and recreational physical activities	3,38	431,72	0,81	0,3692
2	visiting resorts/sanatoriums	5,57	369,49	1,57	0,2135
3	walks in the fresh air	12,02	399,91	3,13	0,0800
4	hardening	20,58	361,45	5,92*	0,0167
5	visiting entertainment centres	0,41	442,53	0,10	0,7560
6	moving games	16,58	352,93	4,89*	0,0293
7	joint performance of physical exercise complexes	33,11	361,04	9,54*	0,0026
8	lack of free time	70,19	483,93	15,08*	0,0002
9	lack of interesting offers	85,31	323,60	27,42*	0,0000
10	low level of quality of services provided by entertainment centres	25,17	362,91	7,21*	0,0084
11	limited budget	104,05	346,86	31,20*	0,0000
12	lack of knowledge and skills in organizing active leisure	52,20	362,37	14,98*	0,0002
13	lack of desire to systematically engage in health-improving and recreational physical activity	64,55	440,36	15,24*	0,0002
14	lack of reasons	15,49	561,05	2,87	0,0932
15	improvement of physical health of family members	1,00	341,00	0,31	0,5812
16	hardening of family members	4,68	358,77	1,36	0,2469
17	improvement of family well-being	0,01	380,72	0,00	0,9623
18	interesting and emotionally charged leisure	0,41	292,53	0,15	0,7023
19	common hobbies	0,49	363,85	0,14	0,7077
20	improving endurance and physical performance of family members	0,17	412,67	0,04	0,8350
21	improving mental performance	1,35	449,60	0,31	0,5779
22	lack of time	119,05	355,17	34,86*	0,0000
23	lack of interesting offers	81,65	309,76	27,41*	0,0000
24	low level of quality of services provided by entertainment centres	32,51	269,72	12,53*	0,0006
25	lack of knowledge	102,82	236,92	45,13*	0,0000
26	lack of skills in organizing active leisure	117,33	279,24	43,70*	0,0000
27	lack of opportunities to join organized leisure	99,70	343,90	30,15*	0,0000
28	lack of reasons	19,43	511,07	3,95*	0,0494
29	quality of family life	189,80	628,16	31,42*	0,0000
30	state of health of family members	139,68	549,72	26,43*	0,0000
31	psychological climate in the family	136,74	595,79	23,87*	0,0000
32	level of social well-being of the family	177,61	518,24	35,64*	0,0000
33	level of satisfaction with everyday family life	115,05	531,60	22,51*	0,0000
34	usual emotional background	122,13	637,73	19,92*	0,0000
35	level of mutual support of family members	153,03	784,63	20,28*	0,0000
36	social activity of the family	97,67	605,84	16,77*	0,0001
37	number of days when the family was engaged in family recreation activities	54,24	260,22	21,68*	0,0000
38	number of days when the family went for a walk	32,29	437,75	7,67*	0,0066

Note. * - in the case of proven statistically significant difference between indicators at $p < 0.05$ where $df=n-1$ is the degrees of freedom for the between group variance, which reflects character variation in each cluster of parents, and $df=n1+n2-2$ is the degrees of freedom for the total variance, which is calculated for the entire set of data; F is the Fisher's test; p-value is the achieved significance level

Table 3. Well-being of families depending on the level of physical activity

Indicators of the state of families in the current period	Low level of physical activity		Medium level of physical activity		Statistical calculations	
	Σr	r	Σr	r	H	p
quality of family life	2726,50	41,31	2944,50	73,61	28,28	<0,001
state of health of family members	2819,00	42,71	2852,00	71,30	22,42	<0,001
psychological climate in the family	2871,50	43,51	2799,50	69,99	18,97	<0,001
level of social well-being of the family	2686,00	40,70	2985,00	74,63	31,07	<0,001
level of satisfaction with everyday family life	2886,00	43,73	2785,00	69,63	18,10	<0,001
usual emotional background	2916,50	44,19	2754,50	68,86	16,38	0,0001
level of mutual support of family members	2978,50	45,13	2692,50	67,31	13,37	0,0003
social activity of the family	2827,50	42,84	2843,50	71,09	21,68	<0,001

Note. PA – physical activity, $\bar{r}$ is the average rank of parameter; Σr is the sum of the ranks; H is the Kruskal–Wallis test; p-value is the achieved significance level

of family well-being, physical activity, and satisfaction with leisure time. In general, respondents are characterized by good or satisfactory levels. More than half of respondents with a sufficient level of physical activity rated their family well-being and satisfaction with family leisure as high or good. A more thorough examination of this issue reveals a more complex connection between involvement in active family leisure and well-being. Similar results are reported in Townsend's research indicating that family involvement in leisure is an important predictor of elements of family well-being from different perspectives (Townsend et al., 2017). This confirms the importance of family in the formation of a healthy lifestyle, communication skills, social integration, and the formation of such positive psychological aspects as self-esteem and moral values. Internal and external factors influence the organization and content of family leisure (Bakiko et al., 2022). We have updated the information on factors of external influence, that is the dependence of family leisure time on the workload and professional activity of parents, previous physical activity experience, family type (in accordance with the period of being officially married), an unformed culture of family leisure, lifestyle, etc. There have been specified innovative forms of leisure activities, in particular, winter types of recreation suitable for families for the following reasons: relative financial availability, convenient location, availability on days off, independence from the season, and weather conditions. Provisions regarding ensuring the proper quality and satisfaction with life and family well-being through HRP, approaches in the direction of forming an appropriate level of physical activity, and the connection of well-being with the level of physical activity of families have gained further development.

Conclusions

The relationship was identified between the level of health-improving and recreational physical activity and family well-being. Thus, the families that participated in the survey by the cluster analysis method were divided into two clusters with a medium and a low level of physical activity. Such families differ significantly ($p < 0.05$) according to 23 categorical indicators. Depending on the cluster, parents prefer different types of active family leisure, have different skills in organizing active family recreation based on health-improving and recreational technologies, and devote different amounts of time to active family recreation. All families with a high level of the current state of family well-being belonged to Cluster 2 (with a medium level of physical activity). Only 47.0% of families included in Cluster 1 (with a low level of physical activity) have a high level of family well-being, which indicates the need to increase the level of their health-improving and recreational physical activity.

Conflicts of interest

The authors declare that they have no competing interests.

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ВЗАЄМОВ'ЯЗОК МІЖ РІВНЕМ ОЗДОРОВЧО-РЕКРЕАЦІЙНОЇ РУХОВОЇ АКТИВНОСТІ І СІМЕЙНИМ БЛАГОПОЛУЧЧЯМ

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Реферат. Стаття: 8 с., 3 табл., 2 рис., 33 джерела.

Мета дослідження – оцінити взаємозв'язок між рівнем оздоровчо-рекреаційної рухової активності та сімейним благополуччям.

Матеріали та методи. Теоретичний аналіз даних спеціальної науково-методичної літератури, узагальнення, систематизація, соціологічні методи дослідження, методи математичної статистики. Дослідження серед батьків проводилося шляхом онлайн-анкетування через заповнення онлайн-анкети, створеної за допомогою гугл-форм. У дослідженні взяли участь 106 сімейних пар. Переважна більшість досліджених сімей (95,1%) мали до двох дітей (дошкільного та шкільного віку).

Результати. Респонденти були розділені за рівнем рухової активності. До кластеру 1 увійшли сім'ї з низьким рівнем рухової активності, до кластеру 2 – із середнім рівнем рухової активності. Залежно від рівня рухової активності виявлено статистично значущі ($p < 0,05$) відмінності між сім'ями за такими параметрами: мотивація до заняття активним дозвіллям, кількість вільного часу, рівень знань та вмінь щодо організації активного дозвілля, причини, що перешкоджають активному відпочинку тощо. Сім'ї вірогідно відрізнялися ($p < 0,05$) за 23 категоріальними параметрами. Виявлено причини, які перешкоджають участі в оздоровчих та рекреаційних програмах рухової активності. Порівняльний аналіз поточного стану сімейного благополуччя виявив статистично значущі ($p < 0,05$) відмінності за всіма досліджуваними параметрами між сім'ями з різним рівнем фізичної активності, тобто сім'ї з належним рівнем фізичної активності мали вищі показники задоволеності, добробуту та якості життя. Низькі показники сімейного благополуччя свідчать про доцільність залучення таких сімей до активного відпочинку та підвищення рівня оздоровчої та рекреаційної рухової активності.

Висновки. Виявлено зв'язок між рівнем оздоровчо-рекреаційної рухової активності та показниками задоволеності, сімейного благополуччя та якості життя.

Ключові слова: активне дозвілля, задоволеність, якість сімейного життя, зимовий відпочинок.

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ORIGINAL SCIENTIFIC ARTICLE

DEVELOPMENT OF AN INSTRUMENT BASED ON SALIENT BEHAVIORAL BELIEFS TO MEASURE ATTITUDE TOWARDS PHYSICAL EDUCATION

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Abstract

Study purpose. The study purpose was to develop an instrument to measure students' attitude towards physical education through salient behavioral beliefs.

Materials and methods. The participants of the study were both boys and girls of grades 7 to 10 from the state of Manipur (India) in the first, second and fourth phase. In the first phase, based on the recommendation of the theory of reasoned action and its extension, the theory of planned behavior, an elicitation study was conducted using open-ended questions, where a total of 308 student responses were collected. The student responses were used to develop items through content analysis. In the second phase, i.e. content validity study, a total of 5 experts were recruited to evaluate the developed items from the elicitation study. In the third phase i.e. pilot study, out of the total of 123 student responses, 104 student responses were found to be usable for analysis. In the fourth phase, i.e. main study, out of the total of 433 student responses, 377 student responses were found to be usable for analysis.

Results. Due to lack of good model fit from the pilot study, a second exploratory factor analysis was conducted with the first half of the main study data which produced a three-factor model, and this model was tested with confirmatory factor analysis with the other half of the main study data. The model fit indices were found to be appropriate, and also the composite reliability and construct validity were found to be appropriate.

Conclusions. This belief-based attitude measuring instrument was found to be valid and reliable for grades 7 to 10 in the Indian physical education context, i.e. schools which incorporate both yoga and physical education in the general physical education curriculum.

Keywords: attitude, physical education, salient behavioral beliefs, theory of reasoned action, theory of planned behavior.

Introduction

In our daily lives, physical activity is crucial. The goal of physical education isn't for students to engage in physical activity solely during school hours. The ultimate desirable outcome of physical education would be for students to engage in enough physical activity each day and to instill a lifelong habit of staying active. Otherwise, physical education is reduced to a simple subject that is exclusively taught in schools.

The growing prevalence of obesity in India makes emphasizing the necessity of physical activity even more important. Obesity has risen substantially as a result of a sedentary lifestyle and a high-calorie diet (Ahrwar & Mondal, 2019).

In India, the majority of children are found to be sedentary and they do not meet the recommended levels of physical activity (Katapally et al., 2016). In this aspect, physical education can be an effective tool for reducing obesity and increasing physical activity however, it is critical to know whether students have a positive experience with physical education in schools. According to Fishbein and Ajzen (1975), experiences may form either positive or negative beliefs and hence either positive or negative attitude towards an object. The attitude object referred in this study is physical education. Assessing attitude may lead us to know whether students are having a positive or negative experience of physical education in schools.

Subramaniam and Silverman (2007) stated that the physical activities that students participate during physical education should have personal value for them and make them feel like active learners. We can prepare teenagers for

lifetime physical activity involvement through this active and meaningful engagement. Studies such as Solmon and Lee (1996) and Wallhead and Buckworth (2004) (as cited in Phillips & Silverman, 2012) found that in order to persuade students to engage in physical activity outside of school, it has been proposed that positive experiences in physical education and the development of favorable attitudes about physical activity are prerequisites.

Attitude is an indicator of how much a person likes or dislikes an object, and «object» is used in a general sense to refer to any aspect of the personal world (Ajzen & Fishbein, 1980). They also stated that the more positive a person's attitude toward an activity is, the more likely he should aim to engage in that conduct; the more negative his attitude is, the more likely he should avoid engaging in that behavior and vice versa.

Ajzen and Fishbein's (1980) the theory of reasoned action (TRA) and also the extension developed by Ajzen (1991) the theory of planned behavior (TPB) has guided this study. According to Ajzen (1991), salient beliefs must be obtained from a sample of respondents who are typical of the research population. If a set of belief statements are chosen at random or based on intuition, many associations to behavior that are not salient in the population will be included. Also, salient beliefs may differ from context to context. In India, the difference in physical education context is that Yoga is part of the physical education curriculum in schools, meaning to say that both yoga and physical education comes under the general physical education curriculum (National Curriculum Framework, 2005). Obtaining salient beliefs from the Indian physical education context is important. Therefore, adapting or using existing comparable instruments may do injustice although Subramaniam and Silverman (2000), Montalvo and Silverman (2008), Phillips and Silverman (2012) and Constantinides and Silverman (2018) were existing comparable instruments which have sound attitude and psychometric theory.

Salient beliefs are those that immediately spring to mind when thinking about the object and function as the dominant factors determining the attitude (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). Specifically, in this study out of the three kinds of salient beliefs only behavioral beliefs was considered since this is assumed to influence attitudes toward the behavior. On the other hand, the other two salient beliefs such as normative and control beliefs are not related to attitude (Ajzen, 1991; Ajzen & Driver, 1991).

The summative belief index and a person's attitude are directly correlated. This type of measurement of attitude can also be termed as belief-based measure of attitude (Ajzen, 1991) and also in research from Sutton et al. (2003) found that positive salient beliefs have positive attitudes. Thus, developing a closed-ended instrument based on salient behavioral beliefs to measure attitude towards physical education among school students i.e. classes 7 to 10 was the objective of the study.

Materials and methods

Study participants

In the first, third and fourth phase, the participants of this study included both boys and girls of classes 7 to 10

from the state of Manipur (India). And in the second phase, 5 experts were recruited for the purpose of content validity.

Study organization

All the phases of data collection were conducted through online using Google forms due to Covid-19 restrictions and the responses were limited to only one throughout.

First phase: Elicitation study – In this phase, open-ended questions were used to elicit salient behavioral beliefs as it is recommended in the TPB. Table 1 shows the open-ended questions. Ajzen and Driver (1991) and Phillips (2011) researches were used to create questions 1 and 2. Questions 3 and 4 were based on Ajzen and Driver's research (1991). Questions 1 and 2 were related to experiential and questions 3 and 4 were related to instrumental.

Purposive sampling was used to pick four schools from the state of Manipur (India) which included two private schools and two central schools to suit the goal of this study i.e. only schools that incorporate both yoga and physical education in the general physical education curriculum. Permission was obtained from the principals of the chosen schools, after which the open-ended questions (URL link using Google forms) were sent to physical education teachers, who subsequently forwarded to students of classes 7 to 10 via social media (WhatsApp). The demographic variables included gender and classes but did not include school and student name for anonymity reason. Participation by the students was voluntary. A total of 308 student responses were collected and kept in Google Sheets. Content analysis was used to develop closed-ended items. Basically, according to Ajzen and Fishbein (1980) the identical salient behavioral beliefs produced by various students are recognized and categorized as the same. It is also referred as modal salient behavioral beliefs. To illustrate, identical salient behavioral beliefs found in this study from three students' responses were "I don't enjoy yoga class because it's boring to me," "I don't enjoy yoga class because it is boring" and "I don't really like yoga because I am not really into yoga as it is boring for me," were considered as same i.e. these three responses of identical salient behavioral beliefs became a single item as "I don't enjoy yoga in physical education class because it is boring." This led to development of 24 closed-ended items with another addition of a negative item making it 25 items.

Table 1. Open-ended questions

1.	What do you enjoy in physical education class? Why?
2.	What you don't enjoy in physical education class? Why?
3.	What do you think are the advantages of physical education class?
4.	What do you think are the disadvantages of physical education class?

Second phase: Content validity study – The 25 items were subjected to content validity. Invitation letters were emailed to experts, along with a URL link using Google forms which included consent form that was included in the email itself. Experts were chosen based on the profession of physical education (Shrotryia & Dhanda, 2019). In total, five experts from physical education profession consented to participate

where four experts were academicians in physical education with experiences ranging from 11 to 30 years and one was a joint secretary at Central Board of Secondary Education, Delhi with an experience in curriculum of physical education for 20 years.

Thank-you emails were emailed to the experts who consented to participate, along with a URL link for evaluating the instrument (25 items) using Google forms, which was included in the email itself. The experts determined whether the items were necessary for measuring attitude towards physical education. To each of the 25 items, the experts were asked to choose from a three-point Likert scale that included "Not essential", "Useful but not essential" and "Essential". The expert responses were collected and stored in Google sheets. All the expert judgments were submitted to content validity ratio (CVR). According to Lawshe (1975), a CVR value of -1 indicates that all experts disagreed on an item, whereas a CVR value of +1 indicates that all experts agreed on an item. CVR is positive when more than half of the experts suggest "essential" to an item and negative when fewer than half indicate "essential" to an item. When more than half of experts rate an item as "essential", it has some level of content validity. The formula for CVR is $CVR = (ne - N/2)/N/2$, where ne = the number of experts who indicated «essential» to each item and N = the total number of experts. Based on the CVR values, 18 items were retained for pilot study.

Third phase: Pilot study and statistical analysis – The most typical response types utilized in attitude scales are Likert items (Lovelace & Brickman, 2013). The 18 items which was proved to having content validity was used for measuring attitude towards physical education by using a 5 point Likert scale. Measurement of attitude in this way can also be termed as belief-based measure of attitude (Ajzen, 1991).

Three central government schools were selected from Manipur based on purposive sampling. Before administering the instrument, permissions were granted by Principals to collect data. URL link using Google forms was created and data was collected based on their consent and assent to participate. It was administered via social media (WhatsApp) through the help of physical education teacher(s). The participants comprised of classes 7 to 10 both boys and girls. Anonymity in school's name and student's name was maintained throughout. A total of 123 student responses were collected and stored in Google sheets. Out of the 123 student responses, 104 student responses were usable for analysis. Student responses which were not usable included inconsistent pattern of responses and straight lining responses. For example, inconsistent pattern of responses were those who agreed on the positive item and again agreed on the negative item (reversed item). And straight lining responses were those who had a same pattern of responses irrespective of the items. The presence of a negative item made easy to recognize genuineness or lack of genuineness in student responses. There were a total response of 42 males and 62 females. Responses of each class were class 7 = 37, class 8 = 20, class 9 = 22 and class 10 = 25. The 104 student responses usable for analysis were subjected to exploratory factor analysis (EFA) where principal component analysis was used as the extraction method with an oblique rotation i.e. direct oblimin. It produced a four factor model with 2 to 5 items in each factor. 13 items were retained in this phase.

Fourth phase: Main study and statistical analysis – Data was collected from eleven central schools of Manipur based on purposive sampling. All the procedures for this phase were the same as pilot study such as administration of the instrument, permission from Principals, anonymity, consent and assent to participate. The participants comprised of classes 7 to 10 both boys and girls.

The 13 items which were retained with respect to exploratory factor analysis was used in this phase. A total of 433 student responses were collected out of which 377 student responses were usable for further analysis. Student responses which were not usable included incomplete responses and inconsistent pattern of responses. There were a total response of 178 males and 199 females. Responses of each class were class 7 = 118, class 8 = 103, class 9 = 74 and class 10 = 82.

Statistical analysis

Confirmatory factor analysis (CFA) was employed to check the four factor model produced by EFA of the pilot study however the model fit was poor. Various methods was tried such as removing items with standardized loading lower than 0.50 and improving multivariate normality by removing cases with respect to observation of Mahalanobis distance of p_1 and p_2 however, the model fit was poor. Due to the lack of model fit, another EFA was conducted with first half of the main study sample i.e. 188 student responses and the other half of the sample i.e. 189 student responses was kept to test the factor model through CFA. According to McDonald (1999) (as cited in Silverman & Subramaniam, 1999), EFA can be conducted again if there is a lack of model fit.

Results

In the first phase i.e. elicitation study, out of the total 308 student responses, identical salient behavioral beliefs were identified and 24 closed-ended items were developed with another addition of a negative item making it 25 items. Items 1 to 12 are instrumental and items 13 to 25 are experiential. Table 2 shows the 25 items (note: neglect the CVR values in this phase).

In the second phase i.e. content validity, items were retained or rejected based on the CVR values, item number 10, 11, 12, 15, 17, 24 and 25 were rejected since CVR values were negative which also suggested that half of the experts did not agree on those items. Item number 19 had negative CVR value however at least one negative item was retained in order to check for inaccurate reflection of response. Item number 19 is basically a reversed of item number 18. Items of positive CVR values ranged from 0.2 to 1. In total, out of the 25 items 18 items were retained i.e. 17 positive items and 1 negative item. Table 2 shows the 25 items with CVR values.

In the pilot study analysis, the usable 104 student responses were taken and EFA was applied. It showed Kaiser-Meyer-Olkin (KMO) as 0.854 and Bartlett's test of sphericity showed it was significant since p-value was below 0.05. Both of these values are deemed as appropriate for running EFA (Hair, L.D.S. Gabriel, et al., 2019). Communalities of the variables which were retained ranged from 0.614 to 0.871 and thus considered as appropriate (Hair, Black, et al., 2019). Total variance explained was 75.346 and thus deemed as ap-

Table 2. CVR values for each items

Item No.	Items	ne	CVR
1	Physical education class gives me knowledge on health.	4	0.6
2	Physical education class teaches me how to keep myself healthy.	5	1
3	I get to learn about games in physical education class.	5	1
4	Physical education class teaches me self-discipline.	3	0.2
5	Physical education class improves my leadership skills.	4	0.6
6	Exercise is important in physical education class.	5	1
7	Physical education class helps me to improve my skills in games.	4	0.6
8	Physical education class helps me to learn teamwork.	4	0.6
9	Yoga is important in physical education class.	3	0.2
10	Physical education class is not important as other subjects.	1	-0.6
11	I get tired for the next class after physical education class.	1	-0.6
12	Physical education class wastes my time.	1	-0.6
13	I enjoy yoga in physical education class.	3	0.2
14	I enjoy games in physical education class because it is fun.	5	1
15	I don't enjoy yoga in physical education class because it is boring.	1	-0.6
16	I enjoy exercise in physical education class.	5	1
17	I don't enjoy games in physical education class.	2	-0.2
18	I enjoy playing games with my friends in physical education class.	5	1
19	I don't enjoy playing games with my friends in physical education class.	1	-0.6
20	I enjoy exercise with my friends in physical education class.	5	1
21	I enjoy learning new activities in physical education class.	4	0.6
22	I enjoy playing different types of games in physical education class.	4	0.6
23	I enjoy learning new games in physical education class.	5	1
24	I don't enjoy repeating the same activity in physical education class.	2	-0.2
25	I don't enjoy excessive exercise in physical education class.	2	-0.2

propriate (Hair, L.D.S. Gabriel, et al., 2019). Recommended factor loadings were considered and the values ranged from 0.576 to 0.911 which were all above 0.50 (Hair et al., 2014). Following the extraction as PCA with a direct oblimin rotation, four factors were retained. The items under each factors ranged from two to five consisting a total items of thirteen. Table 3 shows the retained items after EFA. Items 1, 6, 8, 9, 12 and 13 are experiential and the rest of the items are instrumental.

In the main study, the usable 377 student responses were taken for analysis. Owing to the lack of model fit, we conducted another EFA with the 13 items from the main study sample. EFA was conducted with first half of the main study sample i.e. 188 student responses using PCA as the extraction method with an oblique rotation i.e. promax led to retention of 10 items with a three-factor model where three to four items were present in each factors. The Kaiser-Meyer-Olkin (KMO) observed was 0.773 and Bartlett's test of sphericity showed it was significant since p-value was below 0.05. Communalities of the variables which were retained ranged from 0.502 to 0.845 which was considered as appropriate. Total variance explained was 66.519 and also the factor loadings values ranged from 0.528 to 0.916 which were all above 0.50 which were deemed as appropriate. Table 4 shows the pattern matrix from the first half of the main study sample (188 student responses) and the three-factor model produced and the items retained in each factor. The three factors were named as other activities (OA), health (H) and games (G).

This was followed by CFA to test the three factor model as shown in table 4 with the other half of the main study sample i.e. 189 student responses. Multivariate normality could not be fulfilled although 24 cases were deleted by ob-

Table 3. Retained items after EFA of pilot study

Item No.	Items
1	I enjoy playing games with my friends in physical education class.
2	Physical education class helps me to learn teamwork.
3	Physical education class improves my leadership skills.
4	Exercise is important in physical education class.
5	Yoga is important in physical education class.
6	I don't enjoy playing games with my friends in physical education class.
7	Physical education class helps me to improve my skills in games.
8	I enjoy games in physical education class because it is fun.
9	I enjoy exercise with my friends in physical education class.
10	Physical education class gives me knowledge on health.
11	Physical education class teaches me how to keep myself healthy.
12	I enjoy exercise in physical education class.
13	I enjoy yoga in physical education class.

serving Mahalanobis distance of p1 and p2. Due to non-multivariate normality, generalized least square estimation was used. However, the deletion of 24 cases simultaneously led to improvement in model fit. In addition to this, two more items were deleted since their standardized loading was below 0.50 and this also contributed to improvement in model fit. This follows the recommendation of Awang (2015) that deletion of item(s) in CFA should not exceed more than 20% of the overall items.

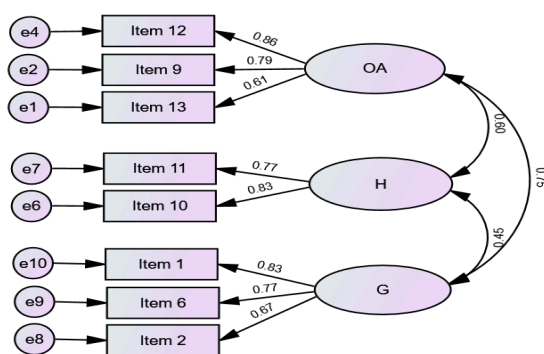
Table 4. Three-factor model produced and the items retained in each factor

Item	Pattern Matrix		
	Component		
	Other activities	Health	Games
Item 12	.768		
Item 8	.744		
Item 9	.625		
Item 13	.549		
Item 11		.865	
Item 10		.800	
Item 3		.580	
Item 1			.916
Item 6			.802
Item 2			.528

Extraction Method: Principal Component Analysis.
 Rotation Method: Promax with Kaiser Normalization.
 a. Rotation converged in 6 iterations.

Goodness of fit index (GFI) greater than 0.90 indicates a good fit (Kline, 2005). Root mean square of error approximation (RMSEA) should be below 0.08 (Browne and Cudeck, 1993). Adjusted Goodness of Fit (AGFI) should be above 0.90 (Tanaka and Huba, 1985). Values of the Comparative Fit Index (CFI) higher than around 0.90 may signify that the model fits reasonably well (Kline, 2005). Chi-square fit statistics/degree of freedom (CMIN/DF) does not exceed the value of 3 (Kline, 2004). Standardized Root Mean Square Residual (SRMR) should be 0.05 or less (Byrne, 2010).

The model fit indices in this study were GFI = 0.959, RMSEA = 0.059, AGFI = 0.914 and CFI = 0.916, CMIN/DF = 1.568 and SRMR = 0.018. Figure 1 shows the CFA diagram.

**Fig. 1.** CFA diagram

Stats tools package offered by Gaskin, J. (2016) has been used for the calculations of composite reliability, convergent and discriminant validity. The standardized loading estimates for all the variables were higher than 0.50. In table 5, the composite reliability (CR) values such as, other activities (OA) = 0.801, health (H) = 0.782 and games (G) = 0.800 which proves construct reliability since the values were higher than 0.70. The average variance extracted (AVE) values were higher than 0.50 for all the three constructs

Table 5. Composite reliability, convergent and discriminant validity

	CR	AVE	MSV	MaxR(H)	H	OA	G
H	0.782	0.642	0.354	0.788	0.801		
OA	0.801	0.577	0.560	0.833	0.595	0.760	
G	0.800	0.573	0.560	0.815	0.453	0.748	0.757

Table 6. Final items with respective constructs

Construct 1: Other activities (OA)	
I enjoy exercise in physical education class.	
I enjoy exercise with my friends in physical education class.	
I enjoy yoga in physical education class.	
Construct 2: Health (H)	
Physical education class teaches me how to keep myself healthy.	
Physical education class gives me knowledge on health.	
Construct 3: Games (G)	
I enjoy playing games with my friends in physical education class.	
I don't enjoy playing games with my friends in physical education class.	
Physical education class helps me to learn teamwork.	

which prove sufficient convergent validity. The AVE value was higher than the maximum shared variance (MSV) value for all the three constructs proving discriminant validity. Table 6 shows the final items retained with their respective constructs.

Discussions

The items found in this study can be considered as unique since they are salient in this specific context i.e. schools which implements both yoga and physical education in the general physical education curriculum. Yoga item, "I enjoy yoga in physical education class" shows the difference in physical education context (table 6: construct 1). Yoga items were not found in existing comparable instruments. In previous studies, one of the reasons why yoga items were not found might be that yoga is not part of the physical education curriculum in their country.

In this study, particularly the items of instrumental and experiential overlapped (table 6: construct 3). Although, initially the questions pertaining to table 1 had separate questions for instrumental and experiential, the EFA pattern matrix indicated an overlapping of items (table 4: factor 3). In the case of Subramaniam and Silverman (2000), Montalvo and Silverman (2008), Phillips and Silverman (2012) and Constantinides and Silverman (2018), their studies had separate items for factors (cognitive and affective) and sub-factors and those determined attitude towards physical education. These could be because of the model they have used which is a dual component i.e. Affective and cognitive factors (Bagozzi & Burnkrant, 1979; Oppenheim, 1992) and that the rotation method they have used in EFA may have been a forced rotation. Fishbein and Ajzen (2010), prefers to use the factor i.e. cognitive and affective as instrumental and experiential since items of these two can overlapped. In this study, although initially the questions had separate factors

however this was not the case as the items of instrumental or experiential overlapped after applying EFA. However, both these items of instrumental and experiential measures the same thing i.e. attitude and so was the case in Ajzen and Driver (1991). It is also not always assured that both items of instrumental and experiential will be included in the final scale and a valid scale to measure attitude need not always necessarily include both instrumental and experiential items (Fishbein & Ajzen, 2010).

The results of this study found that this new instrument for measuring attitude towards physical education based on salient behavioral beliefs were found to be valid and reliable for school students i.e. classes 7 to 10. This new instrument for measuring attitude towards physical education in the Indian physical education context is particularly for those schools which implements both yoga and physical education in the general physical education curriculum. The major strength of this study is that the development of this instrument to measure attitude towards physical education is based on salient behavioral beliefs and hence can be more appropriate since they are salient in this physical education context of India (only schools which incorporate both yoga and physical education in the general physical education curriculum). However, even though it is based on salient beliefs, one of the limitations in this study is that the instruction in the elicitation study was "Write your experiences of the past Physical Education class (not during the Covid-19 situation)". In the elicitation study as seen in Ajzen and Driver (1991), the questions pertained to present and not the past. In this study, elicitation based on covid-19 situation was not possible since physical classes were stopped and therefore questions pertaining to elicitation as shown in table 1 may not be appropriate if it was based during that situation. Due to this reason, the students were asked to write down the answers based on past experiences of physical education class i.e. before Covid-19 and this may create a possibility to some inaccuracy of salient beliefs. Although, we cannot determine precisely the effect of the elicitation on the past experiences instead of the present physical education classes on salient behavioral beliefs in this study, we suggest that this instrument may be used to measure attitude towards physical education since it may not necessarily alter.

This study found that other activities (OA), health (H) and games (G) are the factors which determines attitude towards physical education. Authorities of physical education in India may be benefited by this study and take appropriate action by considering the fact that these factors are influential in determining attitude towards physical education.

For future possible research, as Fishbein and Ajzen (1975) stated that beliefs may change with different experience(s) and therefore, we encourage that future work should go for an elicitation study as per Ajzen and Driver (1991). Also, development of attitude instrument with belief-based for other classes is a possible research.

Conclusion

This instrument which has been developed to measure attitude towards physical education based on salient behavioral beliefs in this context has been found to be valid and reliable. This instrument can be used to measure attitude towards physical education for classes 7 to 10 and particu-

larly for schools which incorporate both yoga and physical education in the general physical education curriculum itself. Also, this belief-based measure of attitude may be more appropriate instead of adapting or using comparable existing instruments since salient behavioral beliefs can be different from region to region and also when there is a difference in context i.e. physical education curriculum.

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Conflict of interest

We declare that there is no conflict of interest.

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РОЗРОБКА ІНСТРУМЕНТАЛЬНОГО ЗАСОБУ НА ОСНОВІ ЯВНИХ ПОВЕДІНКОВИХ ПЕРЕКОНАНЬ ДЛЯ ВИМІРЮВАННЯ СТАВЛЕННЯ ДО ФІЗИЧНОГО ВИХОВАННЯ

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Мета дослідження. Метою дослідження була розробка інструментального засобу для вимірювання ставлення учнів до фізичного виховання на основі їхніх явних поведінкових переконань.

Матеріали та методи. Учасниками дослідження в першій, другій і четвертій фазі були хлопці та дівчата зі штату Маніпур (Індія), які навчалися в 7-10 класах. У першій фазі на основі рекомендації теорії аргументованої дії та її продовження – теорії запланованої поведінки – було проведено дослідження з виявлення поведінкових переконань з використанням відкритих запитань, і в результаті було зібрано загалом 308 відповідей учнів. Ці відповіді учнів використовували для розробки тестових запитань шляхом аналізу змісту. У другій фазі, тобто під час дослідження змістовної валідності, було залучено загалом 5 експертів для оцінки розроблених тестових запитань, одержаних із дослідження з виявлення пове-

дінкових переконань. У третій фазі, тобто під час пілотного дослідження, було встановлено, що із загалом 123 відповідей учнів 104 відповіді учнів придатні для аналізу. У четвертій фазі, тобто під час основного дослідження, було встановлено, що із загалом 433 відповідей учнів 377 відповідей учнів придатні для аналізу.

Результати. Через брак точного підбору моделі з пілотного дослідження було проведено другу оцінку факторної структури з першою половиною даних основного дослідження, у результаті якої було одержано трифакторну модель, і цю модель тестували з використанням оцінки факторів за результатами спостереження з другою половиною даних основного дослідження. Було встановлено, що показники точності підбору цієї моделі є належними, і також було встановлено, що показники структурної надійності та конструктивної валідності є відповідними.

Висновки. Було встановлено, що цей інструментальний засіб вимірювання ставлення на основі переконань є придатним і надійним для 7–10 класів у контексті фізичного виховання в Індії, тобто для шкіл, у яких загальні навчальні плани з фізичного виховання передбачають і заняття з йоги, і заняття з фізичного виховання.

Ключові слова: ставлення, фізичне виховання, явні поведінкові переконання, теорія аргументованої дії, теорія запланованої поведінки.

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ORIGINAL SCIENTIFIC ARTICLE

IMPLEMENTATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN TEST CONTROL OF LEG STRENGTH IN PHYSICAL EDUCATION OF STUDENTS

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Abstract

The purpose of this study was to experimentally substantiate the implementation of information and communication technologies in test control of leg strength in the process of physical education of students.

Materials and methods. The methods used to obtain empirical data included pedagogical experiment, pedagogical testing, mathematical methods for processing digital files, comparative statistical method, variance and correlation analysis. The study participants were 240 students aged 17–19 at the beginning of the study.

Results. A developed device for determining leg muscle strength, built based on the latest information and communication technologies, was presented. The developed design of the device involves the use of analog laser distance sensors the information from which is sent to the processing unit via wireless infrared communication devices and fed to the electronic computing device through an analog-to-digital converter. By calculating the authenticity of the test exercise used to control leg strength, the use of the developed device in practical activities was experimentally substantiated. According to the results of the correlation analysis, it was established that the authenticity of control using the developed device has reached a high level.

Conclusions. A qualitatively new approach to increasing the effectiveness of control in physical education of students was presented, which is implemented in the developed leg strength control device. The applied value of the results of the conducted research is that the device developed based on information and communication technologies provides a qualitatively new form of implementation of leg force control as well as processing and presentation of control information. The use of the device in the practice of physical education of students ensures the effectiveness and high efficiency of the control procedure, the result of which is the receipt of reliable data, which makes it possible to significantly improve the quality and intensify control of this process to ensure the effectiveness of physical education of students.

Keywords: testing, control, physical education, student, leg strength, device, information and communication technologies.

Introduction

At the current stage of society's development, the development of higher education is conditioned by rapid changes dictated by the trends of the international educational space, the requirements of the educational services market, and the

demand for specialists who can meet the challenges and demands of the international labor market. In the context of the training of highly qualified specialists, physical education is defined as one of the priority directions in the pedagogical practice of a higher school (Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020; Shettar, Lathiwale, & Kulhalli, 2021).

The process of European integration increases the requirements for the organization of physical education of students and ensures its effectiveness. (Anikieiev, 2015). This

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necessitates the search for new means and methods, which involves their intensive modernization to move to a qualitatively new level of efficiency and scientific capacity. Information and communication technologies (ICT) are considered a powerful factor in increasing the effectiveness of physical education of students (Di Tore, Schiavo, & D'isanto, 2016; Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021).

Prospective use of ICT in solving problems of the effectiveness of physical education of students is confirmed by active research activities. A significant number of publications are devoted to aspects of the use of modern ICT in physical education (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Blavt, Vanivska, & Stadnyk, 2020; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020). ICT is considered an important component of the educational process (Gogoi, 2019), which provides the possibility of achieving the goals of physical education in the high-quality training of higher education students (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Kozina, Ol'khovyy, & Temchenko, 2016; Shettar, Lathiwal, & Kulhalli, 2021).

Researchers have proposed a wide range of ICT use in physical education in health (Fisher, 2014; Alfrey, & Gard, 2014), educational (Gogoi, 2019; Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020) and training (Mullineaux, Bartlett, & Bennett, 2011; Koryahin, Iedynak, Blavt, Galamandjuk, Prozar, Zaikin, Veselovska, Golub, Kucher, & Gurtova, 2019; Serrien, Tassignon, Verschueren, Meeusen, & Baeyens, 2019) areas. It has been proven that the introduction of ICT makes it possible to effectively collect, process, and transmit information, qualitatively change the methods and organizational forms of physical education for students.

The expediency of introducing modern ICT into the process of physical education of students is substantiated. Several studies cover the dimension of the implementation of control in the pedagogical process of students physical education, which is based on theories, concepts, and approaches to its implementation at a qualitatively new level (Di Tore, Schiavo, & D'isanto, 2016; Gogoi, 2019; O'Brien, Philpott, Lester, Belton, Duncan, Donovan, Chambers, & Utesch, 2021).

Despite the broad presentation of the introduction issue of modern information technologies in the field of physical education, the specifics of ICT in the implementation of control of physical education of students, as a correlator of its effectiveness, is a dynamic issue, which provides an opportunity to highlight constructive ideas and outline the possibilities of their practical application.

Thus, the need for higher education to ensure the quality of physical education, as well as the insufficient provision of control in the process of physical education of students with the latest technologies, contradicts the objective necessity of educational practice, determined the choice of the topic of our research.

The purpose of this study is experimental substantiation to implement ICT in test control of leg strength in the process of physical education of students.

Materials and methods

Research methods

The methods used to obtain empirical data were the pedagogical experiment, pedagogical testing, mathematical methods for processing digital files, comparative statistical

method, variance, and correlation analysis. Technical modeling was used as a method of the empirical level of research. Pedagogical testing involved determining muscle strength traditionally and using a developed device.

Control of the level of leg strength development was implemented using the specialized test exercise "Chair" (Magill & Anderson, 2017). The expediency of using this test to control leg strength is because it is technically a fairly simple exercise that does not require additional equipment. The test involves maintaining a stable squat position, the knee angle is 90 degrees, and the hips should be parallel to the floor. A correctly methodically determined position is recorded and maintained. The time of maintaining a stable position of the body is recorded.

The study involved fixing the time of the correct execution of the test exercise in two ways: traditional – using a stopwatch and using the developed device presented in the study.

Participants

The first and the second-year students from Lviv Polytechnic National University, Kamianets-Podilskyi National Ivan Ohienko University, Lviv State University of Physical Culture named after Ivan Boberskyj and Kherson State University were selected for research. The study involved 240 students, their age at the beginning of the study was 17-19 years. It is important that the number of students in the research groups was sufficient for the demonstrable evaluation of the experiment's results. The requirements for the adequacy of the information volume at the level of $p < 0.05$ were met.

The organization of the study took into account the provisions of the Declaration of Helsinki 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 committee of the Lviv Polytechnic National University.

Organization of research

The experiment was implemented during two academic semesters. At the first stage of the research, all students of the studied sample made three attempts in a test to determine the level of leg strength development. The results were recorded using a stopwatch. The average result was determined based on the results of three attempts.

At the second stage of the study, all students who participated in the pedagogical experiment made three attempts in the test to determine the level of leg strength development. The results were recorded using the device developed and presented in the study.

After that, the reliability and validity indicators of the tests were calculated, the results of which were obtained at the first and second stages of the study. At the same time, the indicators obtained at the first stage of the study were used as a retest to determine test reliability and validity.

Statistical analysis

Within descriptive statistics, the comparative-statistical method of determining of empirical authenticity of tests is

applied. To determine the empirical authenticity of the tests, variance and correlation analysis (between the obtained test results and the correlation criterion) were used. Quantitatively, the degree of authenticity of the tests is expressed using the reliability and validity coefficients, which are calculated using the intra-class correlation coefficient.

Using this analysis, correlation coefficients were calculated to establish numerical values of reliability and validity of the test for determining the level of leg strength development. The results obtained during the control are considered reliable if the test methods used are authentic, and its quantification is a criterion coefficient that quantifies the degree of test reliability and validity and is calculated using the intraclass correlation coefficient. The obtained numerical indicators of which are the basis of the conclusion about the meaning of the test (Magill, & Anderson, 2017).

The methods of mathematical statistics are used, it can be confirmed that the criteria of reliability and validity are adequately met. All statistical analysis was performed using SPSS Version 21.

Results

The implemented experimental study was aimed at eliminating the dependence of subjectivity in the implementation of control of the assessment of the perception of a person who controls the level of leg strength development. By using ICT, they tried to achieve efficiency and objectivity of control. The result of the carried out scientific search was the developed device for controlling leg strength, as a component of physical training in the process of physical education of students.

Today, there are many ways to measure leg strength. We used the test exercise "Chair" because the exercise is easy to reproduce, does not require special equipment, and does not require time. In addition, this test can be used by students in independent work.

However, recording the stability of a certain body position: a right angle between the hip and the lower leg, as well as a right angle between the hips and the body, is associated with the probability of error. There is a possibility of an error in controlling the time of the correct execution of the test task, which makes it impossible and difficult to obtain reliable informative results.

The developed design of the device involves the use of analog laser distance sensors – high-precision laser sensors with a measurement range of no more than 1000 mm, which contain digital interfaces. Thanks to the use of short-range sensors, the quality of control increases. Analog laser distance sensors have high reliability, durability, stability, small dimensions, mass and power consumption, and compatibility with microelectronic devices for information processing at a low cost (Vistak, Dmytrah, Mykytyuk, Sushynskyi, Barylo, Prysiashniuk, & Horbenko, 2017).

Sensors in the developed device are drawn on a ruler. The line of sensors is located vertically on both sides of the student performing the test exercise. Exercise signals are recorded by infrared receivers of non-contact analog laser distance sensors placed on the ruler.

Analog laser distance sensors can detect and calculate with high accuracy the position of objects made of any materials (Wojcik, Vistak, Mykytyuk, Politsanskyi, Diskovskiy,

Sushynskyi, Kremer, Prystay, Jaxylykova, & Shedreyeva, 2020). The principle of measurement by analog laser sensors is based on optical and ultrasonic methods of fixing the dependence of the time of passage of a light pulse on the distance between objects (Hotra, Mykytyuk, Diskovskiy, Barylo, & Vezyr, 2018). Control information is captured by the sensor's laser LED and photodiode, which is mounted in the controlled area in our development of the sensor line.

The laser beam of the sensor through the lens, directed at the student in the specified position of the test exercise, is reflected and focused on a line of photodiodes contained in the infrared radiation receiver, which forms information about the student's position in the form of discrete analysis. Photodiodes convert an optical signal to an electrical one (analog signal to digital). If the position of the student changes, the angle of reflection of the beam changes, and, therefore, the position of the reflected beam is fixed by a photodiode, which controls short-term deviations of the sensor values, avoiding the possibility of incorrect performance of the exercise.

To perform the exercise, the student takes a defined initial position and fixes it, placing himself between a line of sensors (fig. 1). Sensors placed in the line record the student's position and the time it takes to maintain a stable position. Non-contact analog laser distance sensors provide information about the position of the student in front of the sensor in the form of discrete analysis. The signal received by the sensor line is sent to the processing unit via wireless infrared communication devices. The processing unit processes the signal from the line of photodiodes and converts it into an analog signal, which, through an analog-to-digital converter, enters the electronic computing device for further processing.

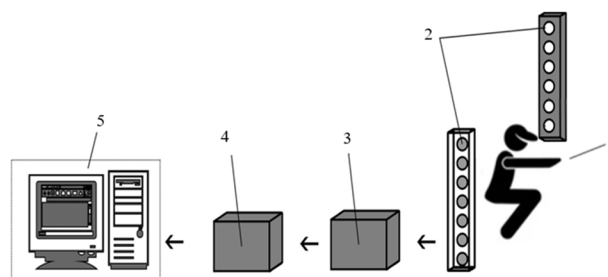


Fig. 1 Structural diagram of the design solution for leg strength control using the developed device, where: 1 – student, 2 – line of sensors, 3 – processing unit, 4 – analog-to-digital converter, 5 – electronic computing device

After the student changes the steady position of the body, the time of the exercise is fixed in digital units, convenient and understandable for perception. The obtained results are displayed using the LCD of the electronic computing device.

The developed device makes it possible to register the moment of the start of the exercise, the maintenance of a stable posture (performance process), and the moment of its end. In the electronic computing device, recording, visualization, and analysis of the received control results are also carried out, following the algorithm of the internal software.

Table 1. Authenticity of the test (rtt)

Curriculum	I		II		I		II		I		II	
	T	A	T	A	T	A	T	A	T	A	T	A
H	0,707	0,876	0,711	0,883	0,777	0,890	0,707	0,876	0,711	0,883	0,713	0,890
V	0,115	0,222	0,117	0,201	0,094	0,225	0,165	0,222	0,047	0,101	0,377	0,525

*Note: H – reliability of the test, V – validity of the text; T – the traditional way, A – using the developed tool, I – first course of study, II – second year of study

The developed device uses an electronic computing device, but it is also possible to use a mobile telecommunication system that has a high-speed interface subsystem and in which the received signal is processed on a real-time scale.

The experimental justification of the use in practical activities of the developed device for controlling leg strength is presented in fig. 2. The authenticity of the leg strength control test was calculated. The determination of such a complex character of the test was used to obtain information about the degree of representativeness of the research procedure. For this purpose, the results of testing students of the 1st and 2nd years were registered traditionally and using the developed device.

According to calculations, the reliability coefficient of the test used in the study, the results of which were recorded in the traditional way using a stopwatch, is within the range of low and medium, which is considered acceptable. The validity coefficient obtained by the traditional method is within the low range. By changing the method of registering the results, we achieved that the authenticity of the test reached a high level.

In the obtained values of the measure of authenticity of the tests, there is a degree of change depending on the method of registering the results. Based on the obtained results, it can be concluded that the reliability of the same test depends on the way the results are recorded.

The effectiveness of using the device for controlling leg strength is ensured by: ease of use and compactness of the device, a comprehensive approach: the combination of the necessary analysis of the obtained control results with a visual form of presentation in the developed device is implemented by software. The use of the software enables simultaneous analysis of the test results of a group of students without loss of information. In addition, the software unifies and intensifies the receipt and processing of control results with the updating and correction of a large array of control information and its accumulation in an integrated database, in which their replication, processing, and interactive analysis using statistical and mathematical methods and algorithms are established.

Discussion

Currently, the implementation of innovations is an important source of determining strategic directions for the development of higher education in Ukraine. This is positioned as an indicator of relevance and effectiveness and is embodied in specific, qualitatively new results of the educational process (Gogoi, 2019). We support scientific approaches (Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021; Shettar, Lathiwal, & Kulhalli, 2021) that

modernization based on the introduction of ICT in physical education of higher schools is now a priority direction for ensuring modern progress in this process. It is significant that information becomes the foundation of the innovation process, and ICT provides the provision of this information at a modern scientific level (Gogoi, 2019; Estivalet, & Springer, 2009).

The conducted scientific research is due to the need to introduce innovations and fundamentally new approaches to the development of the theory of control in physical education. Which is consistent with available information (Ivashchenko, 2020; Ivashchenko, Khudolii, Iermakov, & Harkusha, 2017; Hasegawa, Fujii, Miura, Yokoyama, & Yamamoto, 2019;).

In modern science, attention is focused on the need to significantly improve the quality of scientific research and make radical changes in the organization and examination of the results of physical education (Khudolii et al., 2019; Zanevskyy, & Labartkava, 2020; Solohubova et al., 2020). Control of the results of physical education of students, which is positioned as a powerful mechanism of influence and management, is the basis of the effectiveness of physical education of students (Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020; Shettar, Lathiwal, & Kulhalli, 2021). The results of the study complement the data on pedagogical control in the physical education of students (Kozina, Ol'khovij, & Temchenko, 2016; Koryahin, Blavt, Vanivska, & Stadnyk, 2020; Edwards, 2010).

Data have been expanded that the effectiveness of the introduction of the latest technologies developed based on ICT in the physical education of students, which is determined by their accessibility to users, ease of use, and the degree of meeting the needs of this process (Di Tore, Schiavo, & D'isanto, 2016; Koryahin, Blavt, Vanivska, & Stadnyk, 2020). The importance of ensuring the objectivity and efficiency of control from a practical standpoint is determined by the importance of receiving and studying information about the state of the studied parameters during the physical education of students, as a factor in the effectiveness of this process (Kozina, Ol'khovij, & Temchenko, 2016; Shettar, Lathiwal, & Kulhalli, 2021). Added data on the optimization of physical education of students through the use of ICT and their capabilities in solving forecasting tasks, and designing classes based on objective control of physical education results (Bhat, Nazir, & Khan, 2018; Gogoi, 2019).

The applied value of the results of the conducted research is that the device developed based on ICT provides a qualitatively new form of implementation of leg force control, as well as processing and presentation of control information. Its novelty lies in the use of the potential of modern ICT, which provides a process of operational, rational, pur-

poseful obtaining of results for the effective implementation of control in the physical education of students.

The idea that the reliability of the same test depends on the way the results are recorded has been confirmed. At the same time, all specialists are unanimous in the fact that the leading means of implementing the aforementioned is the technological provision of the ICT-based control procedure, which is a step towards increasing the effectiveness of physical education to achieve a new quality.

Conclusions

One of the priority directions of the development of modern higher education is the rethinking of the doctrine of physical education at the level of European quality, the corresponding modernization of its content, and optimization of its technical support to achieve new quality.

A qualitatively new approach to increasing the effectiveness of control in physical education of students is presented, which is implemented in the developed leg strength control device. The device, developed based on ICT, ensures the unification and intensification of obtaining and presenting control results. The use of the developed leg strength control device in the practice of physical education of students allows solving the problems of prompt, immediate obtaining and accumulation of objective information about the level of leg strength development.

Taking into account the possibility of carrying out a standardized test control procedure, which is a key factor in its objectivity; simplicity, convenience, accessibility, and the possibility of immediate obtaining control data, the use of a leg strength monitoring device developed based on ICT allows to reliably monitor the development of leg strength, which is confirmed by the obtained results of the authenticity of measurements, and to urgently and effectively analyze and interpret the received large volumes of quantitative control information.

The integration of ICT, which performs the functions of a toolkit for solving control tasks, has provided a qualitatively new technological advance in methodology and didactics, organization, and practical implementation of test control in the physical education of students.

Conflict of interest

The authors state no conflict of interest.

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УПРОВАДЖЕННЯ ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ У ТЕСТОВИЙ КОНТРОЛЬ СИЛИ НІГ У ФІЗИЧНОМУ ВИХОВАННІ СТУДЕНТІВ

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Мета дослідження полягала у експериментальному обґрунтуванні упровадження інформаційно-комунікаційних технологій у тестовий контроль сили ніг в процесі фізичного виховання студентів.

Матеріали та методи. Методами отримання емпіричних даних були педагогічний експеримент, педагогічне тестування, математичні методи обробки цифрових файлів, порівняльно-статистичний метод, дисперсійний та кореляційний аналіз. У дослідженні взяли участь 240 студентів, їх вік на початок дослідження становив 17-19 років.

Результати. Представлено розроблений пристрій для визначення сили м'язів ніг, побудований на основі новітніх інформаційно-комунікаційних технологій. Розроблена конструкція пристрою передбачає використання аналогових лазерних сенсорів відстані, інформація з яких бездротовими пристроями інфрачервоного зв'язку надходить

на блок обробки та через аналогово-цифровий перетворювач подається у електронно-обчислювальний пристрій. Обчисленням автентичності тестової вправи, яка використана для контролю сили ніг, експериментально обґрунтовано використання у практичній діяльності розробленого пристрою. За результатами кореляційного аналізу встановлено, що автентичність контролю з використанням розробленого пристрою досягла високого рівня.

Висновки. Представлено якісно новий підхід до підвищення ефективності контролю у фізичному вихованні студентів, що реалізовано у розробленому пристрої контролю сили ніг. Прикладне значення результатів проведеного дослідження полягає у тому, що розроблений на основі інформаційно-комунікаційних технологій пристрій забезпечує якісно нову форму реалізації контролю сили ніг, а також обробку й представлення інформації контролю. Використання у практиці фізичного виховання студентів пристрою забезпечує оперативність та високу ефективність процедури контролю, результатом яких є отримання достовірних даних що дають змогу істотно підвищити якість та інтенсифікувати контроль цього процесу задля забезпечення ефективності фізичного виховання студентів.

Ключові слова: контроль, фізичне виховання, студент, сила ніг, пристрій, інформаційно-комунікаційні технології.

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ORIGINAL SCIENTIFIC ARTICLE

HEALTH-RELATED PHYSICAL FITNESS IS ASSOCIATED WITH TOTAL AND CENTRAL BODY FAT IN CHILDREN AGED 6 TO 10 YEARS

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Abstract

Study purpose. This study purpose was to investigate whether health-related physical fitness is associated with total and central body fat in school children aged 6-10 years.

Materials and methods. A total of 2197 Macedonian children aged 6-10 years (1096 boys and 1101 girls) participated in the study. Health-related physical fitness was measured by the modified EUROFIT test battery: the 20 m shuttle run test (cardiorespiratory fitness); the handgrip strength test, the standing long jump and the 30 s sit-ups tests (muscular strength); the 4×10 m shuttle run test (motor fitness) and the sit and reach test (flexibility). Body mass index, body fat percentage and waist circumference were used as markers of total and central body fat, respectively.

Results. The standing long jump, the 30 s sit-ups, the 4×10 m shuttle run and the 20 m shuttle run tests were negatively associated with all markers of total and central body fat in boys and girls after controlling for age ($p < 0.01$). The handgrip strength test was positively associated with all markers of total and central body fat ($p < 0.01$). No statistically significant correlation was established between the markers of total and central body fat and the sit and reach test.

Conclusions. The present study broadens previous findings in children and adolescents which demonstrate correlations between the health-related physical fitness components, chiefly the muscle strength, the agility and cardiorespiratory fitness and total central adiposity. Fitness assessment should be introduced in future epidemiological and intervention studies in school children because it seems to be an important factor determining health.

Keywords: cardiorespiratory fitness, muscular strength, motor fitness, children, obesity.

Introduction

The Obesity among children and adolescents is a serious problem in the 21st century children's health (Reilly, 2006). Overweight and obesity during the childhood, and especially in adolescence, linger on in the adulthood. Former studies' results indicate that one out of four children at the age of 6 to 14 is affected by overweight (Kotani et al. 1997; Kain et al., 2002). Obesity is a multifactorial problem which is a product of a variety of causes, including those of heredity, social status, lifestyle, eating habits, and physical activity

level (National Institutes of Health of USA, 2000). Physical fitness has proved to be an additional significant subject from a public-health perspective concerning adults (Myers et al., 2007) as well as children and adolescents (Ortega et al., 2008). Those studies which examine the correlation between the status of weigh and health-related physical fitness in young people have frequently reported a decrease of fitness in the course of obesity-increase (Haerens, et al., 2007; Brunet, et al., 2007; Martinez-Tellez, et al., 2016; Fogelholm, et al., 2008; Gontarev & Ruzdija, 2014).

Understanding the relation between physical fitness (including cardiorespiratory fitness, muscular strength and motor fitness) and obesity-related effects among children of the age from 6 to 10 years would make it possible to derive additional information about the question whether physical fitness is to be or not introduced as a health-marker as early

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as at the mentioned ages. We hypothesize that the physical fitness levels are associated with markers of adiposity. The goal of the present study is to examine how health-related physical fitness corresponds with the body mass index (BMI), body fat percentage and waist circumference (WC) in Macedonian children at the age of 6 to 10 years.

Materials & methods

Study participants

The research was conducted on a sample of 2197 children from 19 primary schools in the Republic of North Macedonia, 11 of which are in urban areas and 8 in rural areas. The sample was divided into two sub-samples according to the gender: 1096 male respondents and 1101 female respondents. The average age of the respondents was 8.63 ± 2.34 years. The respondents were treated in accordance with the Helsinki Declaration of 1961 (revision of Edinburgh 2013). The measurements were conducted in March, April and May 2019. The measuring was performed by experts of Kinesiology and Medicine.

Anthropometric measurements

Applying standardized procedures, the measurements of weight, height, and WC were carried out at school; all the instruments were verified before measuring each subject. Weight was measured in underwear and without shoes, with a medical decimal weight scales, to the nearest 0.1 kg, and height was measured barefoot in the Frankfurt horizontal plane with a telescopic height measuring instrument (Martin's anthropometry) to the nearest 0.1 cm. Body mass index was calculated as bodyweight in kilograms divided by the square of height in meters. Waist circumferences were measured twice using inextensible anthropometric tape with the children standing erect and relaxed, with arms at the sides and feet positioned close together. Waist circumference was measured midway between the lowest border of the rib cage and the upper border of the iliac crest, at the end of normal expiration.

Components of the body composition have been determined by the method of bioelectrical impedance (measuring of the electric conductivity – Bioelectrical Impedance Analysis - BIA). The measuring was realized by a Body Composition Monitor, model "OMRON - BF511". In order to provide better precision of the results obtained from the estimation of the body composition, prior to each measuring, we ensured that the preconditions recommended by Heyward & Gibson (2014) had been fulfilled.

Evaluation of Physical Fitness

Six tests, forming part of the EUROFIT battery, validated and standardized by the European Council, were applied in the following order:

Sit and Reach test, Hand Grip test, Standing long jump test, Sit-ups 30 sek, Shuttle run: 4×10 meters, 20 meter shuttle run test.

Statistical analysis

Characteristics of the study sample are described as mean and standard deviation. Gender differences were as-

sessed by one-way analysis of variance. To study the association of health-related physical fitness (i.e. the handgrip strength, standing long jump, 4×10m shuttle run, one-leg stance and 20m shuttle run tests) with BMI, body fat percentage and WC, we conducted linear regression analysis inserting the health-related physical fitness variable as independent variables and BMI, body fat percentage and WC as dependent variables. All these relationships were analysed in separate regression models (one for each fitness test and dependent variable) using age as covariate. The analysis were further adjusted by height when WC was the outcome variable. Since we observed a significant interaction effect between sex and most fitness components, all analyses were performed separately for male and female participants. All the analyses were performed using the Statistical Package for Social Sciences software (SPSS, v. 26.0 for Windows; SPSS Inc., Chicago, IL, USA).

Results

The characteristics by gender of the examined population are presented in Table 1. The analysis of the table shows that the male respondents have greater body weight, waist circumference, higher body mass index values, (BMI), and a greater percentage of body fat in comparison with those of the female respondents ($p \leq 0.010$). Further, the male respondents, compared to the female ones, show better results in all health-related physical fitness tests ($p < 0.001$), except for the test 'sit-and-reach' ($p < 0.001$).

Table 2 presents the relation between the health-related physical fitness and BMI, after adjusting according to the age, in the male respondents. There was an association between all health-related physical fitness and BMI (all $p < 0.001$), except for Sit-and-reach test ($p = 0.759$).

Table 3 shows the correlation between the health-related physical fitness and BMI after adjusting for age in female respondents. The inspection of the table shows that most of the health-related fitness tests associate with BMI (all $p < 0.000$), except for the fitness tests 'sit-and-reach' ($\beta = -0.005 \pm 0.017$, $p = 0.450$) and 4×10-m shuttle run test ($\beta = 0.100 \pm 0.053$, $p = 0.058$).

The association between health-related physical fitness and body fat percentage are shown in Tables 4 and 5 about male and female participants, respectively. There was an association between all health-related physical fitness tests and body fat percentage in male and female participants (all $p < 0.001$), except for the Sit-and-reach test (male $p = 0.715$; female $p = 0.067$).

Tables 6 and 7 show the association between health-related physical fitness and WC after adjusting to the age and height for male and female participants, respectively. There was an association between all health-related physical fitness tests and WC (all $p < 0.001$), except for the Sit-and-reach test (male $\beta = 0.028 \pm 0.035$, $p = 0.418$; female $\beta = -0.009 \pm 0.034$, $p = 0.797$).

Since in both male and female respondents an interaction between the age and all the health-related physical fitness tests, on one hand, and the percentage of body mass index, on the other hand, was established, we repeated the analysis due to the age groups (6, 7, 8, 9 and 10 years of age) for male and female individually. With the male respondents, a statistically significant correlation between the

Table 1. Characteristics of the study participants by gender

Indicators	All (n = 2197)		Boys (n = 1096)		Girls (n = 1101)		F	Sig.
	Mean	SD	Mean	SD	Mean	SD		
Age (years)	8.63	2.34	8.59	1.32	8.66	3.03	0.54	0.462
Height (cm)	132.73	9.95	133.02	9.72	132.45	10.16	1.80	0.180
Weight (kg)	33.03	9.93	33.58	10.29	32.49	9.53	6.60	0.010
WC (cm)	60.29	8.70	61.39	9.06	59.20	8.19	34.88	0.000
BMI (kg/m ²)	18.41	3.49	18.64	3.66	18.18	3.30	9.51	0.002
Body fat %	23.33	8.04	23.78	7.85	22.88	8.19	6.42	0.011
Sitand reachtest (cm)	15.94	6.40	14.37	6.38	17.50	6.04	138.77	0.000
Handgrip strength (kg)*	12.95	3.66	13.61	3.67	12.30	3.54	72.30	0.000
Standing long jump (cm)	106.38	24.13	112.93	24.34	99.87	22.08	173.05	0.000
30 sec sit ups (n)	12.32	5.59	13.59	5.52	11.04	5.37	120.44	0.000
4×10m shuttle run test (sec)	15.35	2.04	14.90	2.02	15.79	1.96	110.45	0.000
20 m SRT (VO ₂ max)	48.47	3.32	49.25	3.59	47.69	2.81	128.08	0.000

Values are presented as mean and standard deviation. *Values are the mean of right hand and left hand. BMI - body mass index; 20 m SRT, 20 m shuttle run test; WC - waist circumference.

Table 2. Association between health-related physical fitness and body mass index in male children, after adjusting for age

Predictors	β	SE	R ²	P
Sitand reachtest (cm)	-0.005	0.017	0.099	0.759
Handgrip strength (kg)	0.443	0.034	0.221	0.000
Standing long jump (cm)	-0.043	0.004	0.171	0.000
30 sec sit ups (n)	-0.159	0.020	0.149	0.000
4×10m shuttle run test (sec)*	0.436	0.057	0.145	0.000
20 m SRT (VO ₂ max)	-0.458	0.028	0.282	0.000

β – unstandardized beta coefficient; SE – standard error; R² – coefficient of determination. *In the 4×10-m shuttle run test, the greater the score (sec) the worse the performance.

Table 3. Association between health-related physical fitness and body mass index in female children. after adjusting for age

Predictors	β	SE	R ²	P
Sitand reachtest (cm)	-0.012	0.016	0.017	0.450
Handgrip strength (kg)	0.418	0.027	0.200	0.000
Standing long jump (cm)	-0.022	0.005	0.038	0.000
30 sec sit ups (n)	-0.081	0.019	0.034	0.000
4×10m shuttle run test (sec)*	0.100	0.053	0.020	0.058
20 m SRT (VO ₂ max)	-0.524	0.035	0.188	0.000

β – unstandardized beta coefficient; SE – standard error; R² – coefficient of determination. *In the 4×10-m shuttle run test, the greater the score (sec) the worse the performance.

4×10-m shuttle run fitness test and the Body Mass Index percentage was not established with the boys at the age of 6 (p = 0.485); with the female respondents, though, a statistically significant correlation was not established between the Standing-long -jump test and the Body Mass Index percentage in the 6-year-old girls (p = 0.051), and with the 8-year-old girls it was the test 4×10-m shuttle run (p = 0.507).

Since with the male respondents an interaction was established with relation to the age, the Standing-long-jump fitness test and WC, we repeated the analysis for each of the

Table 4. Association between health-related physical fitness and body fat percentage in male children, after adjusting for age

Predictors	β	SE	R ²	P
Sitand reachtest (cm)	-0.014	0.039	0.008	0.715
Handgrip strength (kg)	0.627	0.083	0.061	0.000
Standing long jump (cm)	-0.121	0.010	0.132	0.000
30 sec sit ups (n)	-0.428	0.046	0.085	0.000
4×10m shuttle run test (sec)*	1.221	0.132	0.085	0.000
20 m SRT (VO ₂ max)	-1.073	0.063	0.228	0.000

β – unstandardized beta coefficient; SE – standard error; R² – coefficient of determination. *In the 4×10-m shuttle run test, the greater the score (sec) the worse the performance.

Table 5. Association between health-related physical fitness and body fat percentage in female children, after adjusting for age

Predictors	β	SE	R ²	P
Sitand reachtest (cm)	-0.078	0.043	0.008	0.067
Handgrip strength (kg)	0.579	0.074	0.062	0.000
Standing long jump (cm)	-0.102	0.011	0.079	0.000
30 sec sit ups (n)	-0.368	0.047	0.062	0.000
4×10m shuttle run test (sec)*	0.775	0.132	0.037	0.000

Table 6. Association between health-related physical fitness and waist circumference in male children, after adjusting for age and height

Predictors	β	SE	R ²	P
Sitand reachtest (cm)	0.028	0.035	0.393	0.418
Handgrip strength (kg)	0.358	0.086	0.405	0.000
Standing long jump (cm)	-0.096	0.009	0.452	0.000
30 sec sit ups (n)	-0.350	0.040	0.432	0.000
4×10m shuttle run test (sec)*	1.111	0.114	0.439	0.000
20 m SRT (VO ₂ max)	-0.934	0.057	0.514	0.000

β – unstandardized beta coefficient; SE – standard error; R² – coefficient of determination. *In the 4×10-m shuttle run test, the greater the score (sec) the worse the performance.

Table 7. Association between health-related physical fitness and waist circumference in female children, after adjusting for age and height

Predictors	β	SE	R ²	P
Sit and reach test (cm)	-0.009	0.034	0.316	0.797
Handgrip strength (kg)	0.380	0.090	0.328	0.000
Standing long jump (cm)	-0.078	0.010	0.357	0.000
30 sec sit ups (n)	-0.314	0.040	0.355	0.000
4×10m shuttle run test (sec)*	0.919	0.112	0.358	0.000
20 m SRT (VO ₂ max)	-0.823	0.082	0.376	0.000

β – unstandardized beta coefficient; SE – standard error; R² – coefficient of determination. *In the 4×10-m shuttle run test, the greater the score (sec) the worse the performance.

age groups (6, 7, 8, 9 and 10 years). No significant correlation was observed between the Standing long jump and WC in 6-year-old children ($p = 0.183$; respectively). After excluding age from the analyses conducted and the results persisted, we repeated all the analysis (data not shown).

Discussion

The present study results suggest that the health-related physical fitness, estimated through the tests 'Handgrip strength', 'Standing long jump', '30sec sit up', '4×10m shuttle run test', '20m shuttle run test' (VO₂ max) are associated with the measures of 'total and central body fat' in boys and girls at the age from 6 to 10 years, after adjusting for the age. The study results correspond with former studies which have been conducted on children and adolescents, and which indicate an association between the health-related physical fitness components, chiefly those of the muscle strength, agility, the percentage of 4×10-m shuttle run test and cardiorespiratory fitness with the total and central Body fat in the children aged from 6 to 10 (Ruiz et al., 2011; Artero et al., 2010). The excess of body fat is an additional load that is very possible to have a negative impact on the fitness performances, especially in the fitness tests where the body is moving in the space or the weight of some body part is to be overcome. However, fit children are possible to possess higher levels of lean body mass in comparison with their unfit counterparts. In most cases, when the individual is physically inactive, the largest component of total energy expenditure is the resting energy expenditure. This may partially explain why fit children have less fat mass than those who are unfit.

In the present study, just as it is in other studies, the correlation between the health-related components and body fat markers is somewhat lower in the female respondents as compared to the male respondents (Gutin et al., 2004; Artero et al., 2010). The most consistent correlations were established for the '20-m Shuttle run test' in both male and female respondents. The results were fairly consistent regardless of the methodology that was used to assess the body fat mass. However, the correlations were stronger when the body fat markers were measured by bioelectrical impedance. Having an excess of body fat can affect to a greater extent the movements which require for body to move in a vertical axis compared to the body moving in a horizontal axis (Artero et al., 2010).

The further results of the study indicate an inverse correlation between the muscular strength and weight-bearing

tests, and between the total and central adiposity, which is in accordance with earlier research works (Okely et al., 2004; Ara et al., 2004; Deforche, et al., 2003; Xu, et al. 2020). The present study shows a negative relation between Standing-long -jump test and the total adiposity in the respondents of both genders.

Studies of earlier research also indicate that the greater body weight is a barrier in doing fitness tests (Gontarev, et al., 2018). In addition, the research results point at the presence of a negative connection of the Sit-ups test with the total and central adiposity in the respondents of both genders.

It is also important to emphasize that the results show a positive connection of the Handgrip strength test with the total and central body fat (Malina et al., 1995; Casajús et al., 2007; Prista et al., 2003). The suggestion is that, in cases of excessive adiposity, the increases of fat-free mass fail due to the necessity of supporting this extra load (Forbes, 1964; Artero et al., 2010; Elezi et al., 2021). This finding indicates that individuals of excessive fat can acquire better results in tests which do not imply conquering a body weight as well as a particular body part (such as the Handgrip strength test, for example), which is relevant to some late study works (Artero et al., 2010; Elezi et al., 2021).

The exercises which aim at improving the muscle strength are recommended by a greater number of health organizations because of their effect on improving the muscle vigour, power, hypertrophy, muscle stamina, agility, coordination as well as prevention of a number of diseases (Pollock et al., 2000; Kell, et al., 2001; Stump et al., 2006; Wolfe, 2006). The results of longitudinal research works suggest that there is a negative correlation between the changes of muscle strength during the childhood-to-adolescence period and the change of the total adiposity; but the correlation between the muscle strength and the changes in the central adiposity is less explicit (Ruiz et al., 2009).

The present study indicates a negative correlation of the cardiorespiratory fitness with the total and central adiposity, which corresponds with previous research works where a sophisticated methodology used to be applied in assessing the body composition of children aged 8 to 11 (Gutin et al., 2004). Lee and Arslanian (2007) have established that the cardiorespiratory fitness is related to the lower values of visceral and abdominal fat, measured by DEXA in 113 American adolescents at the age of 8 to 17 years. The mentioned findings were alike when the anthropometric methods of assessing the total and central adiposity were used (Ortega et al., 2007). Ruiz et al. (2006) established that the cardiorespiratory fitness is inversely associated to the total body mass that is assessed through the sum of five skinfolds with Swedish and Estonian children at the age of 9 to 10 years. In this direction, they also noted that the cardiorespiratory fitness was associated in inverse way with WC in Spanish children (Ortega, et al., 2007) and Swedish ones (Ortega, Ruiz & Sjöström, 2007). Ortega et al. (2007) established that the Spanish adolescents who possessed higher levels of a cardiorespiratory fitness had also a lower abdominal adiposity (assessed with WC). In addition, the studies of longitudinal research point that, regardless of the initial level of cardiorespiratory fitness, its improvements are associated with a lower risk of developing an excessive obesity/fat during the period of adolescence (Ortega et al., 2011).

The correlation observed between agility (i.e. 4 × 10 m shuttle run test) and the total and central adiposity corre-

sponds with the results obtained in earlier research studies with children and adolescents (Ruiz, et al., 2011; Yamborisut, et al., 2011). The data obtained from our study suggests that the excess of body fat in children appears to be the cause of a lower performance in all tests that require a driving force for lifting the body mass both in children and adolescents (Artero et al., 2010).

When it comes to the correlation between the flexibility assessed by the Sit-and-reach test and the total central obesity, the results of former research works are contradictory. In other studies, however, no correlation was established between the flexibility, when assessed through Sit-and-reach test, and the measures of total and central adiposity, and that corresponds with the results obtained in our study (Ceschia et al., 2016; Sacchetti, et al., 2012; Tokmakidis, et al., 2006; Dumith et al., 2010; Malina, et al., 2011).

The present study's results should be considered with a certain degree of precaution. As with any transversal research work, the direction of association cannot be stated; undoubtedly, a reciprocal association between the fitness and obesity might be found. We, though, cannot be absolutely positive that unmeasured confounder factors, such as the diet, physical activity or genetic factor, have no impact on the obtained results. The confirmation of the present study's findings and, consequently, their ruling out with a representative sample of children require further research studies.

This study broadens the findings of earlier research works with children and adolescents which used to show the correlation of health-related physical fitness components, chiefly the muscular strength, agility and cardiorespiratory fitness with the total and central adiposity in children at the age of 6 to 10 years. The fitness assessment should be introduced concerning future epidemiological and intervention studies of children of the mentioned age, since it appears to be an important factor that predetermines future health and wellbeing.

Conclusions

The present study broadens previous findings in children and adolescents which demonstrate correlations between the health-related physical fitness components, chiefly the muscle strength, the agility and cardiorespiratory fitness and total central adiposity. Fitness assessment should be introduced in future epidemiological and intervention studies in school children because it seems to be an important factor determining health.

Conflict of interest

The authors state no conflict of interest.

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ФІЗИЧНА ПІДГОТОВЛЕНІСТЬ ЗА СТАНОМ ЗДОРОВ'Я ПОВ'ЯЗАНА ІЗ ЗАГАЛЬНИМ УМІСТОМ ЖИРУ В ОРГАНІЗМІ ТА В ЦЕНТРАЛЬНІЙ ЙОГО ЧАСТИНІ В ДІТЕЙ ВІКОМ ВІД 6 ДО 10 РОКІВ

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Мета дослідження. Метою дослідження було з'ясувати, чи пов'язана фізична підготовленість за станом здоров'я із загальним вмістом жиру в організмі та в центральній його частині у школярів віком від 6 до 10 років.

Матеріали та методи. У дослідженні брали участь загалом 2197 македонських дітей віком від 6 до 10 років (1096 хлопців та 1101 дівчат). Вимірювання показників фізичної підготовленості за станом здоров'я здійснювали за допомогою модифікованого набору тестів EUROFIT: «Човниковий біг на 20 метрів» (кардіореспіраторна витривалість); «Міцність стискання руки», «Стрибки в довжину з місця» та «Піднімання тулуба в сід із положення лежачи за 30 секунд» (м'язова сила); «Човниковий біг 4×10 метрів» (рухова підготовленість) та «Нахили тулуба вперед із положення сидячи» (гнучкість). Як маркери загального вмісту жиру в організмі та в його центральній частині використовували індекс маси тіла, відсоток жиру в організмі та обвід талії, відповідно.

Результати. Тести «Стрибки в довжину з місця», «Піднімання тулуба в сід із положення лежачи за 30 секунд», «Човниковий біг 4×10 метрів» та «Човниковий біг на 20 метрів» були негативно пов'язані з усіма маркерами загального вмісту жиру в організмі та в його центральній частині у хлопчиків і дівчинок після врахування вікового фактора ($p < 0,01$). Тест «Міцність стискання руки» був позитивно пов'язаний з усіма маркерами загального вмісту жиру в організмі та в його центральній частині ($p < 0,01$). Статистично значущої кореляції між маркерами загального вмісту жиру в організмі та в його центральній частині та тестом «Нахили тулуба вперед із положення сидячи» встановлено не було.

Висновки. Це дослідження розширює попередні результати в дітей і підлітків, які показують кореляції між складовими елементами фізичної підготовленості за станом здоров'я, переважно м'язовою силою, спритністю та кардіореспіраторною витривалістю, і загальним і центральним ожирінням. До майбутніх епідеміологічних та інтервенційних досліджень у школярів слід упровадити оцінку фізичної підготовленості, тому що вона здається важливим чинником, який визначає стан здоров'я.

Ключові слова: кардіореспіраторна витривалість, м'язова сила, рухова підготовленість, діти, ожиріння.

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ORIGINAL SCIENTIFIC ARTICLE

A STUDY OF GRADE LEVEL AND GENDER DIFFERENCES IN ATTITUDE TOWARDS NONLINEAR PEDAGOGY

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Abstract

It is important to remember that learning outcomes are not the only thing students accomplish, but attitude is also a major learning output.

The study purpose was to investigate students' attitudes, especially regarding the attitude toward nonlinear pedagogy (ATNP), according to gender and grade level in Yogyakarta.

Materials and methods. The study involved 1,160 kids who were in fifth grade in primary schools and in eighth grade in secondary schools. A total of 18 schools from around the province were included in the study. The Test of Science Related Attitudes (TOSRA) was used to gather data. This questionnaire is effective for gathering descriptions of students' attitudes toward nonlinear pedagogy scores for a specific set of participants, since it uses the Likert scale.

Results. The study findings show students have quite different levels of excitement for nonlinear science learning. The male students in primary school have a higher positive attitude than the female students do, ($M = 36.75$; $p < 0.001$). The male students exhibit a more eager attitude than the female students do in junior high schools ($M = 35.78$; $p < 0.001$). The data revealed that the male students in secondary schools have more positive attitudes than the female students do ($8.23, M > F$). According to the grade level of the school, the male students' ATNP at the elementary level is more positive than in junior high schools.

Conclusions. The statistics show that students' opinions toward nonlinear teaching are similar in elementary and secondary schools regardless of the grade level of the schools.

Even still, most secondary school students find physical education less enjoyable than it was in elementary school. This fact provides instructors of physical education with user input. This finding is encouraging for students looking for strategies to bridge the gender gap in classroom settings. The effects of nonlinear pedagogy are also explored.

Keywords: attitudes toward nonlinear pedagogy, grade levels, gender, primary and secondary school students.

Introduction

Several studies have shown that primary school students' attitudes toward science shift when they go to secondary school (DeWitt & Archer, 2015; Geesa et al., 2019). Scholars have found that the positive Attitude toward science diminishes between the ages of nine and fourteen, and that the positive attitude toward science decreases in the final couple of years of primary school (Barmby et al., 2008; Pell & Jarvis, 2001). Furthermore, according to Said et al. (2016), young-

sters are enthusiastic to investigate phenomena in the world around them; but, this enthusiasm fades once they approach junior high school, since students anticipate science classes to be more engaging (Pell & Jarvis, 2001). Likewise, there is a changing interest when learning physical education in primary school students chance when they enter secondary school (Bernstein et al., 2011; Sun, 2012; Sun et al., 2014). Phenomena that exist include the presence of that girls get older who do not participate and choose to do so because they simply lack interest in sport (Sun et al., 2014), they were girls clearly undermined them in PE classes (Hortigüela-Alcalá et al., 2021), even there is girl who said "she doesn't like P.E. She always think teachers and her peers made her fun of in P.E, because she looked stupid" (Olafson, 2002).

As a result, elementary and secondary school are the crucial grade levels for studying changes in children's attitudes toward science.

Differences in approach can be one of the problem factors in physical education learning (Syrmpas et al., 2017). There has been a shift in physical education teaching from the traditional teacher-centered approach to a student-centered approach. Teachers put a lot of emphasis on learning that focuses on structured technical skills, not paying attention to the environment and student desires. In a student-centered approach, the teacher is a facilitator, and students are challenged to critically solve problems through individual exploration (Lee et al., 2017; Yi, Chow Jia, Keith Davids, 2017; Yi Chow, 2021).

Although in the traditional teacher-centered approach mostly (usually 80% or more) students enjoy physical education subjects (Jaakkola et al., 2017; Rekaa et al., 2019; Silverman, 2017). Unlike many subjects and those taught in schools, physical education also includes a substantial component of active play, both in the form of individual sports and sports that have a strong appeal to young people. However, there are still useful children up to 20% of children do not enjoy physical education lessons are distracting lessons. In addition, there are indications that more and more students find physical education less relevant, less interest, and less enjoyable (Gard et al., 2013). Student-centered approach, especially in nonlinear pedagogy created a learning environment that facilitated perceived competence, autonomy, and relatedness, thereby potentially enhancing intrinsic motivation and enjoyment during practice (Lee et al., 2017).

Nonlinear pedagogy is a powerful paradigm for understanding human movement by designing effective learning, coaching, and training programs in sports, sports, and physical education. This type of pedagogy of complexity inherent in learning has a focus on the movement skills of learners, the learning environment, and the teacher or trainer as a complex interacting system (Yi, Chow Jia, Keith Davids, 2017). In this nonlinear pedagogy, the focus is on ecological dynamics. Ecological dynamics is a theoretical perspective that views skill behavior (psychomotor) from the interaction of constraints at the level of perceptual-motor interaction. From this perspective, the acquisition of expertise in individual and team sports is based on continuous interaction between individual learners and application in more specific sports (Davids, 2012).

Physical education is one of the subjects used in the 2013 curriculum in Indonesia which applies student centered learning. Physical education (P.E.) also an important part of the national education program, and it aims to improve physical fitness, movement skills, critical thinking skills, social skills, reasoning, emotional stability, moral action, a healthy lifestyle, and the introduction of a clean environment by providing learning experiences that are organized and carried out systematically based on the values of faith and devotion to God Almighty (Sutapa et al., 2020).

The principle of nonlinear pedagogy that leads to Social Skills is a skill taught through learning at school, which is useful for socializing with fellow students, the school environment and the students living. Learners during the learning process must practice in a setting representative of the performance environment to develop functional abilities (Representativeness) (Renshaw & Chow, 2019), In this case,

the child must be able to communicate and socialise to develop new movements. Learners can also practice together and communicate in the hope that it can be directed to the results of learning actions not only from their body movements (Attentional Focus) (Komar et al., 2019). A non-linear pedagogical also has perspective based on a student centre approach has the potential to increase intrinsic motivation and enjoyment during practice (Lee et al., 2017).

One of the skills that lead to the principle of nonlinear pedagogy in 21st-century learning, 4C, namely 1) Communication is an activity to transfer information both orally and in writing (Hidayatullah et al., 2021). Social skill is included in communication skills because good communication will also have a good social impact (Cronin et al., 2020). 2) Collaborative (collaboration) Is the ability to collaborate or work together, synergize with each other, adapt to various roles and responsibilities, work productively with others; put empathy in its place, and social skills (Social skills) are important to support the role in collaboration (Lee et al., 2014).

In general, each nation has its own set of traditions, cultures, and educational systems, all of which influence attitudes and behavior toward learning. Nonetheless, few Indonesian scholars are worried with students' attitudes, particularly in communication. In Yogyakarta, most teachers ignore the formation of a good attitude in favor of focusing on academic accomplishment. The attainment of these goals, however, does not imply a shift in students' attitudes about scientific study. As a result, the present research is keen to look at students' views toward science depending on their gender and the grade level of the schools they attend, as well as any interactions between the dimensions in terms of their opinions. In a nonlinear approach, the examination of this subject will yield data concerning the students' perception and confidence in science. Scholars and educators may be able to figure out changes in students' communication attitudes in Indonesia, particularly in Yogyakarta, now that the data are available. As a result, the research of communication attitudes in relation to the views of Indonesian students will add to the literature in the area of scientific education.

Materials and methods

Study participants

This research enlisted the participation of 1,160 students from nine elementary and junior high schools. The participants were chosen using the stratified random sampling approach. Students at elementary and junior high schools range in age from 11 to 14. The study was carried out in the Indonesian province of Yogyakarta. This province is located in the west of Indonesia. The distribution of samples is shown in Table 1 below.

Table 1. Distribution of the Sample Based on Gender and Grade of School

Gender	Grade of School		Total
	Elementary	Junior High School	
Male	253	268	521
Female	310	329	639
Total	563	597	N: 1160

Study organization

In this study, a quantitative research design was used. Students' opinions about nonlinear approach science were evaluated using a questionnaire, depending on two variables: gender and school grade. To reach the study's goal, the researchers used TOSRA (Test of Science Related Attitudes). Five scores describe diverse facets of attitudes toward nonlinear approach learning: career interest in sports science, leisure interest in sports science, attitude toward scientific inquiry, nonlinear science's social communication implications, and pleasure of nonlinear lessons. TOSRA offers independent scores to many different areas, according to Eccles (2007), making it simpler for educators and researchers to assess students' communication attitudes.

Instrumentation

The following was the basic process of the current study: selecting the pupils' attitudes, especially students' communication attitudes toward nonlinear science learning as the focus; reviewing relevant literature; identifying the research question; selecting appropriate measuring instruments for the study; selecting schools for the sample; selecting school grade levels for the sample; and selecting an area for the sample. The TOSRA was the equipment that was utilized to acquire the data. Kurniawan (2019) adapted the TOSRA questionnaire, which was originally devised by Fraser (1978). The questionnaire was used to find out how students felt about scientific classes. Fraser (1978) created a TOSRA questionnaire with 70 questions divided into seven scales with ten statements each. TOSRA is a well-designed questionnaire for ATS research (Navarro et al., 2016). This survey was created as a condensed version of the TOSRA. This study used five TOSRA scales that were relevant to the investigation. The societal consequences, especially communication attitudes of science, the normalcy of scientists, pleasure of nonlinear science classes, leisure interest in nonlinear science learning, and interest in a career in sport science are the measures that were chosen. The methods of selecting five chosen items were Squared Multiple Correlation and Alpha If Item Deleted. The alpha scale on these scales ranges from .76 to .89.

The researchers adapted Fraser's dimensions of attitudes toward science learning, which are: (a) communication attitude to nonlinear learning – students' preferences

regarding scientific inquiry in a nonlinear science learning; (b) students' career interests – a professional interest in the field of sport science; (c) leisure activity related to sport science – students are interested in being involved in nonlinear science learning-related activities outside of school in their spare time.

The Cronbach's coefficient was used to measure the internal consistency reliability of TOSRA scales. Cronbach's Alpha Reliability Coefficients for nonlinear scientific learning attitudes .82, enjoyment of nonlearning science lessons .75, leisure interest in nonlinear science .80, nonlinear science learning's social implications .83, and a desire to pursue a career in sport science .80. Students were asked to use the Likert scale to indicate whether they strongly agree (SA), agree (A), undecided or neutral (N), disagree (DA), or severely disagree (SD) with each statement of the instrument.

Students' Attitude Towards Nonlinear Pedagogy (ATNP) was determined via interviews. The questions were: Do you enjoy nonlinear science lessons in the classroom? Do you want to participate in nonlinear scientific learning activities outside of the classroom? Do you wish to work in the field of sport science in the future? Is there a beneficial impact of nonlinear scientific learning on society? Following the distribution of the questionnaire, 92 students (45 men and 47 females) were asked to participate in an interview session. They were chosen based on their attitude ratings, which were divided into three categories: low, medium, and high. Individual interviews lasted around 5-10 minutes. Their perspectives were utilized to back up the quantitative results.

Statistical analysis

Descriptive data analysis was conducted separately and collectively for each grade level and gender, as well as for the two aspects of attitude. The t-test and two-way ANOVA were used after the assumption tests, which included normality ($p > 0.05$) and homogeneity ($p > 0.05$). The t-test was used to see whether there was any correlation between students' ATNP and other characteristics of respondents, such as gender and school grades. The TOSRA questionnaire's mean scores were compared by gender and grade using the ANOVA method. The main impact of both gender and school grade level, as well as the interaction effect of those two factors, were investigated using a two-way ANOVA approach.

Table 2. Dimensions of the Test of Science Related Attitudes (TOSRA)

Dimensions	Description	Item
Communication attitude to nonlinear science learning	Students' preferences on the attitude of communicating with others	1, 2, 3, 4, 5
Social Implications of nonlinear science learning	The positive and negative attitudes regarding the impact of nonlinear science learning on society	6, 7, 8, 9, 10
Students' career interests	Students' future interest in sport science	11, 12, 13, 14, 15
Leisure activity related to sport science	Students want to participate in science-related activities outside of school in their leisure time	16, 17, 18, 19, 20
Enjoyment of nonlinear science learning lessons	The level of students' enjoyment of nonlinear science learning	21, 22, 23, 24, 25
Total		25 items

Results

Attitudes Toward Nonlinear Science Related to Gender

The researchers looked at gender-based disparities in students' ATNP using the statistical approach of t-test. Male and female pupils had statistically differing SATNP, according to the statistics. The sentiments of women were more favorable than those of men. Table 3 shows the differences in ATNP between male and female students. According to Cohen's criterion (1988), female attitudes ($M = 3.79$; $SD = 0.47$) were more favorable than male attitudes ($M = 3.57$; $SD = 0.59$) with a medium effect size ($d = 0.54$).

Table 3. t-test for ATNP Based on Gender

Gender	N	Mean	SD	Df	t-value	Effect size
Male	521	3.57	0.59	1041	14.75**	0.54
Female	639	3.79	0.47			

Note:** $p < .001$

Table 4 illustrates the students' ATNP on the five TOSRA scales depending on gender differences. Overall, the TOSRA scales demonstrate a significant difference between men and females ($p 0.001$) (Table 4).

The findings showed that the average score for social consequences of science was higher than that of the other categories. Male students' mean scores ($M = 4.02$; $SD = 0.67$) are higher than female students' mean scores ($M = 3.96$; $SD = 0.54$).

Communication attitude to nonlinear Science learning receives the lowest rating across all measures for both sexes. On that scale, the mean scores for female students are ($M = 3.43$; $SD = 0.51$) and for male students are ($M = 3.36$; $SD = 0.82$).

Table 4 demonstrates that men scored higher than women for career interest in sport science. On this scale, there is a considerable difference between men and females ($M = 3.65$; $SD = 0.52$; $M = 3.25$; $SD = 0.36$). This suggests that male students favor selecting a profession as a sport science. The

scale of leisure activity related in sport science also shows a significant difference between men ($M = 4.02$; $SD = 0.67$) and females ($M = 3.64$; $SD = 0.43$).

The students' Enjoyment of nonlinear science learning lessons makes up the third TOSRA rating in the questionnaire. The amount of science-related leisure activities also differs significantly between men and women on this measure. As a result, male students scored higher than female students ($M = 3.69$; $SD = 0.70$) ($M = 3.55$; $SD = 0.80$).

SATNP Related to Grade of School

The findings showed that the average score for social consequences of science was higher than that of the other categories. The average rating of Table 5 presents SATNP in elementary and junior high schools for the purpose of assessing SATNP in various grade levels. The data shows there is no discernible difference between the seventh grade of secondary school and the fifth grade of elementary school on the SATNP.

The statistics demonstrate that the mean attitude score of Elementary school students ($M = 3.74$; $SD = 0.54$) is more favorable than that of students in junior high school ($M = 3.68$; $SD = 0.50$), even if this result suggests that the difference was very insignificant.

Attitudes toward Nonlinear Pedagogy Related to Gender and The Grade of The School

The main impact and interaction of gender and grade level were statistically examined using the two-way ANOVA method. Table 7 displays the findings from the TOSRA survey on students' attitudes toward nonlinear pedagogy.

According to this research, men and women have quite different levels of excitement for nonlinear science learning. Boys in primary school have a higher positive attitude than females do, as seen in Table 7 ($M = 36.75$; $p < 0.001$). Boys exhibit a more eager attitude than Females do in junior high schools ($M = 35.78$; $p < 0.001$).

According to Table 8, male primary school pupils are more optimistic than female students. This state persisted

Table 4. Performance of ATNP Based on Gender for Each Scale

Scale	Male (N=521)		Female (N=639)		Mean Difference	t-test
	Mean	SD	Mean	SD		
Communication attitude to nonlinear Science learning	3.36	0.82	3.43	0.51	0.07	4.20**
Social Implications of nonlinear science learning	3.79	0.68	3.96	0.54	0.17	5.20**
Students' career interests	3.65	0.52	3.25	0.36	0.40	8.25**
Leisure activity related to sport science	4.02	0.67	3.64	0.53	0.38	8.06**
Enjoyment of nonlinear science learning lessons	3.69	0.70	3.55	0.80	0.14	4.88**

Table 5. Performance of SATNP Based on Different Grades of School

Level of School	N	Mean	SD	Df	t-value	Effect size
Elementary School (ES)	563	3.74	0.54	1031	1.90	0.14
Junior High School (JHS)	597	3.68	0.50			

Table 6. The Differences of SATNP Based on Grade for Each Scale

Scale	Elementary (N=563)		Junior High (N=597)		Mean Difference	t-test
	Mean	SD	Mean	SD		
Communication attitude to nonlinear Science learning	3.80	0.67	3.53	0.51	0.27	1.25
Social Implications of nonlinear science learning	3.75	0.70	3.72	0.67	0.03	0.79
Students' career interests	3.68	0.62	3.35	0.41	0.33	1.90
Leisure activity related to sport science	3.93	0.67	4.01	0.62	0.08	1.30
Enjoyment of nonlinear science learning lessons	3.86	0.80	3.54	0.80	0.32	6.78**

**p < 0.01

Table 7. Analysis of SATNP Interaction by Grade Level and Gender

Source	SS	Df	MS	M
Gender	16.88	1	16.88	70.10**
Grade	1.70	1	1.685	7.02*
Gender * Grade	0.002	1	0.002	0.008

Note: **p < 0.001; *p < 0.05

Table 8. Simple Main Effect Analysis by Gender and School Grade for SATNP

Source	SS	Df	MS	F	Sig	Post Hoc
Gender						
Male	1.23	1	1.23	5.62*	0.03	E>S
Female	0.73	1	0.73	2.43	0.21	
Grade						
Primary	9.12	1	9.12	35.83***	0.000	M>F
Secondary	8.23	1	8.23	34.72***	0.000	M>F

***p < 0.001; *p < 0.05

into junior high school. According to the study, male secondary school students are more optimistic than female pupils. Male students' ATNP at the elementary level are more favorable than those at junior high schools, according to the school's grade level.

Discussion

Based on gender disparities across the five TOSRA scales, students' ATNP reveals that boys' mean scores are somewhat higher than girls', though not considerably. This demonstrates that both men and women are interested in understanding how sports science applies to daily life. They start to understand that using sports science will improve their life. Particularly among female students, students' perspectives regarding the social consequences of science had a significant role in deciding their choice of scientific electives (Jerrim & Schoon, 2014). Many educators believe that students' perspectives on the social aspects of science may influence their choice of a future profession in science (Osborne et al., 2003).

The findings indicate that some students are comfortable with doing experiments to identify motions and prac-

tice them while learning about sports education, and they favor nonlinear pedagogical learning since it may be effective. during learning, particularly in sport science-related tasks. According to the interview data, some students are interested in doing experiments including sport motions, but they are hesitant to do so due to a lack of confidence. Students are affected by it as well. The teacher is expected to be able to help students in carrying out the movements made by these students. Students should be encouraged to feel confident in their findings and content with their efforts to do scientific research (Toma et al., 2019). By performing experiments, science instructors are meant to change the students' attitudes about science. This practice could serve as an alternate strategy for boosting students' interest in science lesson. According to interview data, which demonstrate that sport students aspire to be athletes or work in the sports sector, the data suggest that male students are more interested in the career of sport science. According to Susilawati et al (2022) study, male Indonesian students score higher on the ATNP in sport science than female students do. According to the results of the interviews, female students want to become physicians, work in a lab, teach science, be an architect, or something similar, whereas male students want to become police officers, soldiers, soccer players, sports, etc. Male students are more interested in physical activities than other pursuits, as seen by this data.

Males are more interested in sport science than females do, according to the feature of leisure interest in the field. This result supports earlier research. Researchers have repeatedly discovered that most females are more physically inactive than boys (Nader et al., 2008; Pugliese & Tinsley, 2007). Shropshire et al (1997) also found Boys were shown to be less influenced by environmental influences and to be much more engaged in physical education than females. Compared to the males, the girls exhibited a more favorable attitude toward the instructor and showed less care for how the curriculum was organized. After learning about sport science, they like to talk about it. Contrary to male students, female students find viewing sports programs on TV, listening to sports discussion on the radio, and discussing sports with friends after school to be boring. In the interviews, more male students than female students indicated a desire to attend sporting events on the weekends. In a nutshell, this finding provides science instructors with critical input to assist them improve female students' attitudes toward sport science. It is proposed that in order to encourage their pupils

to study about sport science, the instructors may set up field excursions.

The TOSRA scale shows no significant difference between elementary and junior high schools for the interest scale in a career in sports science, leisure interests in sport, attitudes towards sport investigation, and the social implications of sport science. Students in grades five and seven have the same ATNP, according to the results. The fact that students express a strong desire to engage in sports science courses lends credence to this condition. According to research, students in both school classes are open to pursuing professions in athletics, which is related to the pursuit of jobs in sports science. They believe it would be fascinating to pursue such a career. The findings indicated that both groups' pupils responded more positively to phrases like "my future aspiration is to be an athlete or in the sports sector."

In a word, pupils in elementary and junior schools have comparable favorable opinions of nonlinear instruction. The TOSRA scores demonstrate this fact: they are interested in jobs in sport science, they like playing sports for fun, they have a positive communicative attitude toward nonlinear scientific learning, and they are aware of the social consequences of nonlinear science learning. However, the interest in science among elementary school pupils who transfer to junior high schools sharply decreases. Related to the level of schools, male students' ATNP in elementary schools are better than in junior high schools. However, when they enter junior high school their attitude toward nonlinear pedagogy declines slightly. As a result, the practical significance of this difference seems dubious. Moreover, even though the female students' attitudes are less positive than those of the male students, their attitudes tend to be the same between elementary and junior high school. This study shows that male students in elementary schools feel more enthusiastic in physical education class. Similarly, male students exhibit more enthusiasm than females do in junior high schools.

Conclusions

At both levels of education, the findings indicate that male students had a higher positive ATNP than female students. Higher specifically, across the board, male students had more positive ATNP than female students. Students in higher grades score less favorably on attitude than those in lower grades. This situation is a reflection of the wider trend affecting physical education instruction in Yogyakarta Province. It suggests that boys are more enthusiastic about science than females are. This unexpected result is in contrast to earlier research. Numerous studies have shown that women generally have more favorable opinions about science than men do. However, the interviews revealed that male students showed more interest in sports science activities than female students did. Male students routinely work more than female students, and as a result, they are better suited to handle the demands of learning than their female peers are.

The data shows that there is no discernible variation in students' ATNP between the fifth grade of elementary school and the seventh grade of junior high school, according to the grade of the schools. The results demonstrate that the mean score of the students' attitude in elementary schools is higher than in secondary schools, despite the fact that this

finding suggests that the differences are extremely modest. It is noteworthy that Yogyakarta pupils disclose that their ATNP is the same in the province's primary and junior high schools, contrary to previous studies. However, children's enthusiasm for science greatly decreases as they attend junior high school. This outcome provides physical education instructors with valuable feedback as they work to maintain the students' favorable perception of nonlinear pedagogy.

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Conflict of interest

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ДОСЛІДЖЕННЯ СТАВЛЕННЯ УЧНІВ ДО НЕЛІНІЙНОЇ ПЕДАГОГІКИ ЗАЛЕЖНО ВІД РОКІВ НАВЧАННЯ ТА ГЕНДЕРНИХ ВІДМІННОСТЕЙ

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Реферат. Стаття: 7 с., 8 табл., 36 джерел.

Важливо не забувати, що результати навчання – це не єдине досягнення учнів, а ставлення також є важливим здобутком навчання.

Мета дослідження. Метою цього дослідження було вивчення ставлень учнів, особливо стосовно ставлення до нелінійної педагогіки (СДНП) у місті Джок'якарта (Індонезія) відповідно до гендера та років навчання.

Матеріали та методи. У дослідженні брали участь 1160 дітей: учні п'ятих класів початкової школи та учні восьмих класів середньої школи. До участі в дослідженні були включені загалом 18 шкіл з усієї провінції. Для збору даних використовували «Тест науково пов'язаних ставлень» (TOSRA). Ця анкета є ефективною для збору описів ставлень учнів до оцінок нелінійної педагогіки для конкретної групи учасників, оскільки в ній використовується психометрична шкала Лайкерта.

Результати. Результати дослідження показують, що учні мають абсолютно різні рівні ентузіазму до нелінійного навчання наук. У початковій школі учасники чоловічої статі виявляють вищий ступінь позитивного ставлення, ніж учасники жіночої статі ($\chi^2 = 36,75$; $p < 0,001$). У молодших класах середньої школи учасники чоловічої статі виявляють завзятіше ставлення, ніж учасники жіночої статі ($\chi^2 = 35,78$; $p < 0,001$). На основі одержаних даних було встановлено, що в середніх школах учасники чоловічої статі мають більше позитивних ставлень, ніж учасники жіночої статі (8,23, $\chi^2 > \chi^2$). Відповідно до років навчання у школі, СДНП учасників чоловічої статі, які навчаються в початковій школі, є позитивнішим за СДНП учасників чоловічої статі, які навчаються в молодших класах середньої школи.

Висновки. Статистичні дані показують, що ставлення учнів до нелінійного викладання є аналогічними в початковій і середній школах, незалежно від років навчання в цих школах. Тим не менш, більшість учнів середньої школи вважає, що фізичне виховання приносить менше задоволення, ніж у початковій школі. Для вчителів фізичного виховання цей факт є вхідним сигналом від користувачів. Цей результат є обнадійливим для учнів, які шукають стратегії подолання гендерної нерівності в умовах навчального класу. Впливи нелінійної педагогіки також досліджуються.

Ключові слова: ставлення до нелінійної педагогіки, роки навчання, гендер, учні початкової та середньої школи.

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ORIGINAL SCIENTIFIC ARTICLE

RESTING HEART RATE AND CARDIOVASCULAR ENDURANCE OF PROVINCIAL CRICKETERS AND MIDDLE-DISTANCE RUNNERS: AN OBSERVATION

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Abstract

Resting heart rate is a reliable biomarker for measuring fitness in terms of cardiovascular health as well as analyzing an athlete's recovery.

The study purpose was to explore the resting heart rate and cardiovascular endurance of the cricketers and middle-distance runners of West Bengal.

Materials and methods. Forty male sub-elite athletes with a mean age of 19.8 ± 2.4 years, height of 1.66 ± 0.05 m, and body mass of 55.5 ± 7.0 kg were randomly selected and categorized as cricketers (20) and middle-distance runners (20). Five-minute RR intervals were recorded during a resting state in the supine position using a Polar V800 smart watch along with a Polar H10 chest strap and a Polar H7 heart rate sensor. Cardiovascular endurance (predicted VO_{2max}) was measured using the Yo-Yo intermittent recovery test Level 1.

Results. Mean resting heart rate, SDNN, rMSSD, pNN50, and predicted VO_{2max} of cricketers and middle-distance runners have been found to be 57.2 ± 5.9 bpm, 53.5 ± 26.6 ms, 68.4 ± 36.8 ms, $40.9 \pm 23.2\%$, and 48.4 ± 1.7 ml/kg/min and 61.7 ± 7.3 bpm, 47.0 ± 18.8 ms, 59.2 ± 27.3 ms, $32.4 \pm 20.9\%$, and 49.0 ± 2.2 ml/kg/min, respectively. No significant difference was observed in time domain parameters and predicted VO_{2max} , but a significant difference ($p=0.033$) was observed in resting heart rate of two groups. A significant negative ($r=-0.62$, $p<0.001$) association has been observed between resting heart rate and predicted VO_{2max} .

Conclusions. The low resting heart rate of the cricketers may possibly have come from higher training load borne by the young players. Based on the players' predicted VO_{2max} , it looks like having good cardiovascular fitness is just as important in modern cricket as it is in middle-distance running.

Keywords: heart rate variability, time domain analysis, VO_{2max} , Polar, Yo-Yo test.

Introduction

Heart rate (HR) has been used for a range of intents under clinical, industrial, and sports settings (Nunan et al., 2010; Baggish & Wood, 2011; Nes et al., 2013). In the clinical perspective, 60-100 beats/min is taken as normal range (sinus rhythm) of resting heart rate (RHR) (Olshansky et al., 2022). Many studies have reported the resting heart rate values of the sports persons (Jensen-Urstad et al., 1997; Rexhepi & Brestovci, 2014; Biswas, 2020). Effective training programs

according to the HR zone can be set if RHR is known (Plews et al., 2013; Vesterinen et al., 2013; Reimers et al., 2018). Numerous studies express that RHR increased due to parasympathetic type of overtraining (Fry et al., 1991; Jensen-Urstad et al., 1997; Berkoff et al., 2007; Reimers et al., 2018). It is well known that Yoga reduces RHR significantly because of its aerobic nature (Biswas et al., 2021). Endurance training also reduces RHR by increasing end diastolic volume (Plews et al., 2013). Studies on RHR and heart rate variability (HRV) are important to identify the training effect, health status, and presence of a clinical state (Baggish & Wood, 2011; Olshansky et al., 2022). On the other hand VO_{2max} is an important marker for understanding cardiovascular

efficiency (Hoque, 2019). The association between RHR and cardiovascular endurance is well documented, but limited research has been conducted on the variation of resting heart rate and cardiovascular endurance of sub-elite cricketers and specialized middle distance runners. Thus, the present study was carried out to explore the resting heart rate and cardiovascular endurance of the cricketers and middle distance runners of West Bengal.

Materials and methods

Study participants

Forty male volunteers were randomly selected from various districts of West Bengal and categorized into two groups: cricketers (20) and middle distance runners (20). All the cricketers who were registered members of the Cricket Association of Bengal (CAB) and West Bengal Athletic Association (WBAA) affiliated 800m and 1500m runners were included in the study. All the volunteers had been trained for more than three years and had competed for their districts at the state level. According to the ECG results, all of the volunteers were free of any cardiovascular disease (Kossmann, 1953). They were also informed about the study content and provided written consent in accordance with the Ramakrishna Mission Vivekananda Educational and Research Institute's academic and research ethics code.

RR intervals recordings

The test technique was explained to all volunteers prior to the testing. The volunteers did not consume anything for at least one hour before the test. Individuals were asked to breathe normally during the RR interval recordings. After 10 minutes of relaxation in a supine position, RR intervals were continually recorded using a Polar heart rate monitor (Polar V800 smart watch with H7 Bluetooth sensor). After two minutes of stabilization, RR intervals were obtained for five (5) minutes. The data was taken in a quiet room between 11:30 a.m. and 3:30 p.m.

Cardiovascular endurance

The Yo-Yo intermittent recovery test Level 1 (YYIR1) was conducted on the same day of RR intervals recording in the afternoon session (between 4:30p.m. and 5:30p.m.) to measure predicted VO_2max . According to the YYIR1 protocol, the volunteers were instructed to perform the test (Bangsbo et al., 2008). A test run was also conducted by the researcher to clear the test protocol. The predicted VO_2max was measured using the formula of Jens Bangsbo (predicted $\text{VO}_2\text{max} = \text{IR1 total distance covered (m)} \times 0.0084 + 36.4 \text{ ml/kg/min}$).

Data sorting

Polar flow sync app was used to export the raw data files to the computer. The Kubios HRV Standard software (version 3.3.1) was used to analyze the time domain parameters. The calculations included the NN interval (from the filtered RR interval), SDNN, rMSSD, and pNN50 (Shaffer & Ginsberg, 2017).

Statistical analysis

Shapiro Wilk normality test was applied to understand the distribution pattern of the data set and majority of individual centric data sets fitted into the normal distribution curve, so parametric significance test, paired sample T test was applied to find out the significance differences if any between the groups. According to the patterns all the data were expressed as Mean $\pm$ Standard deviation. Gnumeric spreadsheet software version 1.10.16 and IBM Statistical Package for Social Sciences (SPSS) ver. 20 and were used for analysis and graphical presentation. The level of significance was set at $\alpha \leq 0.05$.

Results

The demographic characteristics of two groups are shown in Table 1. No significant difference has been found in chronological age of the volunteers, but significant differences were found in height, body mass and BMI of two groups. The body mass of middle distance runners was significantly lower than that of cricketers. The cricketers were significantly taller than the athletes.

Table 1. Basic physical variables of cricketers and middle distance runners

Variables	Cricketers	Middle distance runners	P value
Age (years)	19.1 $\pm$ 2.1	20.4 $\pm$ 2.5	0.69
Standing height (m)	1.69 $\pm$ 0.02	1.63 $\pm$ 0.05	6.9 ^{e-5}
Body mass (kg)	60.3 $\pm$ 3.9	50.7 $\pm$ 6.2	2.5 ^{e-6}
BMI (kg/m ²)	21.1 $\pm$ 1.2	19.0 $\pm$ 1.6	1.2 ^{e-6}

Table 2 displays the values of NN interval, SDNN, rMSSD and pNN50 according to groups. The NN interval of middle distance runners was significantly lower than the cricket players, which indicates a higher resting heart rate of the athletes. The values of time domain parameters of HRV such as SDNN, rMSSD, and pNN50 are lower in athletes than that of cricketers. However, no significant differences are observed in the time domain parameters of two groups.

The figure 1, displayed a clear pictorial view of significant ($r = -0.62$, $p = 1.51\text{E-}5$) negative relationship between pre-

Table 2. Analysis of RR intervals and time domain parameters of HRV are displayed in the below noted table using Kubios HRV Standard software (version 3.3.1).

Parameters	Cricketers	Middle distance runners	P value
NN intervals (ms)	1065.2 $\pm$ 84.1	997.7 $\pm$ 111.7	0.0238
SDNN (ms)	53.5 $\pm$ 26.6	47.0 $\pm$ 18.8	0.3527
rMSSD (ms)	68.4 $\pm$ 36.8	59.2 $\pm$ 27.3	0.3633
pNN50 (%)	40.9 $\pm$ 23.2	32.4 $\pm$ 20.9	0.2524

dicted VO_2max and resting HR. The regression equation to predict predicted VO_2max (Y) in reference to RHR (X) has been found $Y = -0.23 X + 62.01$ with $R^2 = 0.39$.

The pooled RR intervals for cricketers and middle distance runners have been found to be 1059 $\pm$ 105ms and 987 $\pm$ 124ms respectively. All the pooled RR intervals were converted into HR. The mean RHR of the cricketers and middle

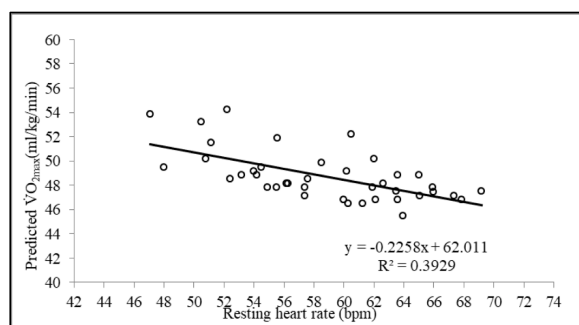


Fig. 1. Relationship between resting heart rate and predicted VO_2max

distance runners have been found 57.2 ± 5.9 bpm and 61.7 ± 7.3 bpm respectively. A significant difference ($p = 0.0328$) has been observed in pooled RHR among the two groups. The predicted VO_2max of the cricketers and middle distance runners have been found to be 48.40 ± 1.69 ml/kg/min and 48.95 ± 2.18 ml/kg/min respectively but did not exhibit any significant difference ($p=0.29$). Although the 95% confidence intervals for HR variation in cricketers and middle distance runners were only slightly different, it was found to be 47.8–64.8 bpm and 46.9–69.0 bpm, respectively. Wide fluctuation in the RHR has been noticed in both groups' volunteers in five-minute segments.

Discussion

The observation of taller players in cricket may have come from the natural selection process where relatively less affluent populations take part in athletics compared to cricket in India. Economic conditions might also influence the height and weight of the players in the same age group. According to chronological age, both groups are similar, but physical structure transformed them into heterogeneous groups. The values of the RHR of both groups are less than the sedentary population (Catai et al., 2002). Rapid fluctuation in RHR has been observed in both groups, which reflects parasympathetic control of the heart (Plews et al., 2013; Biswas, 2020). Although the RHR values of cricketers and athletes are the same as healthy adults in middle Norway (Nes et al., 2013). Time domain parameters such as SDNN, rMSSD, and pNN50 of two groups lie in the normal range, but a relatively high value of time domain parameters has been observed in cricketers (Plews et al., 2013; Shaffer & Ginsberg, 2017). Resting HR of two groups has been observed below normal level (Olshansky et al., 2022). Low RHR, a type of bradycardia, has been observed in both groups (Jensen-Urstad et al., 1997; Plews et al., 2013; Reimers et al., 2018). ECG recorded at rest did not exhibit any arrhythmia or changes that may indicate an abnormal condition of the heart (Kossmann, 1953). In the study, low resting HR at rest indicates parasympathetic dominance (Berkoff et al., 2007). The values of rMSSD and pNN50 also support this observation (Vesterinen et al., 2013; Shaffer & Ginsberg, 2017). The SDNN value of two groups indicates good overall HRV status. A low RHR may be caused by a parasympathetic type of overtraining (Fry et al., 1991). Alteration in the left ventricle may also be the cause of low RHR (Fernandes et al., 2011).

A significantly lower RHR has been observed in cricketers compared to middle distance runners, but no significant difference has been observed in time domain parameters of HRV. From this point of view, only low RHR is unable to express a significant difference in the overall physical state and physiological ability, because the HRV parameters of both groups are merely similar. In recent years, The Cricket Association of Bengal (CAB), implements multi days tournaments (85 overs X 2 days in league stage and 85 overs X 3 days in knockout stage) at the grassroots level, which could be the cause of this acclimatization. The predicted VO_2max of the cricketers was a little higher compared to the cricketers of Kerala, India but lower than elite Australian cricketers (Hoque, 2018). Due to training adaptation, a low resting heart rate has been observed, which is also supported by SDNN and predicted VO_2max . However, the average training years of the cricketers were higher than that of middle distance runners, which may also be the cause of the significantly lower RHR. The observed relationship between resting heart rate and predicted VO_2max is also supported by the findings of Agron and Behlul (2014).

The findings of time domain parameters in the study, such as SDNN and rMSSD values, are lower than elite American track and field athletes (Berkoff et al., 2007). The findings of the RHR of athletes and cricketers are relatively lower than the observations of Jensen-Urstad et al. (1997) and Martinelli et al. (2005). A higher SDNN value has been observed in cricketers than in Brazilian athletes (Martinelli et al., 2005). The findings of the RHR of the cricketers are lower than those of Indian field hockey players (Manna et al., 2009) but higher than the findings of Finland's marathon training runners (Vesterinen et al., 2013).

Conclusions

Bradycardia was discovered in the cricketers and middle-distance runners. The study explores the resting heart rate and predicted VO_2max of the cricketers and middle distance runners, which will help coaches and physical trainers to create HR guided training regimens, understand morning readiness as well as overtraining syndrome. RHR derivative regression equation can be useful for determining predicted VO_2max of grassroots level players.

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Conflict of interest

The authors declare no conflict of interest for this study.

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ЧСС У СТАНІ СПОКОЮ ТА СЕРЦЕВО-СУДИННА ВИТРИВАЛІСТЬ ПРОВІНЦІЙНИХ ГРАВЦІВ У КРИКЕТ І БІГУНІВ НА СЕРЕДНЮ ДИСТАНЦІЮ: СПОСТЕРЕЖЕННЯ

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Показник частоти серцевих скорочень у стані спокою є надійним біомаркером для вимірювання фізичної підготовленості в частині здоров'я серцево-судинної системи, а також для аналізу відновлення спортсмена.

Метою дослідження було вивчення ЧСС у стані спокою та серцево-судинної витривалості гравців у крикет і бігунів на середню дистанцію зі штату Західна Бенгалія (Індія).

Матеріали та методи. Учасниками дослідження стали 40 висококласних спортсменів регіонального рівня чоловічої статі середнім віком $19,8 \pm 2,4$ року, зростом $1,66 \pm 0,05$ м та з індексом маси тіла $55,5 \pm 7,0$ кг, які були відібрані випадковим чином і поділені на категорії гравців у крикет (20) та бігунів на середню дистанцію (20). Реєстрували п'ятихвилинні кардіоінтервали (RR-інтервали) у стані спокою в положенні лежачи на спині з використанням смарт-годинника «Polar V800» разом із нагрудним ременем-пульсометром «Polar H10» і датчиком ЧСС «Polar H7». Вимірювання показників серцево-судинної витривалості (прогнозоване значення максимального споживання кисню – МСК) здійснювали за допомогою інтервального тесту на відновлення Йо-Йо, Рівень 1.

Результати. Було встановлено, що середні показники ЧСС у стані спокою, статистичного відхилення нормальних RR-інтервалів (SDNN), стандартного відхилення RR-інтервалів (rMSSD), відсотку послідовних RR-інтервалів із відмінністю понад 50 мс (pNN50) та прогнозованого МСК гравців у крикет і бігунів на середню дистанцію дорівнюють $57,2 \pm 5,9$ уд./хв, $53,5 \pm 26,6$ мс, $68,4 \pm 36,8$ мс, $40,9 \pm 23,2\%$, $48,4 \pm 1,7$ мл/кг/хв та $61,7 \pm 7,3$ уд./хв, $47,0 \pm 18,8$ мс, $59,2 \pm 27,3$ мс, $32,4 \pm 20,9\%$, $49,0 \pm 2,2$ мл/кг/хв відповідно. Жодної статистично значущої різниці параметрів у часовій області та прогнозованого МСК не спостерігалось, але спостерігалася статистично значуща різниця ($p=0,033$) показників ЧСС у стані спокою двох груп. Спостерігався статистично значущий негативний ($r=-0,62$, $p<0,001$) зв'язок між ЧСС у стані спокою та прогнозованим МСК.

Висновки. Низький показник ЧСС у стані спокою гравців у крикет, можливо, є результатом вищого тренувального навантаження, яке несуть молоді гравці. З огляду на прогнозований показник МСК гравців, здається, що наявність гарного функціонального стану серцево-судинної системи є не меншою мірою важливою в сучасному крикеті, ніж у бігу на середню дистанцію.

Ключові слова: варіабельність серцевого ритму, аналіз у часовій області, МСК, Polar, тест Йо-Йо.

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ORIGINAL SCIENTIFIC ARTICLE

ASSESSMENT OF TRAINING LOADS OF HIGHLY QUALIFIED BASKETBALL PLAYERS

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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 purpose of the study is: 1) development and unification of a system of training loads monitoring by the nature of the physiological impact on the basketball players' body; 2) study of the strategy of preparing a highly qualified basketball team for important international competitions, namely: to find out the nature of the distribution of means of different physiological, as well as technical-tactical and game orientation at different stages of preparation; 3) test basketball players before and after training.

Materials and methods. A team of highly qualified basketball players (masters of sports and masters of sports of international class) in the number of 15 people participated in the research. The assessment of physical load by the nature of the physiological impact on the body of basketball players during 18 microcycles using 4 – 1 system, that is, 4 working days and 1 day off, was carried out. Athletes were tested before and after training.

Results. The dynamics of the means of training by the nature of the physiological impact on the athletes' body have been established. The nature of the distribution of means at different stages of preparation has been established. The test results before and after training are shown.

Conclusions. The research results showed that a certain accounting system based on assessments of the nature of the tasks to be solved and the degree of compliance with the specifics of their game activities has developed in basketball. At the same time, research have indicated the need for accounting and analyzing of the training loads by the nature of physiological impact on the body of athletes.

Keywords: basketball, training loads, highly qualified basketball players.

Introduction

In the theory and practice of basketball, the issues of planning and managing the training process are resolved, as a rule, based on the experience and intuition of coaches (Kondrashin & Koryahin, 1978; Koryahin, 2018; Anastasiadis, 2006).

Effective management of the training of basketball players is possible only when solving the following tasks (Kondrashin & Koryahin, 1978; Koryahin, 1998): 1) creation of a unified system of accounting and analysis of the training loads; 2) determination of the most effective means and methods of training; 3) optimization of the construction of the training process, i.e. finding ways of the most rational distribution of means and methods of training at different

stages of training; 4) development and unification of the system of control over the level of training of basketball players.

The first step towards creating a unified system of accounting and analysis of the training loads can be the classification of exercises used as training tools according to certain characteristics (Altberg, 1971; Poplavsky, 2004; Semashko, 1976).

The systems developed earlier were built on the basis of assessments of the nature of the technical-tactical tasks being solved and the system of their compliance with the specifics of the game activity of basketball players (Raiola, Altavilla, Tafuri, & Lipoma, 2016; Ben Abdelkrim, Castagna, El Fazaa, & El Ati, 2010; Gonzalo-Skok, Sánchez-Sabaté, Izquierdo-Lupón, & Sáez de Villarreal, 2019). Another approach to systematization is based on accounting of the physiological impact of loads on the body of athletes (Hoare, 2000; Montgomery, Pyne, & Minahan, 2010; Ciuti, Marcello, Macis, Onnis, Solinas, & Lai, 2009).

When establishing the gradations of training loads in basketball, two fundamental approaches can be used (Kon-drashin & Koryahin, 1978):

1. Systematization of exercises, taking into account the characteristics of physical loads.

2. Gradation of loads on the base of accounting of physiological changes in the body of athletes that occur when performing exercises.

However, in basketball, such a determination of the parameters of physical exertion is not always possible and a greater priority should be given to the accounting of the physiological reactions of the body that occur during physical loads. Based on the established ratios between the indicators of physical load and physical shifts in the body, all exercises used in the training of highly qualified basketball players were divided into 4 types of training loads:

1. Aerobic exercises.
2. Exercises of mixed aerobic-anaerobic orientation.
3. Exercises of anaerobic-alactate orientation.
4. Exercises of anaerobic glycolytic orientation.

It should be noted that the determination of the immediate training effect of special exercises and their systematization by the nature of the physiological impact do not yet determine how rationally it will be built as a whole. The main question in this problem is: which and in what volume the exercises should be used? Therefore, it is important to find out what is the strategy of training in basketball, what means are given more attention, what are the dynamics of these means at different stages of training? Clarifying these issues allows us to summarize previous experience and subsequently make adjustments to the training process.

Materials and methods

Participants and research organization

A team of highly qualified basketball players (masters of sports and masters of sports of international class) in

the amount of 15 people took part in the research during the period of preparation for important international competitions. During the training period, a 4–1 microcycle was used, that is, 4 working days and 1 day off. A total of 18 microcycles were performed. During the training period, basketball players were tested in order to determine the level of their physical and technical preparedness before and after training. The following tests were used: 6 m and 20 m run, jumping height, shots from the spot (the number of hits out of 40 shots and the time of operation were determined), free throws out of 30 (number of hits), running across the court from one front line to another 3 times for 40 seconds after 1 minute of rest (number of meters covered), Cooper test (Koryahin, 1998; Koryahin, Hrebinka, Prystynskyi, & Prystynska, 2022).

Statistical analysis

To maintain a laboratory journal, to perform operations on sorting the results obtained and their storage, and to calculate statistical data, the MS Excel program was used. The choice of mathematical statistics methods was an adequate to the goals and objectives of our study and included the use of the following methods: the arithmetic mean of the primary data, the error of the average value, the standard deviation and the reliability of the difference between the data obtained.

Results

The results on the distribution of means of different physiological orientation are presented in Fig. 1

As can be seen from Fig. 1, the volume of means of aerobic impact gradually increased from stage to stage, but decreased noticeably during the period of the team's participation in international tournaments (8–9, 13–16 microcycles, see Fig. 2). At the same time, the volume of aerobic-anaerobic exercises increased significantly. With the main interna-

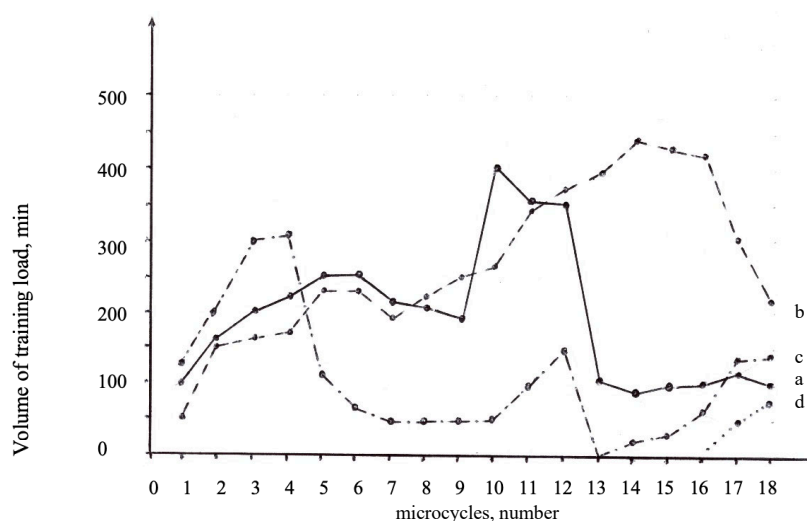


Fig. 1. Dynamics of the volume of training means of different physiological orientation, which were used during the preparation of a highly qualified basketball team for important international competitions: Ordinate axis – the volume of training load, min; Abscissa axis – microcycles, number; a – volume of training load, mainly aerobic orientation; b – aerobic-anaerobic orientation; c – anaerobic alactate and anabolic orientation; d – anaerobic glycolytic orientation.

tional competitions approaching, the volume of aerobic and mixed aerobic-anaerobic means decreased. At this stage, the volume of speed-power means (alactate anaerobic impact) increased and for the first time during the entire training period, exercises aimed at developing the speed endurance of basketball players (anaerobic-glycolytic effects) were used.

The results of the distribution of means of technical, tactical, technical- tactical and game training are presented in Fig. 2.

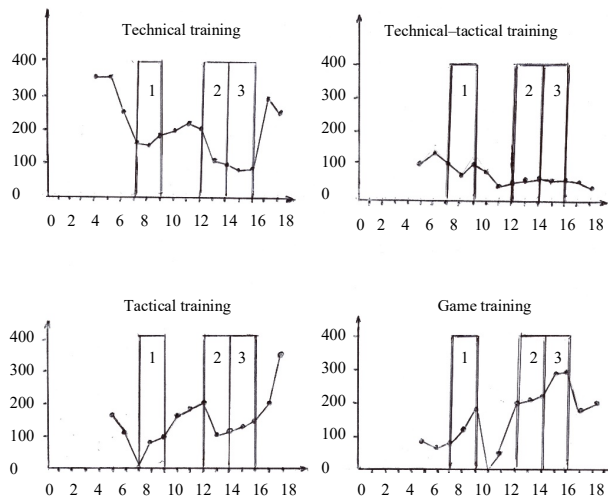


Fig. 2. Dynamics of distribution of means of technical, technical-tactical, tactical and game training at different stages of preparation of basketball players for important international competitions:

Ordinate axis – amount of time, min.

Abscissa axis – microcycles, number.

Columns in Fig. 1, 2, 3 – participation in international tournaments.

As can be seen from Fig. 2, there is a certain pattern in the distribution of means aimed at improving technical, tactical and game training. The volume of technical training gradually decreases as official responsible international competitions approach, the volume of tactical and game training increases.

The results of testing basketball players before and after the preparation for important international competitions are shown in Table 1.

As can be seen from the table, basketball players increased their performance in all tests, with the exception of jumping height. It should be noted that in such tests as the time of work in throws from spots, running 3×40 seconds, the differences are not reliable ($p < 0.95$), but, in any case, there is no decrease in indicators. There are practically no differences in the average values of jumping height indicators (1st examination – 48.8 cm, 2nd examination – 49.0 cm). Therefore, coaches should not ignore the thesis that qualified basketball players can develop jumping ability without using exercises with weights. This, of course, does not mean that you do not need to use jumping exercises in training. In addition, jumping exercises develop “explosive” strength, coordination of movements, specific skills (for example, during a jump shot, fighting for the rebound of the

Table 1. Results of control tests of basketball players before and after the preparation for important international competitions (n = 15)

Indicators	Examination		Difference reliability
	1st	2nd	
Running at 6 m, sec.	1.61±0.67 0.107	1.36±0.067 0.107	>0.99
Running at 20 m, sec.	3.55±0.079 0.125	3.06±0.168 0.267	>0.99
Jumping height, cm	48.8±4.25 6.75	49.0±4.44 7.05	<0.95
Throws number of hits	20.5±2.7 4.29	24.0±2.12 3.37	>0.95
out of 40 time of work, sec.	4.21±0.1 0.159	4.04±0.173 0.276	<0.95
Free throws out of 30, number of hits	20.1±2.51 3.99	23.5±1.73 2.76	>0.95
Running 3×40 sec., m	563±16.6 26.4	572±17.0 27.0	<0.95
Cooper Test, m	2939±87 138	3057±96 153	>0.95

ball, “scoring” the ball into the basket from top to bottom, etc.), helps to maintain the level of jumping ability. However, strength training cannot be ignored. As shown by a study by Jim Hanley, 1973, qualified athletes have fewer opportunities to increase results in jumping ability. The most effective for the strength developing, strength increasing and jumping ability in qualified athletes are exercises with large and maximum weights, which includes jumping on a bench, lifting a barbell, half-squats and deep squats. Our experiment with qualified basketball players confirms this. Physical training, which was allotted 31.9% of the time, included crosses, fartlek, gymnastic exercises, acceleration, jumping with one or both legs pushing up and moving forward, stairs, over barriers, etc. Exercises with weights were not used, which affected the results in the jumping test.

Studies have shown that it is necessary to carry out the gradation of loads based not only on traditional assessments of the nature of the technical-tactical tasks being solved, but also on the basis of accounting of the physiological impact of loads on the body of athletes. A significant contribution here can be the establishment of an urgent training effect of special exercises of basketball players and, on this basis, the creation of a unified system of accounting of the training loads, their systematization by the nature of the physiological changes that they cause in the body of basketball players.

Discussion

The question of the importance of planning and managing the training process was considered by many scientists and coaches at different stages of basketball development (Semashko, 1976; Yukhno, & Preobrazhensky, 1967; Shablinsky, 1989; Koryahin, 2018).

The results of our research coincide with a number of scientific studies (Ben Abdelkrim, Castagna, El Fazaa, & El Ati, 2010; Poplavskyi, 2004; Ferreira, Volossovitch, & Sam-

paio, 2014) on the need to develop a system for planning and managing the training load, creating a unified system for accounting and analysis of training load.

The results of our studies showed a certain accounting system has developed in basketball based on assessments of the nature of the tasks to be solved and the degree of compliance with the specifics of their game activities (Sushko & Mustafa, 2015; Mitova & Ivchenko, 2014). At the same time, studies have indicated the need of accounting and analysis of training loads by the nature of the physiological impact on athletes' bodies (Koryahin, Blavt, Doroshenko, Prystynskyi & Stadnyk, 2020; Anastasiadis, 2006).

Based on the study results, it can be stated that in order to effectively manage the training process, a certain accounting system is needed. Suchlike at this stage of scientific research is the gradation of special exercises of basketball players according to 4 groups, namely: exercises of aerobic, mixed aerobic-anaerobic, anaerobic alactate and anaerobic glycolytic orientation (Koryahin, Hrebinka, Prystynskyi, & Prystynska, 2022; Koryahin, Blavt, Prystynskyi, & Stadnyk, 2021).

The proposed system of accounting for training loads in basketball opens up new opportunities for improving the management system of training processes. Further research should be aimed at finding the nature of the interaction of urgent training effects of special exercises of basketball players and on this basis improve the system of accounting for loads by the nature of the physiological impact of the exercises used in the training of basketball players.

Conclusions

1. Studies have shown that effective management of the training process of highly qualified basketball players is possible not only on the basis of assessing the nature of the technical and tactical tasks to be solved and the degree of their compliance with the game activity of basketball players, but also, which is very important, by accounting the physiological impact of loads on the body of athletes.

2. The proposed gradation of the loads of highly qualified basketball players based on the accounting of physiological changes caused by the performance of exercises, allows effectively manage the training process.

3. Studies have shown that the dynamics of the volume of training means of different physiological orientation during the preparation of a highly qualified team for important international competitions is uneven, which affects the results of control examinations in special tests (see Table 1). Therefore, the distribution of training means at different stages of training should take into account not only technical, technical-tactical, tactical and game training, but also without fail, taking into account the nature of the physiological impact of exercises on the body of athletes.

Conflict of interest

The author declares no conflict of interest.

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ОЦІНКА ТРЕНУВАЛЬНИХ НАВАНТАЖЕНЬ БАСКЕТБОЛІСТІВ ВИСОКОЇ КВАЛІФІКАЦІЇ

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Реферат. Стаття: 5 с., 1 табл., 2 рис., 22 джерела.

Мета дослідження: 1. Розробка і уніфікація системи контролю за тренувальними навантаженнями за характером фізіологічного впливу на організм баскетболістів. 2. Дослідити стратегію підготовки баскетбольної команди високої кваліфікації до відповідальних міжнародних змагань, а саме: з'ясувати характер розподілу засобів різної фізіологічної, а також техніко-тактичної і ігрової спрямованості на різних етапах підготовки.

Матеріали і методи. В дослідженнях брала участь команда баскетболістів високої кваліфікації (майстри спорту і майстри спорту міжнародного класу) у кількості 15 осіб у період підготовки до відповідальних міжнародних змагань. У період підготовки використовувався мікроцикл 4-1, тобто 4 робочих дні і 1 вихідний. Усього було проведено 18 мікроциклів. У період підготовки проводилося тестування баскетболістів з метою визначення рівня їх фізичної і технічної підготовленості до початку і після закінчення підготовки. Використовувались такі тести: біг на 6 м і 20 м; висота вистрибування; кидки з точок (визначалась кількість попадань з 40 кидків і час роботи); штрафні кидки з 30 (кількість попадань); біг майданчиком від одної лицьової лінії до іншої 3 рази по 40 секунд через 1 хвилину відпочинку (кількість подоланих метрів); тест Купера (Koryahin, 1998; Koryahin, Hrebinka, Prystynskyi, & Prystynska, 2022).

Результати. Проведені дослідження показали, що ефективне керування тренувальним процесом баскетболістів високої кваліфікації можливе не тільки на основі оцінок характеру вирішуваних техніко-тактичних і ігрових задач, але й при обліку характеру фізіологічного впливу навантажень на організм спортсменів. Результати тестування баскетболістів до початку проведення й після закінчення показали, що в цілому система підготовки позитивно відобразилась на результатах у всіх тестах, окрім висоти вистрибування (перше обстеження $48,8 \pm 4.25$ см, друге обстеження – $49,0 \pm 4.44$ см, $P < 0.95$), часу роботи у кидковому тесті (перше обстеження – $4,21 \pm 0.1$ сек., друге обстеження – $4,04 \pm 0.173$ сек., $P < 0.95$), у тесті з бігу 3×40 сек. (перше обстеження – 563 ± 16.6 сек., друге обстеження – $572,04 \pm 17.0$ сек., $P < 0.95$). Це свідчить про необхідність більш ефективного, науково обґрунтованого розподілу засобів на різних етапах підготовки.

Висновки. Дослідження показали, що ефективне керування тренувальним процесом баскетболістів високої кваліфікації можливе не тільки на основі оцінок характеру вирішуваних технічних, тактичних задач й ступеня їх відповідності ігровій активності баскетболістів, але й, що є досить важливим, обліку фізіологічного впливу навантажень на організм спортсменів. Запропонована градація навантажень баскетболістів високої кваліфікації на основі обліку фізіологічних змін, що викликані виконанням вправ, дозволяє ефективно керувати тренувальним процесом. Динаміка об'ємів тренувальних засобів різної фізичної спрямованості у період підготовки висококваліфікованої команди до відповідальних міжнародних змагань, носить нерівномірний характер, що відображається на результатах контрольних випробувань у спеціальних тестах. Тому розподіл засобів тренування на різних етапах підготовки повинен здійснюватися із врахуванням не тільки технічної, техніко-тактичної і ігрової підготовки, але й у обов'язковому порядку з урахуванням характеру фізіологічного впливу вправ на організм спортсменів.

Ключові слова: баскетбол, тренувальні навантаження, баскетболісти високої кваліфікації.

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ORIGINAL SCIENTIFIC ARTICLE

DISCRIMINANT ANALYSIS: AGE-SPECIFIC FEATURES OF MOTOR FITNESS OF GIRLS AGED 7 TO 9

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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 purpose of the study was to determine the age-specific features of the motor fitness of girls aged 7 to 9.

Materials and methods. The study participants were 27 girls aged 7, 40 girls aged 8, and 35 girls aged 9. The children and their parents were informed about all the features of the study and gave their consent to participate in the experiment. The study used such research methods as analysis of scientific and methodical literature, pedagogical observations, motor fitness testing, a probabilistic approach to the assessment of the learning process, and methods of mathematical statistics.

Results. The level of proficiency in gymnastic exercises, the level of development of coordination abilities, endurance and speed strength are those indicators that can be used to assess the motor fitness of girls aged 7 to 9. Attention is drawn to the fact that the level of proficiency in exercises is a key element in the motor fitness of girls. The obtained discriminant functions have statistical significance both in the classification of data and in the determination of the structural features of the motor fitness of girls aged 7 to 9.

Conclusions. The standardized and structure coefficients of the discriminant function indicate that the most important indicators in the motor fitness of girls aged 7 to 9 are the level of general endurance, coordination of movements, relative arm strength and the level of proficiency in gymnastic exercises.

Keywords: girls aged 7 to 9, motor fitness, discriminant analysis.

Introduction

The problem of the motor fitness of school students was considered in terms of organizing the physical education process in physical education classes (Ivashchenko, Iermakov, & Khudolii, 2021; Nesen, 2022; Ivashchenko, 2020), conducting sports classes at school (Marchenko & Satdyev, 2021; Driukov & Marchenko, 2021; Zymohliad & Marchenko, 2021), and in investigating the relationship between motivation, motor activity and motor fitness (Capio et al., 2015; Cohen et al., 2014; Cools et al., 2011).

Studies have confirmed the effectiveness of physical education classes in developing motor abilities (Iermakov et al., 2020; Ivashchenko, Khudolii, & Jagiello, 2021; Tkachenko, 2020) and forming motor skills (Kharkovshchenko, 2022; Mugurdinova & Iermakov, 2022; Siedykh, Ivashchenko, Bartik & Veremeenko, 2022). It was established that conducting

sports classes at school on selected sports is effective in motor training of school students (Chang et al., 2020; Lindsey, 2020; Piñeiro-Cossio et al., 2021), and the results indicate a positive effect of the motor fitness level on the amount of motor activity and motivation for physical exercises (Connolly et al., 2020; O'Donnell et al., 2020; Strotmeyer et al., 2020).

In order to determine the specific features of the motor fitness of school students, studies solve the tasks of their fitness classification (Iermakov et al., 2020; Ivashchenko et al., 2020; Marchenko et al., 2021) and structural analysis (Khudolii et al., 2019; Janjic et al., 2018). Multivariate methods of mathematical statistics are used for this purpose. The effectiveness of discriminant analysis in solving such research tasks has been confirmed (Brusseau & Burns, 2018; Courel-Ibáñez et al., 2019; Fridolfsson et al., 2021). The study assumed that the use of multivariate statistics would make it possible to obtain new information about the specific features of the motor fitness of girls aged 7 to 9.

The purpose of this study was to determine the age-specific features of the motor fitness of girls aged 7 to 9.

Materials and methods

Study participants

The study participants were 27 girls aged 7, 40 girls aged 8, and 35 girls aged 9. The children and their parents were informed about all the features of the study and gave their consent to participate in the experiment.

Study organization

The study used such research methods as analysis of scientific and methodical literature, pedagogical observations, motor fitness testing, a probabilistic approach to the assessment of the learning process, and methods of mathematical statistics.

The testing program included common tests that were used to assess the motor fitness of younger grade students (Shevchenko, Khudolii, & Potop, 2020; Khudolii, Golovnin, & Bartik, 2020; Ivashchenko, & Sirichenko, 2020). The study recorded the indicators of height (cm) and body weight (kg) and the results of tests No 3 'Standing long jump (cm)', No 4 '300 m running (s)', No 5 '30 m running from a standing start (s)', No 6 'Seated forward bend (cm)', No 7 'Mixed hang rope pull-ups (times)', No 8 'Shuttle run 4×9 m (s)', No 9 'Combined movements of arms, torso and legs (points)', No 10 'Postural balance test – single leg stance, eyes closed (s)', No 11 'Walking along a straight line after 5 rotations (deviations in cm)'. The study recorded the proficiency level of girls aged 7 to 9 in gymnastic exercises. The coefficient was determined by the formula: $p = (m/n) \cdot 100$, where p is the level of proficiency, m is the number of successfully performed exercises, n is the total number of attempts to perform the exercise. In the experiment, the study controlled the level of proficiency in the following exercises: forward roll; backward roll; shoulder stand with legs bent (girls aged 7); shoulder stand, bridge stand from the supine position, one leg swing upward circle (girls aged 8); rope climbing in 2 steps, rope climbing in 3 steps, one leg swing upward circle (girls aged 9).

Statistical analysis

The study materials were processed by IBM SPSS 20 statistical analysis software. Arithmetic mean and standard deviation were calculated. Discriminant analysis was performed because it enables interpreting differences between classes and classifying objects.

The study protocol was approved by the Ethics Committee of the University. In addition, the children and their parents or legal guardians were fully informed about all the features of the study, and a signed informed consent document was obtained from all the parents.

Results

The results of comparison of the mean values obtained from the tests showed that no statistically significant differences ($p > 0.05$) were observed in indicators No 6 'Seated forward bend (cm)', No 7 'Mixed hang rope pull-ups (times)', No 10 'Postural balance test – single leg stance, eyes closed (s)', and No 11 'Walking along a straight line after 5 rotations (deviations in cm)'. The girls aged 7 to 9 show statistically

significant differences ($p < 0.001$) between them in the results of the following tests: No 1 'Height (cm)', No 2 'Body weight (kg)', No 3 'Standing long jump (cm)', No 4 '300 m running (s)', No 8 'Shuttle run 4×9 m (s)', No 9 'Combined movements of arms, torso and legs (points)', No 12 'Level of proficiency in exercise 1', No 13 'Level of proficiency in exercise 2', No 14 'Level of proficiency in exercise 3'. Thus, the given data show that the level of proficiency in exercises, the level of development of coordination abilities, endurance and speed strength are those indicators that can be used to assess the motor fitness of girls aged 7 to 9 (Fig. 1).

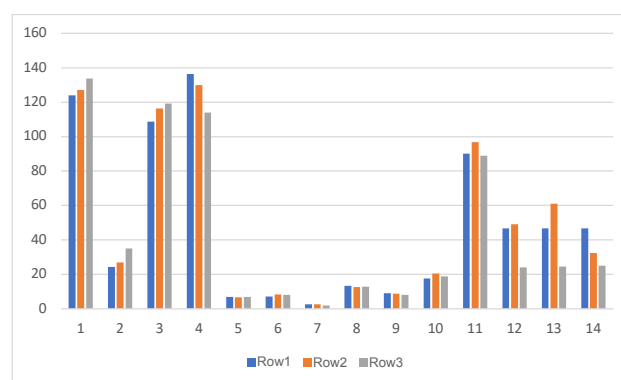


Fig. 1. Indicators of the level of motor fitness of girls aged 7 to 9: aged 7 – row 1; aged 8 – row 2; aged 9 – row 3; 1 to 14 – tests

The results of the statistical analysis of the discriminant functions are shown in Tables 1 and 2. The first function covers 79.1% of variance ($r_1 = 0.887$), and the second function covers 20.9% of variance ($r_2 = 0.702$) (Table 1). Wilks' Lambda criterion ($\lambda_1 = 0.109$, $\lambda_2 = 0.508$) indicates a high discriminative ability of the first and second discriminant functions ($p < 0.001$) (Table 2). Therefore, the analysis of the coefficients of the first and second discriminant functions will make it possible to objectively assess the specific features of the motor fitness of girls aged 7 to 9.

As a result of the analysis, standardized (1) and structure (2) coefficients of the discriminant function were obtained, which, on the one hand, characterize the ratio of the contribution of the variables (1) to each of the canonical functions, and on the other hand, indicate correlations between the variables and the functions (2) (Tables 3 and 4).

It was established that the value of the first function most significantly depends on the results of tests No 1 'Height (cm)', No 4 '300 m running (s)', No 5 '30 m running from

Table 1. Eigenvalues. Girls aged 7 to 9

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	3.673	79.1	79.1	0.887
2	0.969	20.9	100.0	0.702

Table 2. Wilks' Lambda. Girls aged 7 to 9

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	0.109	205.298	28	0.000
2	0.508	62.679	13	0.000

Table 3. Standardized Canonical Discriminant Function Coefficients

No	Content	Function	
		1	2
1	Height, cm	-0.710	-0.361
2	Body weight, kg	-0.038	0.133
3	Standing long jump, cm	-0.294	-0.243
4	300 m running, s	0.624	0.107
5	30 m running from a standing start, s	-0.482	-0.028
6	Seated forward bend, cm	-0.223	0.341
7	Mixed hang rope pull-ups, times	0.317	-0.421
8	Shuttle run 4×9 m, s	0.306	0.540
9	Combined movements of arms, torso and legs, points	0.212	0.163
10	Postural balance test – single leg stance, eyes closed, s	0.258	-0.008
11	Walking along a straight line after 5 rotations, deviations in cm	0.029	0.197
12	Exercise 1, proficiency level	0.375	0.029
13	Exercise 2, proficiency level	0.650	-1.067
14	Exercise 3, proficiency level	-0.403	1.220

Table 4. Structure Matrix

No	Content	Function	
		1	2
1	Height, cm	-0.437*	-0.217
13	Exercise 2, proficiency level	0.390*	-0.370
9	Combined movements of arms, torso and legs, points	0.311*	0.085
4	300 m running, s	0.299*	0.118
12	Exercise 1, proficiency level	0.296*	-0.094
2	Body weight, kg	-0.199*	-0.064
7	Mixed hang rope pull-ups, times	0.103*	-0.001
8	Shuttle run 4×9 m, s	0.052	0.443*
3	Standing long jump, cm	-0.122	-0.224*
14	Exercise 3, proficiency level	0.149	0.223*
5	30 m running from a standing start, s	-0.072	0.182*
6	Seated forward bend, cm	-0.021	-0.126*
10	Postural balance test – single leg stance, eyes closed, s	0.003	-0.089*
11	Walking along a straight line after 5 rotations, deviations in cm	0.016	-0.039*

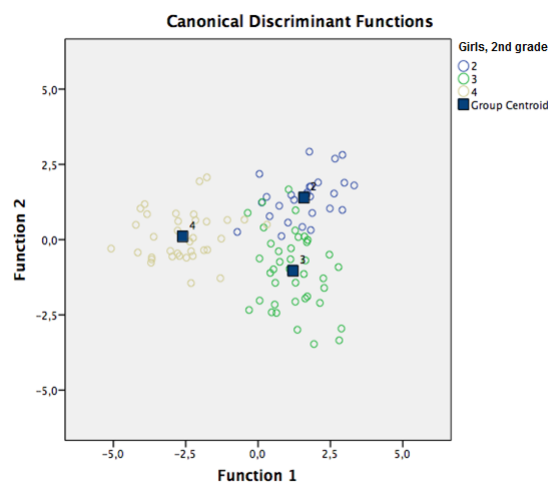
Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function. *Largest absolute correlation between each variable and any discriminant function

a standing start (s)' and the level of proficiency in the gymnastic exercises. The value of the second function most significantly depends on the results of tests No 8 'Shuttle run 4×9 m (s)', No 7 'Mixed hang rope pull-ups (times)' and the level of proficiency in the gymnastic exercises (Table 3).

The analysis of the structure coefficients showed that the first function is most correlated with the results of tests No 1 'Height (cm)', No 9 'Combined movements of arms, torso and legs (points)', No 4 '300 m running (s)' and the level of proficiency in the gymnastic exercises. The second function is most correlated with the results of tests No 8 'Shuttle run

Table 5. Functions at Group Centroids. Girls aged 7 to 9

Girls, age	Function	
	1	2
7	1.587	1.396
8	1.207	-1.036
9	-2.604	0.107

**Fig. 2.** Canonical discriminant functions. A graphical display of the results of the classification of the age-specific features of the motor fitness of girls aged 7 to 9: ■ –centroids for groups aged 7, 8, and 9

4×9 m (s)', No 3 'Standing long jump (cm)' and the level of proficiency in exercise 3 (Table 4).

Thus, the standardized and structure coefficients of the discriminant function indicate that the level of general endurance, coordination of movements, relative arm strength and the level of proficiency in gymnastic exercises are important indicators of the motor fitness of girls aged 7 to 9.

The analysis of the centroid values and the results of the classification of the level of motor fitness of girls aged 7 to 9 indicates that 93.1% of the data were classified correctly, and the graphic material confirms the objectivity of the classification (Tables 5 and 6, Fig. 2).

Discussion

The paper assumed that the motor fitness of girls aged 7 to 9 has age-specific features. It was established that the level of proficiency in exercises, the level of development of coordination abilities, endurance and speed strength are those indicators that can be used to assess their motor fitness. Attention is drawn to the fact that the level of proficiency in exercises is a key element in the motor fitness of girls, with age they master more complex gymnastic exercises, but with an increase in body weight and height, 9-year-old girls have a statistically significantly lower level of proficiency in more complex gymnastic exercises than girls aged 7 to 8.

The obtained data complement the results of the studies by Shevchenko, Khudolii, and Potop (2020), Khudolii, Golovnin, and Bartik (2020); Ivashchenko and Sirichenko (2020) on the markers of the motor fitness of elementary school students as well as the data of the studies by Ha et al.

Table 6. Classification Results^{a,c}

		Girls, age	Predicted Group Membership			Total
			7	8	9	
Original	Count	7	25	1	1	27
		8	4	36	0	40
		9	0	1	34	35
	%	7	92.6	3.7	3.7	100.0
		8	10.0	90.0	0.0	100.0
		9	0.0	2.9	97.1	100.0

a. 93.1% of original grouped cases correctly classified. b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case

(2017), Da Silva Gasparotto et al. (2020), Ruiz et al., (2011) on the specific features of school students' physical fitness and motivation for physical activity.

The analysis of the discriminant functions indicates their statistical significance both in the classification of data and in the determination of the structural features of the motor fitness of girls aged 7 to 9. The values of the centroids and the results of the classification of the level of motor fitness of girls aged 7 to 9 indicate that 93.1% of the data were classified correctly. The obtained data confirm the conclusions by Iermakov et al. (2020), Ivashchenko et al. (2020), Marchenko et al. (2021) about the high informativity of discriminant functions in determining the specific features of the motor fitness of school students.

The standardized and structure coefficients of the discriminant function indicate that the level of general endurance, coordination of movements, relative arm strength and the level of proficiency in gymnastic exercises are important indicators of the motor fitness of girls aged 7 to 9. The obtained data supplement the results of existing studies on the effectiveness of using discriminant analysis both for the classification of school students by their level of motor fitness (Brusseau & Burns, 2018; Courel-Ibáñez et al., 2019; Fridolfsson et al., 2021) and for determining the structural features of their fitness (Khudolii et al., 2019; Janjic et al., 2018).

Thus, the discriminant analysis made it possible to determine the specific features of the motor fitness of girls aged 7 to 9. Motor fitness is affected by body height and weight, and with age, on the one hand, the level of endurance changes, and on the other hand, so does the level of proficiency in gymnastic exercises, which indicates the need for an integrated development of motor abilities in girls aged 7 to 9.

Conclusions

The level of proficiency in gymnastic exercises, the level of development of coordination abilities, endurance and speed strength are those indicators that can be used to assess the motor fitness of girls aged 7 to 9. Attention is drawn to the fact that the level of proficiency in exercises is a key element in the motor fitness of girls.

The obtained discriminant functions have statistical significance both in the classification of data and in the determination of the structural features of the motor fitness of girls aged 7 to 9.

The standardized and structure coefficients of the discriminant function indicate that the most important indicators of the motor fitness of girls aged 7 to 9 are the level of

general endurance, coordination of movements, relative arm strength and the level of proficiency in gymnastic exercises.

Conflict of interest

The authors declare no conflict of interest for this study.

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ДИСКРИМІНАНТНИЙ АНАЛІЗ: ВІКОВІ ОСОБЛИВОСТІ РУХОВОЇ ПІДГОТОВЛЕНOSTІ ДІВЧАТ 7-9 РОКІВ

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Реферат. Стаття: 6 с., 6 табл., 2 рис., 34 джерела.

Мета дослідження – визначити вікові особливості рухової підготовленості дівчат 7-9 років.

Матеріали і методи. У дослідженні прийняли участь: 27 дівчат 7 років, 40 дівчат 8 років, 35 дівчат 9 років. Діти та їхні батьки були інформовані про всі особливості дослідження і дали згоду на участь в експерименті. Були використані такі методи дослідження як аналіз наукової та методичної літератури, педагогічні спостереження, тестування рухової підготовленості, ймовірнісний підхід до оцінки процесу навчання, методи математичної статистики.

Результати. Рівень навченості гімнастичних вправ, рівень розвитку координаційних здібностей, витривалості та швидкісної сили є тими показниками які можуть бути використані для оцінки рухової підготовленості дівчат 7-9 років. Звертає увагу той факт, що рівень навченості вправ є ключовим елементом в руховій підготовленості дівчат. Отримані дискримінантні функції мають статистичну значущість як в класифікації даних, так і у визначенні структурних особливостей рухової підготовленості дівчат 7-9 років.

Висновки. Стандартизовані і структурні коефіцієнти дискримінантної функції вказують, що найважливіми показниками у руховій підготовленості дівчат 7-9 років є рівень загальної витривалості, координації рухів, відносної сили рук та рівень навченості гімнастичних вправ.

Ключові слова: дівчата 7-9 років, рухова підготовленість, дискримінантний аналіз.

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