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[Teorìâ ta Metodika Fìzičnogo Vihovannâ]

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ORIGINAL SCIENTIFIC ARTICLE

INCREASING PHYSICAL LITERACY IN PENCAK SILAT ATHLETES: TWO-MONTHS PEER TEACHING MODEL PROGRAM IN COVID-19

Abdurrohman Muzakki[1ABCDE], Edi Setiawan[2ABCD], Mashuri Eko Winarno[3ABCD], Ruslan Abdul Gani[4ABC], Novi Yanti[5ACD], Bangbang Syamsudar[6ACD] and Martin Hofmeister[7ACD]

[1]University of Muhammadiyah Malang
[2]Universitas Suryakancana
[3]Universitas Negeri Malang
[4]Universitas Singaperbangsa Karawang
[5]Universitas Tanjungpura
[6]STKIP Pasundan Cimahi
[7]Consumer Centre of the German Federal State of Bavaria

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

Corresponding Author: Abdurrohman Muzakki, E-mail: muzakki@umm.ac.id
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Abstract

Study purpose. This study aims to investigate the effect of the peer teaching model on improving the physical literacy of pencak silat athletes.

Materials and methods. This study applied a mixed method. Participants were pencak silat male athletes (n=30) who studied at elementary schools in Cianjur district (Indonesia). Participants were divided into an experimental group (n=15) that carried out the peer teaching model and a control group (n=15) that carried out daily teaching routines without participating in any activities. After implementing the peer teaching model, 15 participants were interviewed about the implementation of peer teaching in school model and the benefits of peer teaching. The quantitative research instrument involved physical literacy-movement competence, cognitive and affective domains. Meanwhile, the qualitative research instrument involved in-depth interviews for 30 minutes. Analysis of quantitative data used IBM SPSS. Analysis of qualitative data used thematic analysis.

Results. The quantitative study results showed that there was a significant increase in physical literacy in the experimental group ($p<0.05$) but there was no increase in the control group ($p>0.05$). The qualitative study results showed that most of participants gave diverse perceptions and all agreed that the peer teaching model could improve the physical literacy of athletes with poor condition.

Conclusions. This study concluded that peer teaching is an alternative teaching that can be used during COVID-19 to improve the physical literacy of pencak silat athletes.

Keywords: Peer Teaching, Physical Literacy, Pencak Silat athletes, Mixed Method.

Introduction

Nowadays, most of the world are facing a high risk pandemic that has a huge negative impact on all areas including physical education in elementary schools to universities (López-Valenciano, Suárez-Iglesias, Sanchez-Lastra & Ayán, 2021; Roe, Blikstad-Balas & Dalland, 2021; Fang, Teng & Wang, 2021). Data reported that the COVID-19 pandemic caused athletes and teachers to carry out offline teaching while some people claimed that online teaching had various obstacles and did not provide optimal results (Jumareng et al., 2021; Sortwell & Ramirez-Campillo, 2022), which could led to a significant decrease in their talent related to physical literacy (Duclos-Bastías, Vallejo-Reyes, Giakoni-Ramírez & Parra-Camacho 2021; Young, O'Connor, Alfrey & Penney, 2021). According to Liu

& Chen (2021) (2021), physical literacy in the context of physical education and sports has a concept as knowledge, motivation, self-efficacy and physical competence for active and sustainable involvement in lifelong physical activity (see Fig. 1).

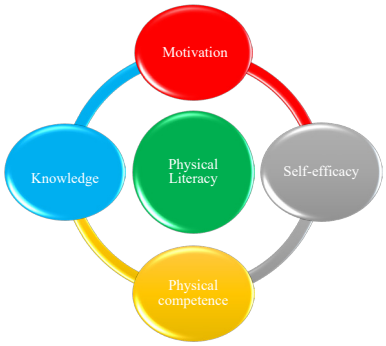

Fig. 1. Physical Literacy Conceptual Model

The benefits of physical literacy that have been well-documented, for example the potential to help children (Pambudi, Sugiyanto, Hidayatullah & Purnama, 2021) and adolescents to improve healthy lifestyles throughout life (Lundvall, 2015; Irmansyah et al., 2021; Rihatno & Nuraini, 2021), promote levels of physical activity and higher physical fitness during the current COVID-19 pandemic crisis (Kwan, Graham, Healey, Paolucci & Brown, 2020). However, until now research on physical literacy is scarce (Edwards et al., 2018) particularly in physical education and sports settings (Warner et al., 2021), so that it becomes an urgency in this research. According to Silverman & Mercier, (2015) the best way to improve physical literacy is teaching that involves the psychomotor, cognitive and affective domains. The teaching method that has the potential to develop the three domains simultaneously is the peer teaching method.

Peer teaching is an athlete-centered instructional which help each other to achieve common goals in teaching activities (Farias, Mesquita, Hastie & Toni O'Donovan, 2018). According to Whipp, Jackson, Dimmock & Soh (2015) peer teaching is a peer or paired teaching model (Thurston, Cockerill & Chiang, 2021), in which athlete who become tutor must teach other athletes to complete a learning task. The tutor is chosen from one athlete who has better abilities than other athletes (Klavina & Rodionova, 2015). While teacher has a task to oversee the teaching process between tutor and athletes. It is expected that by using this model, tutor and athletes could interact with each other, actively involved and work together to develop their potential in teaching activities (Gunduz & Uner, 2019). According to previous studies, peer teaching was claimed to have benefits in improving performance (Lowton-Smith et al., 2019; Kastrena, Setiawan, Patah & Nur, 2020 2020). However, other studies reported that there was still a gap, which showed that peer teaching was less effective because it had several problems such as the feedback provided by tutors might be partially correct, completely wrong or misleading for other athletes (Trabelsi, Gharbi, Masmoudi & Mrayeh, 2020). Therefore, it is highly needed to follow up research on peer teaching models.

Research on peer teaching models has been well documented internationally (Moliner & Alegre, 2020; Tan & Gevera, 2020; Bores-García, Hortigüela-Alcalá, González-Calvo & Raúl Barba-Martín, 2020). However, there is still limited research on peer teaching models that related to physical education. In addition, this study presents a novelty from previous studies, namely applying the peer teaching model to improve the physical literacy of pencak silat athletes through mixed method analysis. Therefore, this study aims to investigate the effect of peer teaching model to improve the physical literacy of pencak silat athletes in physical education at schools.

Materials and methods

Study participants

This research adopted a mixed method, which combined quantitative and qualitative research to solve the problems in this research (Gani et al., 2022). Thirty participants of pencak silat athletes from elementary schools in Cianjur district (Indonesia) had agreed to participate in this study. Ethics clearance was granted by the elementary school committee (approval number: E 277/C-3/2022) prior to any data collection.

The participants were recruited by sending invitation letters via email to schools. From several number of schools that had been received invitation letters, only 30 male athletes responded and showed interest to be further involved in this study and 10 female athletes withdrew. The recruitment activity was carried out in March 2022. The characteristics of participants were: male gender, age: 11-12 years, height: 110-130 cm, weight: 30-40 kg. Participants were divided in 2 groups, half of participants (n=15) allocated to the experimental group who received treatment in the form of a peer teaching model and the rest allocated to the control group (n=15) who did their daily teaching or did not participate in any program.

Instrument

Quantitative Instruments

The physical literacy literature has a multi-dimensional concept, therefore the researcher adopted instruments from previous studies (Bremer, Graham & Cairney, 2020) along with the program leaders (n = 7), including:

Physical Literacy-Movement Competence Domain. Children's movement competence was assessed using locomotor, object-control and balance tests. The criteria for this assessment was the ability of athletes to run, leap or other movements correctly according to the assessment norms then they would get score between 1 to 4 and if it was not according to the assessment norms, then the score would be 0 (Behan, Belton, Peers, O'Connor & Issartel, 2020). As for object control, there were three performance criteria namely: a) the preparatory phase : hands were put in front of the body and the elbows are bent, b) the arms were outstretched when reaching for the ball which enters the field, and, c) the ball was caught by hand only. Each child was evaluated against these criteria. If they met the performance criteria, then they would get score 1 to 4. If they could not met performance criterion, then the score would be 0 (Juliantine, Setiawan, Jumareng, Gani & Asnaldi 2022). The assessment

Table 1. Peer Teaching Model Program

Role	Activities	Duration
Teacher	The teacher conveys the physical activities that will be carried out on that day. Warm-up The teacher selects a tutor from one of the athletes. Teachers provide motivation and self-efficacy to tutors.	10 min
Tutor	Tutors take on the role of teachers to teach athletes to perform physical activities, such as: Team plays with hula hoop Jumping games Push-up games Training punches and kicks in pencak silat	45 min
Teacher and Tutor	Evaluation Cooling-down	5 min

for stability component balance was conducted by assessing how long the child can walking straight line, and standing on one leg. Each child tried two trials for each movement skill and was assessed on the performance criteria (Vernadakis, Papastergiou, Zetou & Antoniou, 2015). The total score of the children (the sum of their individual scores) was calculated.

Physical Literacy-Cognitive Domain. Physical Literacy-Cognitive Domain. The knowledge level of children can be measured using a questionnaire with 10 question items (Bremer, Graham & Cairney, 2020). Examples: "how to do an effective physical activity or exercise during the COVID-19 pandemic (knowledge and understanding). This instrument was assessed using a Likert scale from 1 = has a very low knowledge to 7 = has a very high knowledge. Scores were calculated by averaging the ratings for each item to produce scores on a scale from 1 until seven.

Physical Literacy-Affective Domains. (1) Motivation. The measurement of children's motivation to involve in physical activity and sports during the COVID-19 pandemic could be carried out by using the effort subscale from an intrinsic motivation inventory which consists of 5 question (Bremer, Graham & Cairney, 2020). Likert scale from 1 = Definitely false 7 = Definitely true were applied to assess the questions. An example of an item is: "I try my best to do physical activity and sports during the COVID-19 pandemic". The motivation score was calculated by averaging the ratings for each item to obtain a score on a scale of one up to seven. (2) Self-Efficacy. The measurement of children's self-efficacy could be carried out by using a questionnaire with 16 questions (Bremer, Graham & Cairney, 2020). For example: "I believe I can run 2 kilometers". To assess this question, you can use a Likert scale from 0 = not sure to 10 = considerably sure. Self-efficacy scores were calculated by averaging the ratings for each item to obtain a score on a scale of one up to 10.

Qualitative Instruments

The instrument used in qualitative research was in-depth interviews with participants with a duration of 30 minutes per individual. Interviews were conducted directly via Whatsapps in Bahasa language (Gani et al., 2022).

Study organization

This research was conducted from April to May 2022 in Cianjur district (Indonesia). The research follows the guidelines of the World Medical Association Code of Ethics (Helsinki Declaration for humans) which is intended for research with human subjects. In quantitative research, there were several meetings held, namely the first meeting on April 1, 2022, all participants carried out a pre-test (physical literacy test). The second meeting on April 4, 2022, the experimental group carried out the peer teaching model program while the control group only carried out their usual daily activities (traditional learning) until the 17th meeting (May 9, 2022). At the 18th meeting (11 May 2022), all participants carried out a final test activity, namely a physical literacy test. The peer teaching method program was conducted on Monday, Wednesday and Friday at 08.00-09.00 am. This research was carried out strictly by implementing the COVID-19 health protocol, including: all participants and the research team must be checked for body temperature, used hand sanitizers and were required to have a vaccine card to participate in this intervention program. While the qualitative research was conducted on May 20, 2022, the peer teaching model group was interviewed for 30 minutes in Bahasa language. The peer teaching model program is presented in Table 1.

Statistical analysis

Quantitative analysis

Data from quantitative research were analyzed using IBM SPSS version 25.0 (Armonk, NY: IBM Corp). First, analyzed the descriptive statistics (mean±standard deviation) and the normality of the data (Kolmogorov-Smirnov). Paired sample t-test was used to test differences in physical literacy scores pre-test and post-test in the experimental and control groups (Gani et al., 2022). This study used level of significance $p<0.05$

Qualitative analysis

Qualitative research data were analyzed using qualitative thematics, namely the results of in-depth interviews with participation were analyzed and discussed among researchers, then it would be coded and categorized into three main themes (Gani et al., 2022; Essiet et al., 2022), namely: theme 1 relates to implementing the peer teaching model in school and theme 2 relates to the benefits of peer teaching.

Results

The quantitative results in this study showed that the normality test was normal ($p=0.181>0.05$). While the results

of the statistical descriptive test are presented in Table 2. Table 3 shows that the experimental group (peer teaching model) has a significant effect on increasing physical literacy-movement competence domain ($p<0.05$), physical literacy-cognitive domain ($p<0.05$) and physical literacy-affective domain ($p<0.05$). While the control group showed no increase in physical literacy ($p>0.05$).

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

Theme 1: Implementing metode peer teaching in school

The application of a teaching method in elementary schools is very important (Jumareng et al., 2022), because it cause the teaching process much more fun and not boring for athletes. Therefore, this theme 1 resulting two sub-themes, namely: (i) Implementation of peer teaching methods and (ii) obstacles.

Table 2. Descriptive Statistics between EG and CG

Dependent Variable	EG (n = 15)		CG (n = 15)	
	Pretest	Posttest	Pretest	Posttest
	M(SD)	M(SD)	M(SD)	M(SD)
PLMCD				
Locomotor	2.33(0.617)	3.87(0.352)	2.33(0.617)	2.27(0.799)
Object-control	2.00(0.535)	3.60(0.507)	2.00(0.535)	2.20(0.862)
Balance	2.33(0.488)	3.47(0.516)	1.60(0.07)	1.73(0.704)
PLCD	22.00(2.07)	39.67(2.66)	21.60(2.74)	21.73(2.73)
PLAD				
Motivation	13.27(1.38)	23.00(2.07)	13.27(1.38)	13.607(2.02)
Self-efficacy	44.80(3.36)	73.40(9.18)	37.80(6.36)	38.007(6.31)

M: Mean, SD: Standard Deviation, EG: Experimental Group, CG: Control Group, PLMCD: Physical Literacy-Movement Competence Domain, PLCD: Physical Literacy-Cognitive Domain, PLAD: Physical Literacy-Affective Domain

Subtheme 1: Implementation

Participants shared their experiences on how to succeed in implementing the peer teaching model in elementary schools. In this regard, participants expressed their opinion that:

> This is a valuable experience for us as tutors, because we are required to be responsible for providing subject matter to other athletes or friends. Based on our opinion, this peer teaching model is a positive teaching for the development of the potential of tutors and athletes simultaneously, so that peer teaching must be taken into account to be implemented in the education curriculum in Indonesia (Participant 1).

Indonesia applied a teacher-centered curriculum, in which athletes are less active in teaching activities. Therefore, integrating the peer teaching model in physical education and sports learning is appropriate method as an innovation in physical education learning in elementary schools (Participant 2). Participant 7 further explained that:

> However, in our opinion, to optimally apply the peer teaching model in grade 6 elementary school, a tutor must have learning motivation, self-confidence and broad insight, thus the application of peer teaching will be more effective (Participant 7).

> Of course, although the peer teaching model is claimed to have good effectiveness, the knowledge, skills and psychological factors of the tutor will greatly determine the final outcome of learning achievement (Participant 3).

Regarding this, another participant explained that:

> At the beginning of the implementation of the peer teaching model, we felt anxious and did not have the confidence to become a tutor, but the teacher continued to motivate me so that I succeeded in carrying out my duties as a tutor (Participant 10).

> In addition, teacher has an important role in implementing the peer teaching model, because the teacher acts as a facilitator to explain the subject matter to the tutor, and the teacher must be able to motivate and increase the self-confidence of the tutors and athletes so they willing to learn (Participant 8). Participant 11 gave his perception that:

> I agree that the teacher has a role in guiding tutors as the main tool to achieve success in implementing the peer teaching model in elementary schools (Participant 11).

Subtheme 2: Barriers

Barriers are the main problems that often arise in physical education and sports learning activities in elementary schools,

Table 3. Differences values in pre-test and post in the EG and CG groups

Dependent Variable	EG (n = 15)			CG (n = 15)		
	Pretest-Posttest M(SD)	t	p	Pretest-Posttest M(SD)	t	p
PLMCD						
Locomotor	1.53(0.743)	7.990	0.000	0.067(.799)	0.323	0.751
Object-control	1.60(0.632)	9.798	0.000	0.200(.775)	1.000	0.334
Balance	1.13(0.640)	6.859	0.000	0.133(.834)	0.619	0.546
PLCD	17.66(3.71)	18.412	0.000	0.133(1.846)	0.280	0.784
PLAD						
Motivation	9.73(2.43)	15.488	0.000	0.333(1.234)	1.046	0.313
Self-efficacy	33.60(8.74)	14.888	0.000	0.200(1.26)	0.612	0.550

M: Mean, SD: Standard Deviation, EG: Experimental Group, CG: Control Group, $p<0.05$, PLMCD: Physical Literacy-Movement Competence Domain, PLCD: Physical Literacy-Cognitive Domain, PLAD: Physical Literacy-Affective Domain

and these should be evaluated so that the learning process can run effectively (Participant 4).

Participants gave their perceptions regarding the obstacles in peer teaching, namely:

According to me, the obstacle that often occurred was a dispute between tutors who have arrogant personalities and the athletes which causes unconducive learning activities (Participant 5).

Dispute between tutors and athletes often occur in the teaching process of physical education in elementary schools, therefore the teacher as a facilitator and mentor must be able to provide an understanding to the tutor to preven overacting in teaching (Participant 6).

Participant 9 argued that:

I agree, many tutors behave fiercely or often joke around. But after the teacher giveng them understanding, they started to behave much better and we started to feel comfortable and excited to learn (Participant 9).

Theme 2: Benefits of peer teaching

Although there were obstacles in the process of peer teaching models, the benefits for tutors and athletes were greater, so that theme 2 resulting three sub-themes, including: (i) benefits of peer teaching for physical literacy-movement competence, (ii) benefits of peer teaching for physical literacy-cognitive and benefits of peer teaching for physical literacy-affective (iii).

Subtheme 1: Benefits of peer teaching for Physical Literacy-Movement Competence

The first benefit that can be obtained from the application of peer teaching is related to the domain of movement competence of tutors and athletes. In this case, participant 13 gave the perception that:

After participating in this peer teaching method program, my movement skills experienced a positive increase, it was because the teachers and tutors provided fun physical activity programs. (Participant 13)

Even when the tutor was demonstrating a movement or physical activity to athletes, the physical literacy-movement competence could develop indirectly (Participant 14).

Subtema 2: Benefits of peer teaching for Physical Literacy-Cognitive

It has been proven that peer teaching model has provided some beneficial for the development of physical literacy-cognitive athletes. Participant 7 further explained that:

Our cognitive domain is gradually increasing, because at the beginning of learning the teacher always explains the subject matter to the tutor first, and then the tutor teaches the material to the athletes. This means that in these activities there is a knowledge transfer process from teacher to tutor and from tutor to athlete (Participant 7).

Peer teaching activities started with the teacher providing an understanding to the tutor about the material or motion task that would be studied that day and continues with the tutor's activities explaining and demonstrating the subject matter to athletes. Thus, this cycle indirectly increase our knowledge (Participant 15).

Subtheme 3: Benefits of peer teaching for Physical Literacy-Affective

The third benefit from the application of peer teaching is the increase in the physical literacy-affective domain. Participant 1 expressed his opinion that:

I think our effective domain also increases, it proves that we are more motivated to study physical education (Participant 1).

The peer teaching model is a learning that has the potential to trigger motivation and self-confidence to learn, because the teacher at the beginning of learning always motivates and instills confidence in tutors and athletes (Participant 15). Furthermore, Participant 10 argued that:

When I became a tutor, I was required to be motivated in learning and had to believe in my own abilities to teach our other friends. I believe it promotes our motivation and our self-confidence continues to increase gradually (Participant 5).

The characteristics of peer teaching model are the role of tutors who contribute to help other athletes who have learning difficulties. Peer teaching has a student centered learning system and active learning, in this learning process athletes have more active opportunities to obtain information and provide information (Participant 10).

Discussion

Our study aims to investigate the effect of applying the peer teaching method to improve the physical literacy of pencak silat athletes.

The first quantitative finding in our study showed that the application of the peer teaching method was proven to improve the physical literacy of athletes gradually. This is because the peer teaching method has characteristics, learning stages and learning objectives that lead to the development of the three domains between movement competence, cognitive (Thurston, Cockerill & Chiang, 2021) and affective simultaneously (Metzler, 2011; Iserbyt, 2015). This is in accordance with the opinion of (Silverman & Mercier, 2015) that the effective strategy to improve physical literacy is through learning that presents and transfers cognitive, affective and psychomotor domains. The results of previous studies also reported that student-centered learning has the potential to positively improve physical literacy (Choi, Sum, Leung & Ng, 2018). The results of this study support previous studies which explain that peer teaching is conducive to promote a positive and attractive learning environment for both tutors and learners (athletes). The clear impact of implementing peer teaching is the development of cognitive, psychosocial, affective and motor skills (Jenkinson, Naughton & Benson, 2014; Mirzeoglu, 2014). Meanwhile, different findings occurred in the control group, and there was no significant change in the physical literacy aspect of the athletes.

The second qualitative finding in this study shows that most of the athletes who received the intervention program gave diverse and positive perceptions towards the implementation of peer teaching models to improve physical literacy aspect. Finally, our research has implications for being a solution for teachers to improve physical literacy during the COVID-19 pandemic crisis and our research can provide information for lecturers, coaches, teachers and athletes about the importance of using the peer teaching method.

Conclusions

Based on the results and findings in this study, we can conclude that the peer teaching method program has an effect

on improving the physical literacy of pencak silat athletes. However, the scope of this study was limited in term of the small number of participants who came from one area in Indonesia, so further studies are needed by involving a large number of pencak silat athletes from other regions. Future studies are interesting to follow up, for example comparing the peer teaching method with the sport education model.

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Conflict of interest

The researcher declares that there is no conflict of interest in this research.

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ПІДВИЩЕННЯ РІВНЯ ФІЗИЧНОЇ ГРАМОТНОСТІ У СПОРТСМЕНІВ, ЯКІ ЗАЙМАЮТЬСЯ ПЕНЧАК-СИЛАТОМ: ДВОМІСЯЧНА ПРОГРАМА ПІДГОТОВКИ ЗА МОДЕЛЛЮ ВЗАЄМОНАВЧАННЯ В ПЕРІОД ПАНДЕМІЇ COVID-19

Абдуррохман Музаккі[1ABCDE], Еді Сетіаван[2ABCD], Машурі Еко Вінарно[3ABCD], Руслан Абдул Гані[4ABC], Нові Янті[5ACD], Банбан Сьямсудар[6ACD], Мартін Хофмейстер[7ACD]

[1]Університет Мухаммадія в Малангу
[2]Університет Сур'яканчана
[3]Малангський державний університет
[4]Каравангський університет імені Сінгапербангса
[5]Університет Танджунгпура
[6]Педагогічний коледж Пасундан в Чімахі
[7]Центр споживачів німецької федеральної землі Баварія

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

Реферат. Стаття: 8 с., 3 табл., 1 рис., 40 джерел.

Мета дослідження. Метою цього дослідження є вивчення впливу моделі взаємонавчання на підвищення рівня фізичної грамотності спортсменів, які займаються бойовим мистецтвом пенчак-силат.

Матеріали та методи. У цьому дослідженні застосовували змішаний метод. Учасниками дослідження були спортсмени чоловічої статі (n=30), які займалися пенчак-силатом і навчалися в початкових школах в окрузі Чианджур (Індонезія). Учасників розділили на експериментальну групу (n=15), яка займалася за моделлю взаємонавчання, і контрольну групу (n=15), яка виконувала повсякденну навчальну програму без участі в жодних заходах. Після реалізації моделі взаємоначання було проведено опитування 15 учасників із питань реалізації взаємонавчання в шкільній моделі та переваг взаємонавчання. Інструмент кількісного аналізу включав фізичну грамотність, рухову компетентність, когнітивну та емоційну сфери. Тоді як інструмент якісного аналізу передбачав проведення поглиблених інтерв'ю протягом 30 хвилин. Для аналізу кількісних даних використовували програмне забезпечення IBM SPSS. Для аналізу якісних даних використовували тематичний аналіз.

Результати. Результати кількісного дослідження показали статистично значуще підвищення рівня фізичної грамотності в експериментальній групі ($p<0,05$), але в контрольній групі підвищення не було ($p>0,05$). Результати якісного дослідження показали, що більшість учасників висловила різні думки й усі погодилися, що модель взаємонавчання може покращити фізичну грамотність недостатньо підготовлених спортсменів.

Висновки. За резльтатами цього дослідження було зроблено висновок, що взаємонавчання є альтернативною формою навчання, яку можна використовувати під час пандемії COVID-19 із метою підвищення рівня фізичної грамотності спортсменів, які займаються пенчак-силатом.

Ключові слова: взаємонавчання, фізична грамотність, спортсмени, які займаються пенчак-силатом, змішаний метод.

Information about the authors:

Muzakki, Abdurrohman: muzakki@umm.ac.id; https://orcid.org/0000-0002-5034-2346; Faculty of Teacher Training and Education, University of Muhammadiyah Malang, Jl. Bendungan Sutami No.188, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Setiawan, Edi: edisetiawanmpd@gmail.com; https://orcid.org/0000-0001-7711-002X; Faculty of Teacher Training and Education, Universitas Suryakancana, Jl. Pasirgede Raya, Bojongherang, Kec. Cianjur, Kabupaten Cianjur, Jawa Barat 43216, Indonesia.

Winarno, Mashuri Eko: m.e.winarno.fik@um.ac.id; https://orcid.org/0000-0002-2064-5418; Department of Physical Education, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Gani, Ruslan Abdul: ruslan.abdulgani@staff.unsika.ac.id; https://orcid.org/0000-0002-7608-1658; Faculty of Teacher Training and Education, Universitas Singaperbangsa Karawang, Jl. HS.Ronggo Waluyo, Puseurjaya, Telukjambe Timur, Karawang, Jawa Barat 41361, Indonesia.

Yanti, Novi: noviyanti@fkip.untan.ac.id; https://orcid.org/0000-0002-5994-2153; Faculty of Teacher Training and Education, Universitas Tanjungpura, Jl. Prof. Dr. H. Hadari Nawawi, Bansir Laut, Kec. Pontianak Tenggara, Kota Pontianak, Kalimantan Barat 78124, Indonesia.

Syamsudar, Bangbang: bangbangsyamsudar7@gmail.com; https://orcid.org/0000-0002-0969-0146; Faculty of Physical Education, STKIP Pasundan Cimahi, Jl. Permana No.32B, Citeureup, Kec. Cimahi Utara, Kota Cimahi, Jawa Barat 40512, Indonesia.

Hofmeister, Martin: martin.j.hofmeister@gmail.com; https://orcid.org/0000-0002-0693-7887; Department Food and Nutrition, Consumer Centre of the German Federal State of Bavaria, Mozartstraβe 9, 80336 Munich, Germany.

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ORIGINAL SCIENTIFIC ARTICLE

DEVELOPMENT OF TENDA IOT174 VOLLEYBALL LEARNING TO IMPROVE COGNITIVE ABILITY, FIGHTING POWER AND SPORTIVITY ON COLLEGE STUDENTS

Nur Ahmad Muharram[1AB], Suharjana[1BC], Djoko Pekiki Irianto[1AC], Wawan Sundawan Suherman[1CD], Slamet Raharjo[2BD] and Pungki Indarto[3BD]

[1]Universitas Negeri Yogyakarta
[2]Universitas Negeri Malang
[3]Universitas Muhammadiyah Surakarta

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

Corresponding Author: Nur Ahmad Muharram, E-mail: nurahmad.2019@student.uny.ac.id
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Abstract

The study purpose was to improve the cognitive abilities, fighting power and sportivity on the Physical Education Students Study Program at Universitas Nusantara PGRI Kediri.

Materials and methods. This study used the Research and Development method. A small-scale field trial was carried out in the sports building of the Universitas Nusantara PGRI Kediri, which implemented volleyball courses. Practical large-scale trials were carried out at STKIP Trenggalek which implemented volleyball courses, Kahuripan University which implemented volleyball courses, and STKIP Pacitan which implemented volleyball courses. The instruments used to collect data were observation, interviews, and assessment of the effectiveness of the test results as regards increasing cognitive abilities, fighting power and sportsmanship; for the validity of the cognitive abilities assessment instrument, validity was 0.865 and reliability was 0.836, for the fighting power assessment instrument, validity was 0.836 and reliability was 0.700, for the sportivity assessment instrument, validity was 0.897 and reliability was 0.824. The data analysis technique used was quantitative descriptive analysis and normality test analysis, and t-test.

Results. Based on the obtained results, the pretest and posttest values have a significant difference with the significance value for all variables being 0.000 < 0.05. For the cognitive ability variable, it was 0.000 < 0.05, for the fighting power variable, it was 0.000 < 0.05, and for the sportivity variable, it was 0.000 < 0.05.

Conclusions. Based on the results of the study, it was shown that the development of TENDA IOT174 volleyball learning improves cognitive ability, fighting power and sportivity in college students.

Keywords: volleyball learning, Tenda IOT174, cognitive ability, fighting power, sportivity.

Introduction

Human life today is much influenced by the development of technology, and in using this technology is accompanied by a pattern of behavior from the community towards today's technology (Cahyono, 2016). New discoveries related to technology have appeared in various fields or groups of science, including sports science (Ellapen & Paul, 2016). Sport is one of the sciences that can be linked to today's technology and is believed to be able to support progress or facilitate sports activities (Ratten, 2020). It can be said that technology in sports activities is expected to be able to get information more quickly and the level of truth can be accounted for (Giblin et al., 2016). The development of technology in information and communication systems is closely related to people's lives in the current era of the industrial revolution 4.0 (Ellitan, 2020). This is evidenced by the communication technology and information technology commonly referred to as mobile phones which have made it easier for people to find information (Chhanabhai & Holt, 2010). This technology can be an alternative for people to search for information and this technology has the characteristics of being able to be carried anywhere or more practical, because today's cellphones are supported by the internet network, where there are already various sources of information (Daeng, Mewengkang, & Kalesaran, 2017).

Mobile phones or communication tools in the current era are device operating systems that can support sophistication, so they are commonly called smart communication tools (Srivastava, 2005). In Indonesia, a communication device that has been widely used by the people of Indonesia has circulated, namely an operating system called Android (Setiawan et al., 2017). From various studies it has been proven that this communication tool gets the first rank or rank in Indonesian society with a percentage of 73.81% in 2015 Startcounter in (Brian Cusack, 2015). Linux-based mobile devices in which there is an operating system and applications are called Android (Cardoso, 2015). In developing and initiating an application that can allow an open platform or commonly referred to as Android (Lee, 2011). There are two types contained in this system, the first is a system that can support Google or Google Mail. The second type is one that does not have full support from Google or OHD (Safaat, 2015).

Based on observations or observations in the field aimed at students who have received volleyball courses at the Nusantara University, PGRI Kediri, Physical Education Study Program which states that almost students show difficulties in understanding the cognitive abilities of basic volleyball techniques or are in the "don't understand" category with a percentage of 85% of level 1, level 3, level 5 and level 7 who have received volleyball learning courses. This is because the basics of each student are different, so that when they are presented with the basic technical material in the volleyball game, the student still has difficulty implementing it in practical activities, because students only practice when learning volleyball takes place, there is no such theory or guide book. which becomes a reference or additional reference about volleyball courses. The results of this observation are very helpful in finding a new approach to volleyball cognitive abilities when students do a practical learning. It also takes fighting power and sportivity.

Students who have cognitive abilities can activate and utilize their knowledge effectively to solve problems (Turner, 2010). Cognitive ability can also be referred to as intelligence and the term intelligence has a broad and complex meaning. The concept of experts on intelligence is different, the difference in this concept mainly lies in the emphasis on certain aspects of mental abilities which are seen as qualities of intelligent behavior. In learning students who have a cognitive level in the low category, will have difficulty learning it and take a longer time to achieve learning outcomes because it is constrained by the ability to grasp the learning material (Awali, 2018).

Fighting power is a person's ability to use his intelligence to direct, change his way of thinking and actions when facing obstacles and difficulties that can make him miserable. In short, fighting power is a person's ability to deal with problems (Nashori & Kurniawan, 2006). Fighting power is not only visible from a physical point of view, but also from a psychological perspective. Therefore, carrying out the task requires perseverance and thoroughness in a long time to measure a child's fighting power from non-physical aspects. Non-physical fighting power will affect physical fighting power (Suparno, 2002). The learning method used, for example by implementing applications in learning, can certainly affect fighting power (Sari & Sylvia, 2014). Meanwhile, sportivity is an attitude of appreciating the noble values in a sport. The beginning of the term sportivity or can also be called sportsmanship is a term used in the world of sports (Raharja, 2019). In increasing cognitive ability, fighting power and sportivity appropriate efforts are needed. One of them is by following technological developments that are applied in learning.

However, the application of the latest technology in assisting learning is still limited. Therefore, with the technology that wants to be developed, it is hoped that it can help learning, especially in volleyball courses for students to improve cognitive abilities, fighting power, and sportivity in volleyball learning that has been given in accordance with the concept of the semester learning design that has been given. Field observations state that handbooks or modules for students have not been able to make students understand this, so researchers have the idea that in this era of the industrial revolution 4.0, students are more likely to hold cellphones than books related to learning, especially cognitive abilities of basic volleyball techniques, where one of the of these students do not really understand the instructions from the lecturer of the course. From the problems above, the researcher has the idea to develop a learning media related to basic techniques in technology-based volleyball games in the 4.0 industrial revolution era, namely using the Android application. Where later the technology can provide knowledge related to cognitive abilities, fighting power, and sportsmanship of basic volleyball techniques for students so that later with the learning video using the IOT174 tent it can help how to understand cognitive abilities, fighting power, and sportivity in basic techniques with movements correct.

Materials and Methods

Study participants

This research was The Research and Development which produces a product. Based on explanation (Borg & Gall, 2010) that research and development uses research findings to design new procedures and products, which are then systematically tested in the field, evaluated, and refined until they meet certain criteria of effectiveness, quality, or the same standard. The resulting product can later be used to facilitate the delivery of material in learning basic volleyball techniques through the Tenda IOT174 application. Small-scale trials amounted to 30 samples, large-scale trials amounted to 146 samples, and effectiveness tests totaled 40 samples.

Study organization

This research used the TENDA IOT174 application which was adapted to the characteristics of physical education students taking volleyball courses. TENDA IOT174 is a learning media developed to improve cognitive and affective abilities in volleyball learning which is adjusted to the semester implementation plan at private universities under the PGRI foundation. The development of this learning media is application-based which is in accordance with the volleyball learning material in the PGRI college. This application serves to analyze every movement of students when implementing a basic technical movement in volleyball games, namely upper passing, lower passing, smash, and also serving. Analysis into the application appears that the angle of motion has been adjusted to the basic technical movements

in accordance with the theory in the volleyball game. This application makes it easier for students to find out the extent of the movements that have been implemented by students in the field, so that students will improve every corner of the basic volleyball technique movement if there is something wrong in that corner. The TENDA IOT174 application has features in it related to basic volleyball techniques, when analyzed students can also download the results of the analysis of each of these movements so that students can re-observe the movement at every angle starting from the upper body corner (upper corner) and lower body (bottom corner). This TENDA IOT174 application is android based and requires an internet network to use it.

Assessment of basic volleyball techniques using the TENDA IOT174 application which was carried out for 4 meetings with a duration of 1 meeting for 120 minutes. The assessments taken include 3 assessment domains, namely cognitive, fighting power and sportivity. The data of this study consisted of pretest and posttest data from each assessment. The instruments used to collect data are observation, interviews, assessment of the effectiveness of the test results of increasing cognitive ability, fighting power and sportsmanship, for the validity of the cognitive assessment instrument validity 0.865 and reliability 0.836, fighting power validity 0.836 and reliability 0.700, sportivity validity 0.897 and reliability 0.824.

Statistical analysis

Statistical analysis using software Statistical Package for Social Science (SPSS) version 21 (SPSS Inc., Chicago, IL, USA). The first analysis is normality test uses the Chi-Square test, while the difference test used the Paired Sample t-Test. All statistical analyzes used a significant level ($p \leq 0.05$).

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Universitas Negeri Yogyakarta.

Results

The first test carried out is a prerequisite test in the form of a normality test as follows:

Table 1. Normality Test

Variabel		Significance	Information
Cognitive ability	Pretest	0.255	Normal
	Posttest	0.363	Normal
Fighting power	Pretest	0.096	Normal
	Posttest	0.636	Normal
Sportivity	Pretest	0.979	Normal
	Posttest	0.139	Normal

Based on the data in the table 1 above, the calculation of the normality test used Chi Square. The significance value on all variables > 0.05, this indicates that all research variable data has a normal distribution. Furthermore, hypothesis testing will be conducted to determine the difference between the data before and after the study.

Paired Sample T Test

The Paired Sample T Test results and basic volleyball techniques using the TENDA IOT174 application.

Table 2. Paired Sample T Test

Field of Volleyball Learning	Mean	t count	Difference	Sig.	%
Cognitive ability	82.166 91.233	-7.043	9.067	0.000	11.03%
Fighting power	78.166 87.600	-9.840	9.434	0.000	12.06%
Sportivitas	81.333 92.400	-10.751	11.067	0.000	13.60%

Based on Table 2 above, the pretest and posttest values have a significant difference with the significance value on all variables 0.000 < 0.05. The increase in the pretest and posttest of the cognitive domain was indicated by the t-value of -7.043 at a significance of 0.000, so it can be concluded that the increase in cognitive scores before and after learning experienced a significant increase. The increase in the pretest and posttest in the realm of fighting power is indicated by a t-value of -9.840 at a significance of 0.000, so it can be concluded that the increase in the value of fighting power before and after learning has a significant increase. The increase in the pretest and posttest in the realm of sportivity is indicated by the t-value of -10,751 at a significance of 0.000, so it can be concluded that the increase in the value of sportivity before and after learning experienced a significant increase. The contribution of basic volleyball techniques using the TENDA IOT174 application for the cognitive ability aspect is 11.03%, the fighting power aspect is 12.06%, and the sportivity aspect is 13.60%.

Discussion

Based on results that the pretest and posttest values have a significant difference with the significance value on all variables 0.000 < 0.05. Based on these results indicate that the use of the TENDA IOT174 application can increase cognitive ability, fighting power and sportivity on college students. This is probably because the TENDA IOT174 application is very effective to use and its features are very supportive.

In the era of the industrial revolution 4.0, a lecturer is required to be able to develop something with the intention that students can understand and apply the learning without any obstacles in understanding, analyzing and also practicing. The basic technique of android-based volleyball is TENDA IOT174 which combines movement analysis and also the anatomy of motion and angles when performing basic volleyball technical movements, ranging from upper body and lower body movements. So that the basic techniques of volleyball through the TENDA IOT174 application can be used properly as a support or material in learning, especially volleyball for students and can improve cognitive abilities, fighting power and sportivity. TENDA IoT174 application is a development tool. Based on the results obtained, it shows that the development of the TENDA IOT174 application is successful, so that it can

improve Cognitive Ability, Fighting Power and Sportivity on College Students. Development is needed to keep up with the times so that learning can be more optimal.

Development in general means a pattern of growth, gradual change (evolution) and gradual change. Sumarno argues that development means the process of translating or elaborating design specifications into the form of physical features. Development specifically means the process of producing learning materials (Sumarno, 2012). Meanwhile, according to (Sumarno, 2012) development focuses not only on needs analysis, but also on broad issues of early-late analysis, such as contextual analysis. Development aims to produce products based on the findings of field tests. In essence, development is an educational effort both formal and non-formal which is carried out consciously, planned, directed, regularly and responsibly in order to introduce, grow, guide, develop a personality basis that is balanced, intact, aligned, knowledge, skills according to talent, desires and abilities, as a provision on their own initiative to add, improve, develop themselves in the direction of achieving optimal human dignity, quality and abilities as well as independent individuals (Wiryokusumo, 2011).

The TENDA IOT174 application used in volleyball learning can increase students cognitive ability. This is probably because learning volleyball using the TENDA application can be followed and understood by students well, because students who have high cognitive abilities will easily accept the learning material presented (Taub, Floyd, Keith, & McGrew, 2008). Cognitive abilities are thought processes, such as problem solving, comparing, evaluating and creativity. In addition, cognitive aspects include intellectual functions such as understanding, knowledge and thinking skills (Sujiono, 2010). Cognitive abilities related to receiving and reintroducing material are needed because every thought process must use previously learned facts and ideas (Munandar, 2014). Students who have high cognitive abilities in the learning process look faster than the group of students who have low cognitive abilities. This is because factors such as cognitive originating from students, (cognitive strategies) can significantly affect learning abilities and the quality of learning outcomes in physical education. This means that students who have high cognitive abilities tend to be more optimal in the learning process that follows (Paulina, 1997).

The TENDA IOT174 application used in volleyball learning can increase students' fighting power. Previous research shows that there are 11 soccer athletes or 29% have fighting power in the high category, 18 soccer athletes or 47% have fighting power in the medium category and as many as 9 soccer athletes or 24% in the low category. So from these results it can be seen that the highest level of fighting power is in the medium category, the rest in the high and low categories (Susila, 2018). Fighting power affects academic achievement, this is evidenced by students who have high scores, have high fighting power, while students with low scores have low fighting power (Huda & Agus, 2017). Students' efforts in overcoming learning difficulties are called fighting power (Stoltz, 2006). Students who have high fighting power will direct all their potential to achieve achievements or can provide the best results (Fahmi & Rachmahana, 2008). Fighting power is an internal factor of students that needs to be considered (Sari & Sylvia, 2014), because fighting power can give encouragement to students to always achieve learning success and get the best learning achievement. Fighting power is an intelligence or ability to change, or process a problem or difficulty and make it a challenge that must be solved so as not to hinder the ideals and achievements to be achieved. Strength will also determine student success (Diana, 2008). Someone who has fighting power is able to respond to a situation with a positive response (Pool & Sewell, 2007). In addition, fighting power is able to give one's self-confidence and positive behavior (Arifin, 2020), fighting power can increase student motivation in learning (Aulia et al., 2019; Mayangsari et al., 2021). But, many factors affect fighting power, it is explained that fighting power is influenced by one's self-concept and self-efficacy (Ipriani & Nugroho, 2015).

Volleyball learning by using the TENDA IOT174 application can increase spotivity. This shows that the learning provided through the TENDA IOT174 application can provide a useful experience according to the level of development. This is because sports education is designed to provide an authentic and rewarding sports experience for students. So that the application used can provide real experience to students in participating in sports and can assess not only movement skills but also the attitudes shown during learning activities. A person's attitude is also influenced by his social development. A person's social development will not go well if it is not trained and taught, school is one of the factors that also influences the personality and social behavior of individuals. Therefore, learning needs to be presented in accordance with the needs of the level of development, and covers all aspects of both cognitive, affective, and psychomotor, so that it can shape the character of students to be physically and mentally healthy, and foster a sense of sportivity (Raharja, 2019). Sportivity is ethically appropriate which is made manifest by following the rules of the game, respecting opponents, and committing to fair play, while fair play is identified with certain behaviors characterized by respect for the rules, maintaining equal opportunity and impartiality (Gómez & Sánchez, 2014). Sportivity involves an intense struggle to succeed, a commitment to the spirit of play so that ethical standards will take precedence over strategic advantage when conflict (Weinberg & Gould, 2007).

Based on the explanation above, it shows that in today's learning technology is needed to keep up with the times. In volleyball learning by using the TENDA IOT174 application, it can improve cognitive ability, fighting power and sportivity on college students.

Conclusion

Based on the results of the study, it was shown that the basic volleyball technique using the TENDA IOT174 application have a significant difference with the significance value on all variables $0.000 < 0.05$. On the cognitive ability variable was $0.000 < 0.05$, on the fighting power variable was $0.000 < 0.05$, and on the sportivity variable was $0.000 < 0.05$. The contribution of basic volleyball techniques used the TENDA IOT174 application for the cognitive aspect is 11.03%, the fighting power aspect is 12.06%, and the sportivity aspect was 13.60%.

Conflict of interest

The researcher declares that there is no conflict of interest in this research.

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РОЗРОБКА ЗАСТОСУНКУ ДЛЯ НАВЧАННЯ ВОЛЕЙБОЛУ «TENDA IOT174» ДЛЯ ПІДВИЩЕННЯ КОГНІТИВНИХ ЗДІБНОСТЕЙ, ФІЗИЧНОЇ ПІДГОТОВЛЕНОСТІ ТА СПОРТИВНОЇ МАЙСТЕРНОСТІ СТУДЕНТІВ КОЛЕДЖУ

Нур Ахмад Мухаррам[1AB], Сухарджана[1BC], Джоко Пекік Ірianто[1AC], Ваван Сундаван Сухерман[1CD], Сламет Рахарджо[2BD], Пункі Індарто[3BD]

[1]Джок'якартський державний університет
[2]Малангський державний університет
[3]Університет Мухаммадія в Суракарті

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

Реферат. Стаття: 7 с., 2 табл., 38 джерел.

Метою дослідження було покращення когнітивних здібностей, фізичної підготовленості та спортивної майстерності в рамках навчальної програми студентів фізичного виховання в Кедірійському університеті Нусантара Асоціації вчителів Індонезії (Східна Ява, Індонезія).

Матеріали та методи. У цьому дослідженні використовували метод наукового дослідження та розробки. Маломасштабні польові випробування проводили в спортивній будівлі на території Кедірійського університету Нусантара Асоціації вчителів Індонезії, який упровадив курси з волейболу. Практичні повномасштабні випробування проводили в Тренгалекському педагогічному коледжі (Індонезія), Університеті Кахуріпан (Індонезія), і Пачитанському педагогічному коледжі (Індонезія), які упровадили курси з волейболу. Як інструменти для збору даних використовували спостереження, опитування та оцінювання ефективності результатів тестів щодо підвищення когнітивних здібностей, фізичної підготовленості та спортивної майстерності; стосовно валідності інструмента для оцінки когнітивних здібностей, показник валідності становив 0,865, а надійності – 0,836, стосовно валідності інструмента для оцінки фізичної підготовленості, показник валідності становив 0,836, а надійності – 0,700, стосовно валідності інструмента для оцінки спортивної майстерності, показник валідності становив 0,897, а надійності – 0,824. Як метод аналізу даних використовували кількісний описовий аналіз та аналіз перевірки нормальності розподілу, а також t-критерій Стьюдента.

Результати. На підставі одержаних результатів установлено, що значення попереднього та підсумкового тестування статистично значущо різняться, при цьому рівень значущості за всіма змінними приймає значення 0,000 < 0,05. Для змінної когнітивних здібностей він дорівнював 0,000 < 0,05, для змінної фізичної підготовленості він дорівнював 0,000 < 0,05, для змінної спортивної майстерності він дорівнював 0,000 < 0,05.

Висновки. На підставі результатів дослідження було підтверджено, що розробка застосунку для навчання волейболу «TENDA IOT174» підвищує показники когнітивних здібностей, фізичної підготовленості та спортивної майстерності студентів коледжу.

Ключові слова: навчання волейболу, застосунок «Tenda IOT174», когнітивні здібності, фізична підготовленість.

Information about the authors:

Muharram, Nur Ahmad: nurahmad.2019@student.uny.ac.id; https://orcid.org/0000-0002-8741-0664; Department of Sports Coaching Education, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Suharjana: suharjana_fikuny@yahoo.com; https://orcid.org/0000-0003-0984-8086; Department of Sports Coaching Education, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Irianto, Djoko Pekik: djoko.pekik@uny.ac.id; https://orcid.org/0000-0002-8635-7830; Department of Sports Coaching Education, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Suherman, Wawan Sundawan: wansuherman@uny.ac.id; https://orcid.org/0000-0002-5565-0751; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Raharjo, Slamet: slamet.raharjo.fik@um.ac.id; https://orcid.org/0000-0002-0708-867X; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Indarto, Pungki: pi311@ums.ac.id; https://orcid.org/0000-0002-2261-0403; Universitas Muhammadiyah Surakarta, Jl. A. Yani, Mendungan, Pabelan, Kec. Kartasura, Kabupaten Sukoharjo, Jawa Tengah 57162, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECTIVENESS OF SIX-WEEK BALANCE TRAINING WITH PERTURBATION INTERVENTION IN ENHANCING DYNAMIC BALANCE OF BASKETBALL PLAYERS

Ai Choo Lee[1ABCDE], Mohansundar Sankaravel[1ABCDE] and Zhee Xuen Chen[2ABCDE]

[1]Universiti Pendidikan Sultan Idris
[2]DBC Physiotherapy Centre, Melaka

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

Corresponding Author: Mohansundar Sankaravel, E-mail: mohan@fsskj.upsi.edu.my
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Abstract

Background. It is known that all sports require dynamic balance and more specifically towards contact sports such as basketball which puts players through array of perturbation and collision during the game. The purpose of this study was to find out the effectiveness of six-week balance training with perturbation in enhancing dynamic balance of basketball players.

Materials and methods. The study participants were ten basketball players who volunteered and were randomly distributed into an Experimental Group (N=5) and a Control Group (N=5). The Experimental Group received a six weeks balance training intervention with perturbation for a total of 18 sessions, while Control Group kept regular training. The Y-balance test was used in pre-test and post-test to measure dynamic balance of both groups. Independent sample t-test was used for the analysis of results.

Results. The study findings revealed that the Experimental Group improved significantly in dynamic balance at p=0.000 after having undergone the 18 sessions of intervention with perturbation, while there was no significant improvement in the Control Group.

Conclusions. This study concluded that the six-week balance training with perturbation is effective in enhancing dynamic balance control in basketball players. This intervention can be modified or integrated into a neuromuscular training program to further improve dynamic balance of basketball players, hence, may help in reducing injury risk. This intervention also can be suggested as a training regime for other contact sports that require excellent balance control.

Keywords: basketball, dynamic balance, perturbation, proprioception.

Introduction

It is known that all sports requires dynamic balance and more specifically towards contact sports such as basketball which puts players through array of perturbation and collision during the game. Basketball continues to increase in popularity at all levels of play, from recreational to professional (Caine et al., 1996) and remains immensely popular, not just in the United States, but throughout the world (Cantwell, 2004). The basketball game place packed emphasize on the speed and power of athletes (Starkey, 2000). As stated by Meeuwisse (Meeuwisse et al., 2003), games were responsible for the majority of injuries causing more than seven sessions of time loss, resulting in a rate of severe injury 3.69 times greater than that of during practices. Hence, it can be foreseen that the frequency of injury during game was two times higher than during practices (9.9 versus 4.3 injuries per 1000 athlete-exposures) (Dick et al., 2007), According to Ferretti and colleagues (Ferretti et al., 1992) the frequency of injuries during a game is much higher than during a practice. It can be attributed to the high level of competition and the amount of effort that the players put into the game. They also noted that the increased risk of getting injured is caused by the high intensity of the competition. In games, fewer players generally participate, but the activity is usually at a very high level of intensity. This high intensity physical effort and its associated fatigue, combined

with a more unpredictable, competitive environment, may predispose game participants to acute injury compared with practice participants. As such, injuries during games were more likely to be due to player contact or other contact than were injuries occurring during practice (Starkey, 2000).

It is noted that unpredictable physical contact and perturbation is a factor to acute injuries when players are fatigue during intense games, also, they loss focus and their ability to maintain dynamic balance to resist the perturbation. Hence, this is when the injuries incidence rate increase. Furthermore, referring to Yde and Nielsen (1990), contact with other player was the main reason for time loss injuries; followed by non-contact injuries. As stated by Dick et al. (2007), half of the game injuries were coupled with player contact whereas nearly one fifth of game injuries were from contact with the floor.

Lee and Lee (2018) in their study indicated that great frequency of ankle and knee injuries in contact-sports among Malaysian athletes. A probable cause for the susceptibility of the ankle to be injured was its close proximity to the contact surface (e.g. equipment and opponent's body), which is the focus of activity in the contact-sports. They also found that the lower extremities (65.5%) were the common location for injuries in contact-sports. These findings were also similar with other studies (Choo et al., 2018; Lee et al., 2017). The researchers were also asserted that the lower extremities (51.1%) appear to be the most frequent site for the injuries as well (Choo et al., 2018). Injuries to the lower extremities especially knee and ankle regions were exposed to injuries at any time when the athletes with poor balance control required to run, turn, change of direction, and jump during weight bearing sporting activities. Consequently, they proposed that lack of balance control perhaps a contributory factor for lower extremity injuries (Choo et al., 2018; Lee et al., 2017). According to Cumps et al. (2007), rate of injury for player with poor balance was two to seven times compared with rate of injury for player with good balance. Poor balance ability has been significantly associated with an increased risk of ankle injury in a number of sports.

Generally sensorimotor or balance training programs are prescribed to improve balance ability. According to Teichmann et al. (2018), when sensorimotor or balance training has been incorporated into rehabilitation programs which can improve static and dynamic balance in both athletic and non-athletic populations. However, these rehabilitative exercises often represent relatively slow perturbations to human sensorimotor function (>350 ms), while empirical observations suggest that injuries occur in a time span of between 17 and 50 milliseconds after initial ground contact.

Fitzgerald et al. (2000) studied on efficacy of perturbation training in non-operative anterior cruciate ligament rehabilitation programs for physically active individuals. A group of subjects were received standard rehabilitation program and other group received the standard program augmented with a balance training with perturbation. Although both the standard program and the balance training with perturbation may allow individuals to return to high-level physical activity, the balance training with perturbation appears to reduce the risk of continued episodes of giving way of knee during athletic participation, and it allows individuals to maintain their functional status for longer periods.

Yom et al. (2014) conducted a study based on lateral in-flight perturbation during drop landings. They determined that lateral in-flight perturbations affect both frontal plane and sagittal plane lower-extremity biomechanics. Developmentally, these outcomes indicated that the athletes characteristically adjust their mechanics to land carefully after a semi-anticipated frontal plane perturbation, such as a push or a bump sideways by an opponent while in the air. Generally, the ability to generate sufficient, eccentric extensor and adductor moments about the lower extremity joints is of primary importance. Consequently, these researchers has demonstrated the importance of developing a proper dynamic balance and landing mechanics are crucial in reducing the risk of being in abnormal or excessive movement of biomechanics at the lower extremities. As a result, the reduced moment in hip abduction and adduction can decrease the shearing force and loading on the soft tissue causing less strain and hence reduce the likelihood of getting injured during in-flight lateral perturbation during games.

Therefore, this study was conducted to determine the effectiveness of six weeks balance training with perturbation in improving dynamic balance of university basketball players. The researcher is hoping that if this intervention is effective in improving dynamic balance, study finding may be beneficial and referred to basketball coaches and players to include this intervention into basketball training regime. With improved dynamic balance ability, it may reduce the risk of lower extremities injuries among basketball players.

Materials and methods

Study Design

This study used an experimental design to investigate the effectiveness of six weeks balance training with perturbation on dynamic balance among university basketball players. All ten eligible subjects who satisfied the inclusion norms were randomly allocated to either Experimental Group (EG) or Control Group (CG) by drawing an envelope indicating either EG or CG in order to eliminate bias.

Sampling Method

Purposive sampling method was utilized to recruit eligible subjects. The population in this study are Sultan Idris Education University Basketball players' age ranging from 20 to 25 years old. There were total of 60 Basketball club members with ten state representatives or advanced level players and ten intermediate or high school team representatives previously and five players with three years' experience and training and competing for UPSI Hystrix Basketball club. Besides the above mentioned basketball club members, there were non-club members i.e. recreational basketball players also volunteered in this study. The eligible subjects were screened using self-reported questionnaire. After the screening process, ten basketball players who fulfilled the inclusion criteria were recruited in this study as study subjects.

Inclusion and Exclusion Criteria

The subjects must be free from any lower extremities injuries and possess normal musculoskeletal functions in all joints within six months of participation. These

volunteers must have at least two years' experience in playing basketball. Subjects were included only if their vestibular and neurological functions were normal. University basketball players who had injuries within six months prior to this study and had impaired vestibular and neurological functions were excluded because these impaired functions would affect balance control.

Research Procedure

A total of ten subjects were randomly assigned into two groups i.e. Experimental Group and Control Group. The subjects in Experimental Group were undergone six weeks of balance training with perturbation while Control Group remained their normal training routine without any intervention. A written informed consent was distributed and subjects were required to fully understand the research procedures before participating in the study. They were allowed to withdraw in anytime without any reason given. The balance training with perturbation intervention consisted of 31 training variations. The experimental group was trained three sessions per week for six weeks with a total of 18 sessions. The control group remained their normal training without any additional intervention. Before starting the balance training with perturbation intervention (pre-test) and after balance training with perturbation intervention (post-test), all subjects were required to undergo Y-balance test for dynamic balance pre-test and post-test measures. The subjects in control group were also undergone pre and post-test procedures. Every subject from experimental group and control group was given one practice trial for familiarization of testing protocols. During the testing sessions, all subjects performed two trials and the average score was recorded for data analysis to avoid measurement error that may influence study results.

Balance Training with Perturbation Intervention

In this study, the experimental group was undergone the balance training with perturbation intervention while maintaining their normal training routine. Each intervention session lasted about 30 to 45 minutes. Warming up and cooling down sessions were involved before and after the training sessions. The balance training with perturbation intervention were designed to alter or modify vestibular input, and proprioception input to enhance sensorimotor integration in Central Nervous System (CNS). Proprioception input was modified with varies stances i.e. a) tandem stance, b) split squat stance, c) single leg stance, d) bilateral jumping and landing, e) single leg jumping and landing. Apart from progression in varies stances, vestibular input was challenged with various unexpected disturbance i.e. perturbation. Types of perturbation were differentiate by a) numbers, b) speed and c) predictability (i.e. constant or random). The intervention variations were progressed with the combination of various stances and types of perturbation on basis of simple and less challenging to complex and more challenging (Table 1). All training variations were progressed gradually as to challenge the vestibular and proprioception inputs which are important factors in improving dynamic balance to enhance the sensitivity of sensorimotor integration in CNS.

Table 1. Combination of Training Variations

Visual Eyes condition	Vestibular Types of perturbation	Proprioception Stance
	a. numbers	Tandem
	b. speed	Split squat
	c. predictability	Single leg
Open	-constant	Bilateral jumping and landing
	-random	Single jumping and landing

Research Measurement Instrument

The Y-Balance Test was utilized in this study as it is considered a useful tool in detecting injury susceptible subjects Gonell et al. (2015). Besides that, it has proven excellent levels of inter-rater test–retest reliability as reported in a study conducted by Lee and Ong (2012). The study revealed excellent test-retest reliability using Intraclass Correlation Coefficients i.e. 0.98, 0.98, and 0.99 on anterior, posteromedial, and posterolateral directions respectively.

The Y-Balance Test required subjects to balance on one leg while concurrently reaching as far as possible with the other leg in three different directions i.e. anterior, posterolateral and posteromedial (Figure 1). This test is used to measure the subject's strength, stability and balance in various directions. The subjects did a practice trial before testing sessions started. The subjects repeated the test with same leg for two successful reaches. After completed two successful reaches, they repeated this process with the other leg. Once subjects completed two successful reaches with each leg, they progressed to next test directions.

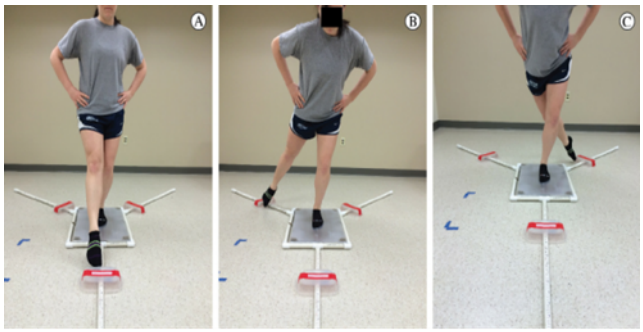

Fig. 1. Y- Balance Test

Statistical Analysis

Dynamic balance measures using Y-Balance Test were recorded and analyzed using independent sample t-test and paired sample t-test in Statistical Package for Social Science version 22. Independent sample t-test was used to compare the difference in dependent variable between Experimental Group and Control Group. The paired sample t-test was used to compare the difference on dynamic balance before and after intervention within Experimental Group to determine the effectiveness of balance training with perturbation intervention. The level of significance was predetermined at $p<0.05$.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Universiti Pendidikan Sultan Idris.

Results

The demographic data of both Experimental Group and Control Group are similar in age, height and weight indicating that they were recruited from homogeneous group. The descriptive characteristics for these ten subjects in this study were shown in Table 2.

Table 2. Demographic Data of Experimental Group and Control Group

Variables	Experimental Group (n=6) (μ±SD)	Control Group (n=6) (μ±SD)
Age (years)	22.4 ± 1.34	23.6 ± 0.894
Height (cm)	169.8 ± 5.58	170.6 ± 5.72
Weight (kg)	64.0 ± 14.17	67.6 ± 11.41

Table 3 and Figure 2 portrayed the result of comparison between Experimental Group and Control Group for dynamic balance on absolute reach before the intervention. The pre-test value of dynamic balance on absolute reach between Experimental Group (79.44 ± 3.94 cm) and Control Group (78.66 ± 9.43 cm) revealed that there was no significant difference, indicating both groups were in homogeneous group (p = 0.869) before the balance training with perturbation intervention. After Experimental Group undergone 18 sessions of balance training with perturbation intervention, the result indicated there was significant difference for dynamic balance on absolute reach (p = 0.000*) between the Experimental Group (88.62 ± 4.51 cm) and Control Group (78.87 ± 9.05 cm).

Table 3. Pre-Test and Post-Test Between Experimental Group and Control Group for Dynamic Balance on Absolute Reach using Y-Balance Test Before and After Intervention

	Control Group (μ±SD)	Experimental Group (μ±SD)	p
Pre test	78.66 ± 9.43	79.44 ± 3.94	0.869
Post test	78.87 ± 9.05	88.62 ± 4.51	0.000*

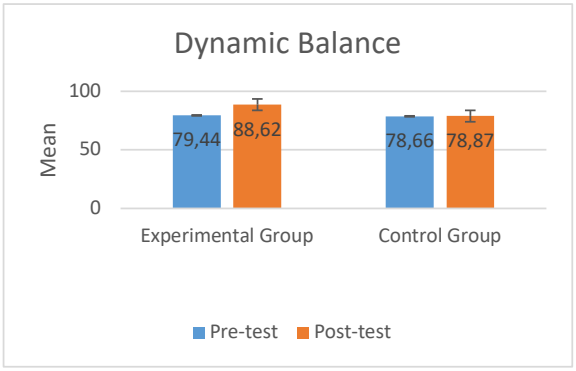

Fig. 2. The Mean of Experimental Group and Control Group for Dynamic Balance on Absolute Reach in Centimetres using Y-Balance Test Before and After Intervention

For the result before and after intervention of Experimental Group, after the 18 sessions of balance training with perturbation intervention, the mean of dynamic balance on absolute reach had increased from 79.44 cm to 88.62 cm (increased 9.18 cm). Study finding indicated that there was a significant improvement in dynamic balance on absolute reach (p = 0.000*) after intervention (Refer Table 4 and Figure 2).

Table 4. Pre-Test and Post-Test of Experimental Group for Dynamic Balance on Absolute Reach using Y-Balance Test Before and After Intervention

	Pre test (μ±SD)	Post test (μ±SD)	p
Experimental Group	79.44 ± 3.94	88.62 ± 4.51	0.000*

Discussion

The study finding indicated that the six weeks of balance training with perturbation intervention was effective in improving the dynamic balance of university basketball players. The Experimental Group obtained improvement in their dynamic balance after undergoing the balance training with perturbation while Control Group did not indicate any improvement because they only followed normal training routine without undergone any intervention. Withal, the dynamic balance improvement of Experimental Group was due to the progression of perturbation variations on different level of intensity to prevent plateauing. The progressively designed variations has challenged the proprioceptive input and vestibular input of the subjects by pushing on the subjects' shoulder with and without their knowledge which resulted in different forms of physiological stress that induced different neural and muscular adaptation (Lesinski et al., 2016).

In consequences, this finding has demonstrated that proprioception is an important factor in maintaining dynamic balance and sensing the position of limbs in space when vestibular and visual aspects of balance component is altered as proposed from a previous study by Irrgang et al. (1994), the vestibular system itself functions as an important apparatus that assists in maintaining the body upright against force of gravity. Whereas the visual aspects provide input to assist in balance control by counteracting the effect of head movement and the proprioception aspect receive inputs from the joints and surrounding structures and receptors to provide sensation of limbs in spaced. All these units must function optimally or dynamic balance will be affected after the postural perturbation.

This is in agreement with Lee and Lim (2020), as they trained Wushu players on trampoline to alter their proprioception. Their intervention were improved the dynamic balance of the subjects because of the repeated sensory feedback and continuous exposure to perturbation. In addition to that, the subjects were continuously challenged their postural changes and center of gravity trajectory while using trampoline. These things provided more challenging environment to proprioceptive input and vestibular input. By the rebounding nature of trampoline the vestibular input were also challenged and altered during perturbation.

The improvement of dynamic balance in Experimental Group is also due to the improved ability to maintain

dynamic balance in response to the balance disrupting force by perturbation or external forces, since the human body is not statically stable even during quiet double-limb stance, the Central Nervous System is constantly making adjustments to keep the center of mass over the base of support (Han et al., 2009). In previous studies, it is suggested that the Central Nervous System utilizes a "throw and catch" pattern to generate joint torques on opposite sides of the joint to maintain balance while standing. Henceforth, subjects were required to maintain dynamic balance while resisting against the balance disturbing force caused by the tension in the elastic tubing perturbation which will impose an accentuated neural training effect that can improve dynamic balance ability (Loram & Lakie, 2002).

Meanwhile, the manipulation of proprioceptive input and vestibular input through 31 combinations of variations is believed to be able to enhance the sensitivity of sensorimotor integration. Rapid sensorimotor integration from Central Nervous System indicating one has excellent dynamic balance ability. As stated by Piegaro, A (Piegaro, 2003), a four weeks balance training program is effective in improving dynamic balance significantly. Consequently, this explained that six weeks of balance training with perturbation is sufficient in inducing significant improvement in the dynamic balance of the experimental group in this study.

Furthermore, Cumps and colleagues (Cumps et al., 2007) reported that an improvement in balance ability is essential in reducing injury risk of basketball athletes. Therefore, when the experimental group displayed significant improvement in dynamic balance, it is a precursor in reduction of injury risk during game contacts.

Implications of Study

Study finding may help to explain the importance of dynamic balance on basketball players and other contact sports that required good dynamic balance control to reduce the risk of sustained lower extremities injuries. Therefore, it is suggested that this balance training program with perturbation can be considered to implement as one part of training regime for contact sports, hoping to improve dynamic balance of the players.

Conclusion and Recommendations

Dynamic balance ability is inversely proportional to risk of sustained lower limb injury and is important in improving sports performance in athletes especially basketball players. The six weeks balance training with perturbation revealed significant improvement in dynamic balance of Experimental Group. Hence, this intervention is essential for basketball players to improve their dynamic balance. It is suggested that this intervention could be modified or integrated into a training program to further improve dynamic balance of basketball players and other contact sports, indirectly, it may help in reducing risk of injury.

Imminent research may include larger sample size and longer intervention period. Stance variations and base of support may change to foam mats, tilt boards, seesaw apparatus such as tilting platforms and movable platforms to provide more difficult and challenging proprioceptive input and vestibular input. Intervention variations may design by considering the level of subject population and sports specific in order to challenge dynamic balance ability.

Conflict of interest

The researcher declares that there is no conflict of interest in this research.

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ЕФЕКТИВНІСТЬ ШЕСТИТИЖНЕВИХ ТРЕНУВАНЬ НА ЗБЕРЕЖЕННЯ РІВНОВАГИ З ІНТЕРВЕНЦІЙНИМ ЇЇ ЗОВНІШНІМ ПОРУШЕННЯМ У ПОКРАЩЕННІ ДИНАМІЧНОЇ РІВНОВАГИ БАСКЕТБОЛІСТІВ

Ай Чу Лі[1ABCDE], Мохансундар Санкаравел[1ABCDE], Чжі Сюен Чен[2ABCDE]

[1]Університет освіти імені Султана Ідріса
[2]Центр фізіотерапії DBC

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

Реферат. Стаття: 7 с., 4 табл., 2 рис., 22 джерела.

Історія питання. Відомо, що всі види спорту вимагають динамічної рівноваги, а особливо контактні види спорту, такі як баскетбол, який змушує гравців проходити цілу низку порушень рівноваги та зіткнень протягом гри. Метою цього дослідження було з'ясувати ефективність шеститижневих тренувань на збереження рівноваги в умовах її зовнішнього порушення в покращенні динамічної рівноваги баскетболістів.

Матеріали та методи. У дослідженні брали участь десять баскетболістів, які добровільно погодилися та були випадковим чином розподілені на експериментальну групу (N=5) та контрольну групу (N=5). Експериментальна група отримувала інтервенційні заходи у формі шеститижневих тренувань на збереження рівноваги в умовах її зовнішнього порушення протягом загалом 18 занять, а контрольна група продовжувала звичайні тренування. Для вимірювання показників динамічної рівноваги під час попереднього та підсумкового тестування в обох групах використовували тест на збереження рівноваги на базі підлогової платформи у формі літери Y. Для аналізу результатів використовували t-критерій Стьюдента для незалежних вибірок.

Результати. За результатами дослідження було встановлено, що показники динамічної рівноваги в експериментальній групі після проходження 18 занять у рамках інтервенційних заходів із зовнішнім порушенням рівноваги статистично значущо покращилися за рівня достовірності p=0,000, тоді як у контрольній групі статистично значущого покращення не спостерігалося.

Висновки. За результатами цього дослідження зроблено висновок, що шеститижневі тренування на збереження рівноваги в умовах її зовнішнього порушення є ефективними для покращення контролю динамічної рівноваги в баскетболістів. Ці інтервенційні заходи можна змінювати або інтегрувати до програми нервово-м'язових тренувань із метою подальшого покращення динамічної рівноваги баскетболістів, отже, з її допомогою можна знизити ризики травмування. Ці інтервенційні заходи також можна рекомендувати як режим тренувань для інших контактних видів спорту, які вимагають відмінного контролю рівноваги.

Ключові слова: баскетбол, динамічна рівновага, зовнішнє порушення, пропріоцепція.

Information about the authors

Lee, Ai Choo: lee.ac@fsskj.upsi.edu.my; https://orcid.org/0000-0003-4634-9083; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, 35900, Malaysia.

Sankaravel, Mohansundar: mohan@fsskj.upsi.edu.my; https://orcid.org/0000-0003-2425-7399; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, 35900, Malaysia.

Chen, Zhee Xuen: chenzheexuen@outlook.com.my; https://orcid.org/0000-0001-8887-7736; DBC Physiotherapy Centre, 189-1F-01 & 1F-02, Jalan Persisiran Bunga Raya, 75300, Melaka, Malaysia.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF VMBR TRAINING ON PSYCHOLOGICAL DIMENSIONS OF ANXIETY AND MENTAL TOUGHNESS OF TABLE TENNIS PLAYERS

Arnav Sharma[1ABCDE] and Brij Kishore Prasad[1AC]

[1]Lakshmibai National Institute of Physical Education

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

Corresponding Author: Arnav Sharma, E-mail: arnavsharma164@gmail.com
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Abstract

Study purpose. The study was conducted to examine the effects of Visual Motor Behavior Rehearsal (VMBR) Training on sports anxiety and mental toughness of table tennis players after six weeks of the training.

Materials and methods. Fifty male state-level table tennis players within the age group of 17 to 23 years were selected from Inspire Table Tennis Academy, Secunderabad, Telangana and divided randomly into two groups, the Control and Main Groups, each one consisting of 25 subjects. The Main Group underwent VMBR Training for six weeks, three times a week, and the Control Group was not involved in any kind of training program except for their daily practice. Measurements of anxiety of all table tennis players with the use of Sports Anxiety Scale-2 (SAS-2) with three dimensions which were somatic, worry and concentration disruption developed by Ronald E. Smith, Frank L. Smoll, Sean P. Cumming, and Joel R. Grossbard in 2006 and Sports Mental Toughness Questionnaire (SMTQ) with three dimensions which were confidence, consistency and control developed by Michael Sheard, Jim Golby, and Anna Van Wersch in 2009 were taken at the beginning of and after the experimental period of six weeks.

Results. Significant effect was found in the Main Group at a significance level of 0.05 for dimensions which were sports mental toughness and somatic, worry and concentration disruption from anxiety scale dimensions of table tennis players.

Conclusions. The visualization and imagery has been used as an effective tool for enhancing performance. Visual-Motor Behavior Rehearsal is a systematic psychological technique that helps table tennis players in overcoming psychological factors.

Keywords: visual motor behavior rehearsal, sports anxiety scale, sports mental toughness.

Introduction

The definition of Cognitive anxiety is as "negative expectations and cognitive concerns about oneself, the situation at hand and potential consequences", and somatic anxiety defines as "one's perceptions of the physiological affective elements of the anxiety experience, that is, indications of autonomic arousal and unpleasant feelings states such as nervousness and tension" (Soundarapandiyan Dhinakaran et al., 2020)

Visual Motor Behavioural Rehearsal serves as the cornerstone of all programmed mental skill training in applied sports psychology. The primary goals of VMBR are to make players feel more confident and perform better while also reducing stress, negative emotions, and anxious thoughts (Singh & Bhowmik, 2020).

Cognitive restructuring strategy used in Cognitive Behavioural Therapy assists athletes in locating the root of their stress, comprehending their emotional reactions, and empowering them to respond more positively. Players begin to see challenges as opposed to dangers as a result, leading to an increase in positive feelings and performance satisfaction (Oelberger, 2020). The use of visualisation and imaging as a method for improving performance has proven to be successful. Visual-Motor Behaviour Rehearsal, however, is a methodical psychological strategy that aids athletes from a variety of sports in overcoming psychological challenges and improving performance. The technique known as Visual-

Motor Behaviour Rehearsal (VMBR) involves mentally recording an event and playing it again piece by piece. Technique improvement, mistake analysis and repair, and completion preparation are all phases in VMR that help athletes perform better. raise psychological thresholds and skill development (Chauhan et al., 2020). The foundation of VMBR is the idea that using imagination before doing a task may make it simpler and more precise. It is also feasible to achieve intellectual and physical feats by using imagination in ways that go beyond what is achievable for athletes. Through visualization exercises, VMBR training enables athletes to become aware of their motor performance flaws, which helps them to reduce errors and enhance performance (Chaudhary, 2018). VMBR is proven as one of the methods that can help novice learning process became faster and more accurate. Combining VMBR training with physical practice help in skill performance enhancement become more efficient (Sa'ari & Isa, 2018)

One of the most popular sports in the world is Table Tennis. Table Tennis, which has been around for just over a century, has steadily risen to become the seventh-largest sport in the world (Jiangzhou et al., 2020). By concentrating on high degrees of achievement, it is possible to comprehend self-confidence in sports. According to scientists, self-assured athletes are those that are both physically and intellectually capable of using their current abilities to win (Öntürk & Asma, 2020)

Mental imagery can be defined as a "quasi-perceptual experience" that "resembles perceptual experience, but occurs in the absence of appropriate external stimuli" (Nanay, 2021). It occurs regularly in everyday life, be it while recalling past experiences, projecting ourselves into the future, or picturing the path someone is explaining to us. It should be emphasized that the term imagery refers to more than just visual elements. When imagining spatial relationships, motions of things and their components, and spatial transformations such mental rotation, it is possible to use object imaging, which involves perceiving the specifics of particular items and situations in terms of shape, colour, brightness, and texture (Blazhenkova, 2016).

Similar neural activity in the brain are triggered by perception and imagery (Dijkstra et al., 2017). If we can conjure up accurate mental representations, our brain will respond as if we had actually seen that image (Maier et al., 2021) similar brain regions become active. Yet, the time course and mechanisms with which imagery engages perceptual networks remain to be better understood. An emerging view holds that imagery and perception follow distinct dynamics during early visual processing with similarities arising only during later, high-level visual processing. However, confounds of visual stimulation and paradigms favoring observation of high-level processes associated with subjective imagery strength may have precluded evidence of earlier shared mechanisms. We therefore manipulated prior knowledge that informs early-stage top-down predictions and tracked electrophysiological brain responses while fully controlling visual stimulation. Participants saw and imagined objects associated with varying amounts of semantic knowledge. Imagery and perception were equally influenced by knowledge at an early stage (P1 component). Additionally, research indicates a link between vividness of images and perception in the visual regions. These findings suggest that improving visual perception is necessary to enhance imagery's vividness (Dijkstra et al., 2017). It is likely that by enhancing our perception in the visual domains, we will be able to execute imaging better.

In a sporting context, imaging has been defined as the mental state in which athletes envision themselves as they prepare for a task or work to enhance performance. Both deliberate and unintentional recall processes can result in imagery, which is when a person perceives an image or experiences a movement as an image without really witnessing the real thing. In this setting, imagery has a key role in enhancing motor task performance (Di Corrado et al., 2014)

On the basis of reviews related to literatures, available research findings, and researchers own understanding, it was hypothesized that there would be a significant improvement in selected psychological dimensions of state level male Table Tennis players after the 6 weeks Visual Motor Behaviour rehearsal training programme.

Therefore, an investigation into the effects of training in Visual Motor Behaviour Rehearsal was conducted in this study on selected psychological dimensions of sports anxiety that were somatic anxiety, worry and concentration disruption and mental toughness dimensions that were confidence, consistency, control. Through some previous studies on Visual Motor Behaviour Rehearsal training it, it was observed that, the intervention was conducted among athletes with a majority of team sports like Hockey, Football, Handball and closed skill sports where the movements were pre-defined like Archery (Sa'ari & Isa, 2018). Considering the inherent demands of such intense and emotional activities, racket sports place a special emphasis on the mental component of performance (Cece et al., 2020) athletes, parents. The researchers thought to conduct Visual Motor Behaviour Rehearsal training to examine its effect on selected psychological dimensions of Table Tennis players.

Material and methods

Study participants

To attain the purpose of the study, 50 male Table Tennis player of state level were selected as subjects from Inspire Table Tennis Academy, Secunderabad (Telengana). The age of the subjects was ranged between 17 to 23 years. For administration feasibility two intact groups were formed, one was Control Group and second group was Main Group.

Study organization

On the basis of the available literature, the age group 17-23 was selected on the basis of few researches which suggested for the application of cognitive intervention or psychological skill training to the subjects. In a study where 20 male players were selected age ranging from 17-23 years from LNIPE, Gwalior for the application of VMBR training, the result was found that there was significant difference found in sports competition anxiety of treatment group is less than control group with a 4 weeks of training (Ashish et al., 2017). As per the findings of the related research studies, variables selected for the present study were Somatic anxiety, Worry and Concentration disruption under Sports anxiety

and Confidence, Consistency and Control under Mental Toughness.

Research design used for this study was Pre-Test Post-Test randomized group Design.

Training protocols:

1. Control Group:

The participants of the Control Group undertook only regular Table Tennis practice.

2. Main Group:

Fig. 1. Main Group players giving responses to the questionnaires

The participants of the Main Group went through the Visual motor Behaviour rehearsal training programme. This was scheduled for three days (Monday, Wednesday and Friday) per week in the morning between 6.30 a.m. to 7:10 a.m. for six weeks. The visual motor Behaviour rehearsal training programs consisted of warm up for 5-8 minutes of stretching and jogging. In evening they went for their regular Table Tennis practice.

The training protocol of Visual Motor Behaviour Rehearsal Training (Cox, 2012) involves the following procedure:

A: Phase 1- Players of Main Group takes part in the Progressive muscle relaxation technique that involved systematically tensing and relaxing specific muscle groups in a predetermined order of forehead and scalp, neck and shoulder, upper chest, thighs and calves for 5-8 minutes.

Figure 2 Main group players experiencing VMBR Training session

B: Phase 2- Players of Main Group takes part in the Visual presentation of game related contents like motivation, skills, technique and matches shown with help of projector for the duration of 5 to 7 Minutes. Then they were instructed to step into Visualization to recreate the mental image and see every detail through successful visualization for 5 to 7 minutes.

C: Phase 3- Players of Main Group takes part through Imagery technique, whatever they had seen during second phase, they reconnected the skills with their own involving somatic sensations, sound of audience, colleagues' motivation, sights and emotions which they had experienced during actual game conditions for 5 to 8 minutes.

The above specified information can also be implemented with the reproduction of training by others researchers/ followers with slide modification in the frequency and duration of the technique. As the present training schedule was set on the basis of supportive literatures available on the previous conducted studies, (Singh & Bhowmik, 2020). The results are likely to be approximately same if conducted with same procedure with the similar age group among male table tennis players.

The tools used for the purpose of the study to examine Sports Anxiety, (SAS-2) Sports Anxiety Scale-2 with an alpha coefficient for the Somatic, Worry, and Concentration Disruption scales were 0.89, 0.91 and 0.84, respectively, and the total score alpha was 0.91. Thus, the SAS-2 exhibits acceptable internal consistency (Smith et al., 2006, p. 2) developed by Ronald E. Smith, Frank L. Smoll, Sean P. Cumming, and Joel R. Grossbard with 15 statements on a 4 point likert scale anchored by Not at all, A Little Bit, Pretty Much, Very Much was used. To examine Mental Toughness, (SMTQ) Sports Mental Toughness Questionnaire with Cronbach's alpha showed acceptable internal consistency for each of the three factors: Confidence = 0.80, Constancy = 0.74 and Control = 0.71. Constancy, and Control developed by Michael Sheard, Jim Golby, and Anna Van Wersch with 14 statements on a 4-point likert scale anchored by Very true, mostly true, A Little true and not at all was used (Sheard et al., 2009).

Administration of the Test:

Players were instructed to fill the questionnaires with their honesty and clearly understanding each statement. They were also instructed to ask for any doubt if necessarily required for the statement's understanding. There was no time limit to fill the questionnaires. The questionnaires were filled twice, pre and post, i.e., before and after 6 weeks of VMBR Training for both Control and Main Group of the selected Table Tennis players.

Statistical Analysis

First, normality assumption of data was checked by Shapiro-Wilk test, after that Levene's test was used to test the Homogeneity of Variances between experimental and Control Group. The assumptions of normality and homogeneity was not violated, thus parametric test was implemented where data obtained from the Control and Main Group, before and after the experimental period were statistically analyzed with dependent 't' test with the help of SPSS Version 20.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research

and was approved by the Research Ethics Committee of the Lakshmibai National Institute of Physical Education.

Results

Table 1. Descriptive Statistics (Mean and Standard Deviation) of Psychological Variables

Variables	Control Group		Main Group	
	Mean	SD	Mean	SD
Pre-Confidence	16.36	1.46	16.92	1.35
Post-Confidence	16.52	1.50	17.32	1.60
Pre-Consistency	09.04	1.36	9.680	1.34
Post-Consistency	09.28	1.27	10.08	1.52
Pre-Control	09.12	1.45	09.44	1.47
Post-Control	09.44	1.35	09.92	1.18
Pre-Somatic	11.84	1.28	11.68	1.51
Post-Somatic	11.80	1.41	11.04	1.36
Pre-Worry	12.36	1.43	11.84	1.65
Post-Worry	11.80	1.35	10.92	1.49
Pre-Concentration Disruption	10.44	1.55	10.96	1.61
Post-Concentration Disruption	10.76	1.56	10.28	1.30

Table 1 showed the descriptive statistics (mean and standard deviation) of Control Group and Main Group before 6 week of training and after 6 week of training on selected psychological variables (Confidence, Consistency, Control, Somatic Anxiety, Worry and Concentration Disruption).

Table 2. Dependent sample t-test of Anxiety and Mental Toughness between Control and Main Group of Table Tennis players

Variables	Control Group		Main Group	
	t- Value	p-Value	t- Value	p-Value
Confidence	0.778	.444	1.852	.076
Consistency	0.901	.376	1.922	.067
Control	1.034	.311	2.071	.049
Somatic	0.101	.921	2.268	.033
Worry	1.593	.124	3.016	.006
Concentration Disruption	0.902	.376	2.652	.014

Table 2 showed the inferential statistics (dependent t-test) of Control Group and Main Group before 6 week of training and after 6 week of training on selected psychological variables (Confidence, Consistency, Control, Somatic Anxiety, Worry, and Concentration Disruption). No significant effect was found among players of Control Group at 0.05 level of significance. Significant effect was found in Main Group for Control, Somatic Anxiety, Worry and Concentration Disruption from sports mental toughness and anxiety scale dimensions of Table Tennis players at 0.05 level of significance. It also showed that, there was No significant

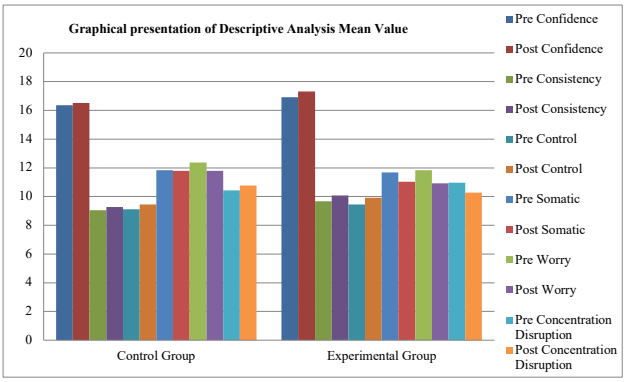

Fig. 3. Graphical Representation of Descriptive Analysis

effect found in Main Group for Confidence and Consistency from sports mental toughness dimensions at 0.05 level of significance.

Discussion

Table Tennis is an example of an open skill sport where it is challenging to manage a player's emotions and where anxiety and negative thoughts are swiftly elevated (Martinent & Decret, 2015). Table Tennis is one of the most challenging sports for an athlete to constantly perform at their best. Martinent and Decret (2015) discovered that the psychological variables most reflected in Table Tennis include self-confidence, optimistic thinking, and the capacity to relax and manage emotions. The mental skills capable of satisfying psychological needs can make Table Tennis student-athletes mentally tough. The dynamic link that exists among the skills calls sports practitioners to be judicious in developing mental toughness (Maranan & Lopez, 2021).

The present study evaluated the effect of six (6) weeks Visual Motor Behaviour Rehearsal training to examine its effect on Anxiety and Mental Toughness of Table Tennis players. To achieve the purpose of the study dependent t-test was applied. As per the previous studies that were conducted with more frequency and duration of the VMBR Training has shown significant effect on psychological variables conducted with 8 and 12 weeks of training as well (Chaudhary, 2018; Choudhary et al., 2018; Sa'ari & Isa, 2018; Singh & Bhowmik, 2020). In a research study, which was conducted on Table Tennis players, where 20 male players were selected age ranging from 17-23 years from LNIPE, Gwalior for the application of VMBR training, the result was found that there was significant difference found in sports competition anxiety of training group is less than control group with a 4 weeks of training (Ashish et al., 2017). Considering Table Tennis as an open skill sport, it was necessary to conduct the training with other psychological dimensions such as mental toughness, to check whether 6 weeks of VMBR Training could be beneficial to the dimensions of anxiety and mental toughness or not. Visual Motor Behaviour Rehearsal has its origin in the techniques used in Behaviour therapy, which rely upon imagery and visualization rehearsal for anxiety reduction. Desensitization and anxiety management training both being with relaxation training, followed by imagery related to anxiety to phobic situations. The goal of

each is to train the client to be in anxiety related settings but with the, achievement of a relaxed, rather than anxiety state. In essence, these Behaviour therapies emphasize retraining of emotional aspects of situations (Chauhan et al., 2020) Visual-Motor Behaviour Rehearsal research initially grew from case study illustration to more recent sophisticated research design. Visual-Motor Behaviour Rehearsal training contributes to the enhancement of sports performance across a wide variety of different sports, besides its approach to mental practice seems to require the synergistic involvement to both relaxation and mental imagery. A significant decrease in sports competition anxiety was also observed for Visual-Motor Behaviour Rehearsal Group (Alrahamneh & Elbokai, 2011). A study of the effects of Visual Motor Behaviour Rehearsal on athletes with special needs where 63 male and female athletes of national team age ranging from 20 to 35 years participated in the study. Based on a pre assessment of subject's anxiety and self-control the subjects were the assigned to experimental conditions. Visual Motor Behaviour Rehearsal post-assessment data for experimental performance was analyzed by means of two groups. Pre- to post-assessment data indicated that the Main Group had a significant main effect, indicating a significant improvement in self-concept and low anxiety (Alrahamneh & Elbokai, 2011). The Effectiveness of Visual-Motor Behaviour Rehearsal (VMBR) to Reduce the Anxiety and to Improve Self Concept for Athletes with Special Needs. The VMBR includes imagery and breathing techniques that also allowed participants to significantly affect several of the dependent variables' subfactors of Mental Toughness. The belief that visual-motor behaviour rehearsal improves self-confidence, emotions, negative thoughts, and primarily anxiety of the players can be used to explain the marginally significant improvement. Participants are taught breathing techniques as a relaxation technique, which helps the players stay calm and react to situations positively and to remain calm under pressure. Negative energy control helps to ignore the negative thought, and distraction helps to refocus attention (Singh & Bhowmik, 2020). Psychology skill-training programme has positive impact on the performance of national Table Tennis players (Lim et al., 2018).

In the present study, there was no significant difference seen in other dimensions like Confidence and Consistency from Mental Toughness to enhance these parameters. The reason may be due to the fact that the duration, i.e., 6 weeks, as well as frequency wasn't sufficient, or with just a fraction of score, i.e., with 0.026 for confidence and 0.017 for consistency which was above 0.05, it was found insignificant at 0.05 level of significance. The reason may be due to the fact that the participants were required with more consistent serious account in training session and the duration specifically considering the dimensions of confidence and consistency. But still, it's also a debatable matter of fact for showing insignificant with very less score considering the sample size which was taken in the Main Group. In fact, according to a research, it was stated that in order to attain significant improvement in self-confidence, subjects attended 24 sessions of self-talk and imagery training under psychological skill training to get significant effect in self-confidence (Heydari et al., 2018). The proven effectiveness if provided with the continuation of third slice after 6 weeks with one more post-test, the result may vary and could have a possibility of getting significant effect among all the selected psychological variables. The study could also be conducted on playing ability and other psychological dimensions of Table Tennis players to reach performance effects based on the intervention technique.

Conclusion

The study gives us an understanding of various psychological components that affect performance. Previous literature also indicated that the visualization and imagery has been used as an effective tool for enhancing performance. However, Visual-Motor Behaviour Rehearsal is a systematic psychological technique helps Table Tennis players in overcoming psychological factors. VMBR (Visual-Motor Behaviour Rehearsal) involves replaying an event step by step based on a mental video. The steps of Visual Motor Behaviour Rehearsal that contribute to improved performance are; Technique enhancement, error analysis & correction, preparation for completion improve psychological parameters. Thus, future research could be undertaken with a long duration to understand the effectiveness of Visual Motor Behaviour Rehearsal on psychological parameters and applied as per the athlete's requirement, thus helping an athlete to enhance his/her performance and improve psychological parameters. Research has shown mental toughness and anxiety have significant impact through cognitive intervention technique. More research is needed to understand the relationship between cognitive intervention with players' ages anxiety and mental toughness, gender differences in anxiety and mental toughness, individual versus team sports, and sexual diversity in anxiety and mental toughness.

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Conflict of interest

The authors do not have any conflicts of interest.

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ВПЛИВ ТРЕНУВАННЯ НАВИЧКИ ВМРП НА ПСИХОЛОГІЧНІ АСПЕКТИ ТРИВОГИ ТА ПСИХІЧНОЇ ВИТРИВАЛОСТІ ГРАВЦІВ У НАСТІЛЬНИЙ ТЕНІС

Арнав Шарма[1ABCDE], Брідж Кішоре Прасад[1AC]

[1]Національний інститут фізичного виховання імені Лакшмі Бай

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

Реферат. Стаття: 7 с., 2 табл., 3 рис., 24 джерела.

Мета дослідження. Це дослідження було проведене для вивчення впливу тренування навички візуально-моторної репетиції поведінки (ВМРП) на спортивну тривогу та психічну витривалість гравців у настільний теніс після шести тижнів такого тренування.

Матеріали та методи. Для участі в дослідженні були відібрані п'ятдесят гравців у настільний теніс державного рівня чоловічої статі у віковій групі від 17 до 23 років з Академії настільного тенісу «Інспайе», місто Секундерабад, штат Телангана (Індія), і розділені випадковим чином на дві групи, контрольну та основну, кожна з яких складалася з 25 учасників. Основна група проходила тренування ВМРП протягом шести тижнів, тричі на тиждень, а контрольна група не брала участі в жодній програмі тренувань, окрім своїх повсякденних вправ. Вимірювання тривожності всіх гравців у настільний теніс за допомогою Шкали Спортивної Тривоги-2 (SAS-2) із трьома аспектами, якими були соматичний компонент, занепокоєння та порушення концентрації, розробленої Рональдом Е. Смітом, Френком Л. Смоллом, Шоном П. Каммінгом і Джоел Р. Гроссбард у 2006 році, та Опитувальника на предмет спортивної психічної стійкості (SMTQ) із трьома аспектами, якими були впевненість, послідовність і контроль, розробленого Майклом Шеардом, Джимом Голбі та Анною Ван Верш у 2009 році, проводили на початку та після завершення експериментального періоду тривалістю шість тижнів.

Результати. Статистично значущий вплив було встановлено в основній групі на рівні значущості 0,05 для таких аспектів, як спортивна психічна витривалість і соматичний компонент, занепокоєння та порушення концентрації, за аспектами шкали тривожності гравців у настільний теніс.

Висновки. Візуалізація та уявлення образів були використані як ефективний інструмент для підвищення показників. Візуально-моторна репетиція поведінки – це систематична психологічна техніка, яка допомагає гравцям у настільний теніс долати психологічні чинники.

Ключові слова: візуально-моторна репетиція поведінки, шкала спортивної тривоги, спортивна психічна витривалість.

Information about the authors:

Sharma, Arnav: arnavsharma164@gmail.com; https://orcid.org/0000-0002-5268-8316; Department of Physical Education and Pedagogy, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Prasad, Brij Kishore: brijhockey@gmail.com; https://orcid.org/0000-0001-9447-989X; Department of Health Sciences, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

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ACUTE MODERATE-INTENSITY STRENGTH EXERCISE INCREASES ANTI-INFLAMMATORY CYTOKINES IN OBESE FEMALES

Fansah Adila[1ABD], Purwo Sri Rejeki[1ABD] and Lilik Herawati[1ACD]

[1]Universitas Airlangga

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

Corresponding Author: Purwo Sri Rejeki, E-mail: purwo-s-r@fk.unair.ac.id
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Abstract

The study purpose was to prove the effect of acute moderate-intensity endurance and strength exercise on increasing IL-6 levels in obese females.

Materials and methods. A total of 21 obese women aged 20-25 years were recruited from among university students and given two modes of acute exercise intervention, namely moderate-intensity endurance and strength exercise carried out for 35 minutes/session. Subjects were divided randomly into three groups, namely K_1 (control group without intervention; n = 7), K_2 (Acute moderate-intensity endurance exercise; n = 7), K_3 (Acute moderate-intensity strength exercise; n = 7). ELISA was used to analyze serum IL-6 levels before and after exercise. The data analysis technique used the One-way ANOVA test and continued with the Tukey HSD post-hoc test with a significance level of 5%.

Results. The results of the One-way ANOVA test showed that there was a significant difference between serum IL-6 levels after exercise and delta (Δ) in the three groups ($p \leq 0.01$). The results of the Tukey HSD post-hoc test showed that there was a significant difference between serum IL-6 levels after exercise and delta (Δ) at K_3 with K_1 ($p \leq 0.01$), K_3 with K_2 ($p \leq 0.01$), while there was no significant difference in serum IL-6 levels ($p \geq 0.05$) at K_2 with K_1.

Conclusions. Overall, our study concluded that 35 min/session of acute moderate-intensity strength exercise was effective in increasing anti-inflammatory cytokines, such as IL-6, in obese females.

Keywords: endurance exercise, anti-inflammatory, cytokines, obesity, strength exercise.

Introduction

Obesity is a health problems that occur in developed and developing countries (Friedman, 2009). Currently, around 13% of the adult population worldwide was obese in 2016 and the prevalence rate has almost tripled from 1975 to 2016 (WHO, 2021). The trend of obesity prevalence continues, it is estimated that by 2030 20% of the world's adult population will be obese (Kelly et al., 2008). The increase in the prevalence of obesity is directly proportional to the increases in morbidity and mortality worldwide (Abdelaal et al., 2017; Hruby & Hu, 2015). It is because obesity risk of chronic disease morbidities, like disability, depression, diabetes mellitus, hypertension, kidney failure, cardiovascular disease, and several types of cancer (Piché et al., 2020; Hruby & Hu, 2015; Friedman, 2009), so it can reduce the quality of life of obese people (Ogden et al., 2014; Hotamisligil, 2006), and increase the risk of death (Abdelaal et al., 2017; Hruby & Hu, 2015).

Obesity is a condition of increased accumulation of excess fat that can interfere with health (Panuganti et al., 2022). Increased adipose tissue can induce increased pro-inflammatory cytokine secretion and result in the initiation of low-grade chronic inflammation (Petersen & Pedersen, 2005; Ellulu et al., 2017; Zatterale et al., 2020). Increased pro-inflammatory cytokines are associated with metabolic dysfunction and glucose homeostasis (Raman et al., 2018). Exercise can be used as physical therapy in improving systemic metabolic disorders caused by obesity in peripheral tissues, including muscle, liver (Starkie et al., 2003; Pereira et al., 2017), and central nervous system, including hypothalamus (Ropelle et al., 2010). Besides that, exercise can as will be used to maintain homeostasis of pro and anti-inflammatory cytokines (Docherty et al., 2022; Ross et al., 2021).

Exercise performed acutely has a positive effect on inhibiting the development of chronic disease through the post-exercise inflammatory response (Kramer & Goodyear, 2007). One of the inflammatory responses that increase post-exercise is muscle interleukin-6 (IL-6) levels (Fischer, 2006; Pedersen & Febbraio, 2008). Muscle IL-6 levels increase up to 100-fold during exercise and decrease rapidly after exercise (Docherty et al., 2022). The magnitude of the increase in muscle IL-6 levels during exercise depends on the mode of exercise, intensity of exercise, duration of exercise, and capacity of exercise in each individual (Ostrowski et al. 1999; Febbraio & Pedersen, 2002; Mendham et al., 2011). The American College of Sports Medicine (ACSM) explain that appropriate exercise doses can improve several health-promoting parameters, such as decreased systemic inflammation, by decreasing the secretion of proinflammatory cytokines (Garber et al., 2011; Theodorou et al., 2016; Dieli-Conwright, 2018).

Exercise has an anti-inflammatory effect by increasing the secretion of IL-6 in muscle to stimulate increased secretion of IL-10 (Starkie et al., 2003; Ropelle et al., 2010) hence inhibiting pro-inflammatory secretion, like TNF-α (Docherty et al., 2022). However, several studies reported inconsistent results (increase, decrease or no significant change) in IL-6 levels following moderate-intensity exercise (Mendham et al., 2011; Dimitrov et al., 2017; Windsor et al., 2018; Andarianto et al., 2022; Sugiharto et al., 2022). Factors that might influence the inconsistency of results at the IL-6 level, namely differences in exercise mode, exercise intensity, and duration of exercise (Fischer et al., 2006; Nindl et al., 2009; Mendham et al., 2011; Hennigar et al., 2017; Cerqueira et al., 2020; Andarianto et al., 2022). Therefore, the aim of this study was to prove the effect of acute moderate-intensity endurance and strength exercise on increasing IL-6 levels in obese females.

Materials and Methods

Research design

The design of this research is a randomized pretest-posttest control group design. A total of 21 obese female with inclusion criteria aged 20-25 years, body mass index (BMI) 27-35 kg/m^2, normal blood pressure, normal resting heart rate, normal oxygen saturation (SpO_2), normal fasting blood glucose (FBG), and normal hemoglobin (Hb) were recruited from among students and randomly divided into three groups, namely K_1 (n = 7, control group without intervention), K_2 (n = 7, acute moderate-intensity endurance exercise), dan K_3 (n = 7, acute moderate-intensity strength exercise). The Health Research Ethics Commission, Faculty of Medicine, Airlangga University, Surabaya has reviewed and approved all these research procedures with the registration number: 284/EC/KEPK/FKUA/2021.

Endurance and strength exercise program

The exercise program implemented in this study used two different exercise modes, namely endurance and strength exercise. Endurance exercise is running on a treadmill with an intensity of 60-70% HRmax for 35 minutes (Rejeki et al., 2022). Strength exercise was carried out using gym equipment with an intensity of 60-70% 1-RM which was carried out for 5 sets @12-15 reps and active rest between sets of 30 seconds. The exercise method used in strength exercise is circuit exercise which is divided into 2 (upper body and lower body). Upper body include, chest press, shoulder press, and tricep push-down, while lower body include leg extension, leg press, and leg curls. Warming up and cooling down out for 5 minutes each (Rejeki et al., 2022; Rejeki et al., 2021).

Anti-inflammatory cytokine measurement

Analysis of IL-6 levels before and after exercise was carried out using the ELISA kit (Catalog Number: E-EL-H6156; Elabscience, Inc., USA) method with a sensitivity level of 0.94 pg/mL and detection range 1.56-100 pg/mL.

Statistical analysis

The data in tables 1-2 are shown with mean ± SD. Paired Sample T-Test was applied to evaluate differences in serum IL-6 levels between before and after exercise in each group, while the One-way ANOVA test and Tukey's HSD post-hoc test were used to determine differences in levels intergroup serum IL-6. The level of significance applied in the statistical analysis used $p \leq 0.05$. SPSS software versi 21.0 was used in the overall statistical analysis.

Results

Baseline data on the characteristics of study subjects between groups can be seen in Table 1.

The results of the One-way ANOVA test showed was no significant difference in the mean baseline data for the characteristics of study subjects between groups ($p \geq 0.05$).

Table 1. The results of descriptive statistical analysis of the characteristics of research subjects

Parameter	K_1 (n=7)	K_2 (n=7)	K_3 (n=7)	p-value
Age (years)	22.14±1.68	21.29±1.50	21.71±1.38	0.584
BW (kg)	76.88±6.42	74.39±7.07	74.88±8.35	0.799
BH (m)	1.58±0.06	1.57±0.07	1.55±0.07	0.566
BMI (kg/m^2)	30.56±3.36	30.22±2.52	30.98±2.90	0.890
FM (kg)	33.32±5.74	32.77±4.51	33.33±4.62	0.971
FM (%)	40.57±5.36	43.90±2.36	44.46±3.47	0.164
FMI (kg/m^2)	12.89±2.51	13.32±1.79	13.92±2.33	0.691
FFM (kg)	44.67±2.47	41.63±2.95	41.55±5.13	0.226
FFMI (kg/m^2)	17.82±1.17	16.90±0.90	17.22±0.96	0.257
SMM (kg)	20.11±1.36	18.52±1.45	20.08±5.30	0.590
SBP (mmHg)	114.00±7.35	109.72±9.23	114.29±10.27	0.579
DBP (mmHg)	76.86±7.38	77.86±8.19	82.14±8.53	0.443
RHR (bpm)	76.86±10.90	76.86±5.18	82.29±8.26	0.400
SpO2 (%)	98.26±0.49	98.00±0.82	98.00±1.15	0.777
FBG (mg/dL)	89.00±6.16	93.43±4.24	90.00±6.81	0.352
Hb (g/dL)	15.19±1.73	15.23±1.33	15.79±1.43	0.712

Description: Data are presented with mean ± SD. One-way ANOVA test was used to obtain the p-value.

Table 2. Results of analysis of mean serum IL-6 levels between groups

Period of Time	IL-6 (pg/mL)			p-value
	K_1 (n=7)	K_2 (n=7)	K_3 (n=7)	
Before exercise	246.06±99.59	276.07±146.83	257.26±75.71	0.879
After exercise	263.33±127.32	327.67±61.16	527.89±122.03*†	0.001
Delta (Δ)	17.27±122.25	51.60±138.85	270.63±144.85*†	0.005

Description: Data are presented with mean ± SD. One-way ANOVA test and followed by Tukey's HSD post-hoc test was used to obtain the p-value. (*) Significant with K1 ($p \leq 0.01$). (†) Significant with K2 ($p \leq 0.05$).

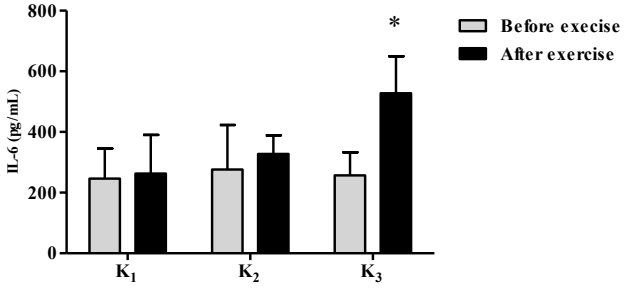

Fig. 1. The results of the analysis of IL-6 levels between before and after exercise intervention. Description: Data are presented with mean ± SD. Paired Sample T-Test was used to obtain the p-value. (*) Significant with before exercise ($p \leq 0.01$).

The analysis of the mean serum IL-6 levels between before and after endurance and strength exercise are presented in Figure 1.

The results of the Paired Sample T-Test showed was significant difference mean serum IL-6 levels between before and after exercise at K_3 ($p \leq 0.01$), whereas at K_1 and K_2 there was no significant increase ($p \geq 0.05$). The results of the analysis of the mean serum IL-6 levels based on the time period presented in Table 2.

Based on the One-way ANOVA test, there was no significant difference in the mean serum IL-6 levels before exercise ($p \geq 0.05$), while after exercise and delta (Δ) showed a significant difference ($p \leq 0.01$). The Tukey's HSD post-hoc test showed was a significant difference in the mean serum IL-6 levels after exercise between K_3 and K_1 (p=0.001), K_3 with K_2 (p=0.007), while K_2 and K_1 did not show a significant difference (p=0.516). The results of Tukey's HSD post-hoc test showed was a significant difference in mean delta (Δ) serum IL-6 levels between K_3 and K_1 (p=0.007), K_3 and K_2 (p=0.019), while K_2 and K_1 did not show a significant difference (p=0.516).

Discussion

The aim of this study was to prove the effect of acute moderate-intensity endurance and strength exercise on increasing IL-6 levels in obese females. The results showed that strength exercise significantly increased serum IL-6 levels, while endurance exercise did not show a significant. Griffen et al. (2021) reported that markers of systemic inflammation decreased after strength versus endurance exercise. Another study revealed that serum IL-6 levels were higher in strength exercise compared to endurances (Sabag et al., 2017). Docherty et al. (2022) in their research explained that strength exercise can increase muscle-derived (myokine), such as IL-6 which can help regulate anti-inflammatory responses. IL-6 can act as a pro-inflammatory and anti-inflammatory cytokine (Nara & Watanabe, 2021). Exercise has complex benefits for the body (Ruegsegger & Booth, 2018). This is because exercise involves not only skeletal muscle contraction but also systemic activity of the respiratory and circulatory systems (Nara & Watanabe, 2021). During exercise, muscle contraction increase so that it can stimulate myocytes to produce the myokines involved in autocrine regulation of metabolism in muscles as well as in paracrine/endocrine regulation of other organs and tissues, including the brain, liver, and adipose tissue through their receptors (Lee & Jun, 2019; Pedersen, 2019; Carson, 2017). This is one of the pleiotropic functions of IL-6 in various tissues and organs (Muñoz-Cánoves, et al., 2013). Muscles that move during exercise create stressors and secrete myokines, such as IL-6 (Lira et al., 2017). Increased IL-6 triggers the release of anti-inflammatory cytokines that will balance inflammation after exercise (Abd El-Kader & Al-Shreef, 2018). Muscle contraction will trigger the hypothalamic–pituitary–adrenal axis (HPA-axis) to be active so that cortisol levels (Bonato et al., 2017), and potent anti-inflammatory hormones in the blood increase (Ruijters et al., 2016). Muscle contractions also trigger activation of the sympathetic nervous system to increase catecholamine levels. Catecholamines can suppress the production of lipopolysaccharide (LPS) producing TNF-α and IL-1β (Gleeson et al., 2011), thereby reducing levels of pro-inflammatory cytokines (Cerqueira et al., 2020; Gleeson et al., 2011).

Obesity is the accumulation of excess fat in adipose tissue that can interfere with health (Panuganti et al., 2022). Obesity can be caused by an imbalance between caloric intake and long-term energy expenditure (Fan & Evans, 2017; Hruby & Hu, 2015). In addition, lifestyle, unhealthy eating patterns, and lack of physical activity can also trigger obesity (Rejeki et al., 2021; Sugiharto et al., 2022; Kim et al., 2015). Lifestyle modification recommended in obesity management (Gadde et al., 2018). Controlling energy expenditure and energy intake is one of the main mechanisms in regulating energy balance (Sugiharto et al., 2021; Gadde et al., 2018). Exercise can be used as an effective method of increasing energy expenditure, so exercise can be used as physical therapy in overcoming and preventing obesity (Rejeki et al., 2021, Sugiharto et al., 2021; Tsuchiya et al., 2014; Wiklund, 2016). Acute exercise can trigger an increase in the release of IL-6 (Andarianto et al., 2022) to activate the extracellular signal-regulated kinase 1/2 (ERK1/2) pathway, leading to increased lipolysis in visceral fat (Yang et al., 2020). Continuous increase in lipolysis can suppress adipose cell proliferation, resulting in a decrease in visceral fat tissue (Wedell-Neergaard et al., 2019). In addition,

exercise is suspected to have an anti-inflammatory effect by increasing the secretion of IL-6 to stimulate an increase in IL-10 secretion (Starkie et al., 2003; Ropelle et al., 2010), so that it will inhibit the secretion of pro-inflammatory, such as TNF-α which will have an impact on reducing chronic systemic inflammation (Docherty et al., 2022; Ellingsgaard et al., 2019).

IL-6 is one of the most popular myokines being discussed in several previous studies (Zunner et al., 2022; Karstoft & Pedersen, 2016; Pedersen & Febbraio, 2012). IL-6 has a dual role namely, it can act as a pro-inflammatory cytokine, and act as an anti-inflammatory when released by contracting muscles (Zunner et al., 2022; Pedersen & Febbraio, 2008). IL-6 has regenerative and anti-inflammatory functions, especially when secreted by skeletal muscle during exercise (Kistner et al., 2022; Fischer 2006). As an anti-inflammatory cytokine, IL-6 has been reported to inhibit pro-inflammatory effects, like inhibiting TNF-α, increasing M2 macrophage polarization, and insulin sensitivity (Sindhu et al. 2015; Pedersen et al., 2001; Mauer et al., 2014). Increased levels of IL-6 mediated by exercise can reduce the risk of non-communicable diseases, such as diabetes mellitus, cardiovascular disease, and some types of cancer (Severinsen & Pedersen, 2020). This has proven that exercise has many health benefits, one of which can improve the body's metabolism (Thyfault & Bergouignan, 2020).

The limitation of this study is the number of subjects used in the study only amounted to 21 people, if the number of subjects used was greater it could describe the condition of obese women in Indonesia. This study did not observe the molecular mechanisms involved in increasing serum IL-6 levels, so only the results of increasing serum IL-6 levels were obtained without knowing the mechanism involved. During the intervention period, the subjects were not quarantined, so we could not control the activities of the research subjects in detail.

Conclusion

In general, it can be concluded that the 35 min/session acute moderate-intensity strength exercise was effective in increasing anti-inflammatory cytokines, like IL-6 in obese female. This study can be used as a basis in the management of preventing the increase in the prevalence of obesity and as an effort to reduce the impact of morbidity, mortality and improve the quality of life of obese.

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Conflict of interest

The authors do not have any conflicts of interest.

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СИЛОВІ ВПРАВИ СЕРЕДНЬОЇ ІНТЕНСИВНОСТІ ІЗ СИЛЬНИМ ФІЗИЧНИМ НАВАНТАЖЕННЯМ ПІДВИЩУЮТЬ РІВЕНЬ ПРОТИЗАПАЛЬНИХ ЦИТОКІНІВ У ЖІНОК ІЗ ОЖИРІННЯМ

Фансах Аділа[1ABD], Пурво Срі Реджекі[1ABD], Лілік Хераваті[1ACD]

[1]Університет Айрланга

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

Реферат. Стаття: 7 с., 2 табл., 1 рис., 66 джерел.

Метою дослідження було довести вплив силових вправ із сильним фізичним навантаженням і вправ на витривалість середньої інтенсивності на підвищення рівня інтерлейкіну-6 (IL-6) у жінок з ожирінням.

Матеріали та методи. Для участі в дослідженні була залучена загалом 21 жінка з ожирінням віком 20–25 років зі студенток університету, вони отримали два режими інтервенції у формі вправ із сильним фізичним навантаженням, а саме: вправи на витривалість і силові вправи середньої інтенсивності, які виконувалися протягом 35 хвилин/заняття. Учасниць випадковим чином розділили на три групи, а саме: K_1 (контрольна група без інтервенції; n = 7), K_2 (вправи на витривалість із сильним фізичним навантаженням середньої інтенсивності; n = 7), K_3 (силові вправи із сильним фізичним навантаженням середньої інтенсивності; n = 7). Для аналізу рівнів інтерлейкіну-6 у сироватці до та після виконання вправ використовували ферментний імуносорбентний аналіз (ELISA). У методиці аналізу даних використовували однофакторний дисперсійний аналіз із наступним розрахунком середнього Тьюкі за одержаними результатами за рівня значущості 5%.

Результати. Результати однофакторного дисперсійного аналізу показали наявність статистично значущої різниці між рівнями інтерлейкіну-6 у сироватці після виконання вправ та дельтою (Δ) у трьох групах ($p \leq 0,01$). Результати розрахунку середнього Тьюкі за одержаними результатами показали наявність статистично значущої різниці між рівнями інтерлейкіну-6 у сироватці після виконання вправ та дельтою (Δ) у парах K_3 з K_1 ($p \leq 0,01$), K_3 з K_2 ($p \leq 0,01$), тоді як у парі K_2 з K_1 статистично значущої різниці між рівнями інтерлейкіну-6 у сироватці не було ($p \geq 0,05$).

Висновки. Загалом, на підставі результатів нашого дослідження було зроблено висновок, що силові вправи із сильним фізичним навантаженням середньої інтенсивності по 35 хвилин/заняття були ефективними для підвищення рівня протизапальних цитокінів, таких як інтерлейкін-6, у жінок з ожирінням.

Ключові слова: вправи на витривалість, протизапальний, цитокіни, ожиріння, силові вправи.

Information about the authors:

Adila, Fansah: fansahadila@gmail.com; https://orcid.org/0000-0002-1736-9133; Sports Health Science, Faculty of Medicine, Universitas Airlangga, Jl. Mayjen Prof. Dr. Moestopo No.47, Pacar Kembang, Kec. Tambaksari, Kota SBY, Jawa Timur 60132, Indonesia.

Rejeki, Purwo Sri: purwo-s-r@fk.unair.ac.id; https://orcid.org/0000-0002-6285-4058; Physiology Division, Department of Medical Physiology and Biochemistry, Faculty of Medicine, Universitas Airlangga, Jl. Mayjen Prof. Dr. Moestopo No.47, Pacar Kembang, Kec. Tambaksari, Kota SBY, Jawa Timur 60132, Indonesia.

Herawati, Lilik: lilik_heraw@fk.unair.ac.id; https://orcid.org/0000-0002-8014-6952; Physiology Division, Department of Medical Physiology and Biochemistry, Faculty of Medicine, Universitas Airlangga, Jl. Mayjen Prof. Dr. Moestopo No.47, Pacar Kembang, Kec. Tambaksari, Kota SBY, Jawa Timur 60132, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

POSITIVE EFFECTS OF PLYOMETRIC TRAINING ON INCREASING SPEED, STRENGTH AND LIMB MUSCLES POWER IN ADOLESCENT MALES

Shidqi Hamdi Pratama Putera[1ABD], Hari Setijono[1ABD], Oce Wiriawan[1ABD], Nurhasan[1ABD], Heryanto Nur Muhammad[1BD], Agus Hariyanto[1BD], Anindya Mar'atus Sholikhah[1BD] and Adi Pranoto[2CD]

[1]Universitas Negeri Surabaya
[2]Universitas Airlangga

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

Corresponding Author: Shidqi Hamdi Pratama Putera, E-mail: shidqi.20002@mhs.unesa.ac.id
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Abstract

The study purpose was to prove the effectiveness of a plyometric jumping jack, countermovement jump, and tuck jump training in increasing speed, strength, and limb muscle power in adolescent males.

Materials and methods. A total of 33 subjects from Santri Pondok Pesantren An-Nur 2 Al-Murtadlo Malang Regency, males, aged 18-22 years voluntarily participated in the study. The subjects were divided into 3 intervention groups, namely PJJ (n = 11, plyometric – jumping jacks), PCJ (n = 11, plyometric – countermovement jump), and PTJ (n = 11, plyometric – tuck jump). Plyometric jumping jacks, countermovement jump, and tuck jump training was conducted for 30 minutes/session, intensity 70-90% 1-RM, frequency 3x/week for 6 weeks. Measuring limb muscle power used the Jump Meter Digital (MD) Test, measuring limb muscle strength used the Back & Leg Dynamometer, and measuring speed used the 30 m running test. The data analysis technique used the Paired Sample T-Test with a significance level of 5%.

Results. The results obtained were as follows: mean speed between pretest and posttest on PJJ (4.56±0.16 vs. 4.36±0.15 second, ($p \leq 0.001$)), PCJ (4.61±0.15 vs. 4.54±0.14 second, ($p \leq 0.001$)), PTJ (4.55±0.19 vs. 4.48±0.18 second, ($p \leq 0.001$)), limb muscle strength between pretest and posttest in PJJ (111.45±18.94 vs. 139.27±20.23 kg, ($p \leq 0.001$)), PCJ (117.73±21.03 vs. 129.55±19.24 kg, ($p \leq 0.001$)), PTJ (115.46±17.66 vs. 125.91±18.62 kg, ($p \leq 0.001$)), limb muscle power between pretest and posttest in PJJ (422.86±34.61 vs. 493.12±49.24 joule, ($p \leq 0.001$)), PCJ (410.70±38.25 vs. 462.20±38.55 joule, ($p \leq 0.001$)), PTJ (404.20±45.63 vs. 441.78±46.90 joule, ($p \leq 0.001$)).

Conclusions. Based on the results of the study, it was concluded that plyometric jumping jacks, countermovement jumps, and tuck jumps performed for 30 minutes/session, with an intensity of 70-90% 1-RM, frequency 3x/week for 6 weeks are effective in increasing limb muscle power, strength and speed.

Keywords: plyometric training, speed, limb muscle strength, limb muscle power.

Introduction

Plyometrics is one type of strength training that is widely used in team and individual sports to improve sports performance (Ramírez-delaCruz, et al., 2022; Davies et al., 2015; Sammoud et al., 2019). Plyometrics involves multi-joint movements (i.e., jumping, jumping, jumping) that utilize a stretch-shortening cycle, where muscles are rapidly stretched (eccentric phase) and then immediately shortened (concentric phase) (Marzouki et al., 2022; Ramirez- Campillo et al., 2018; Granacher et al., 2015). Plyometrics can improve motor skills and body composition, such as optimizing bone health and reducing fat mass when combined with a daily training routine (Wang & Zhang, 2016).

To achieve good health conditions and good performance in sports, having the good physical condition is a major component (Malm et al., 2019). Physical condition is the basis for achieving optimal skills (Adams et al., 2018). Without good physical condition, it will be difficult to carry

out an training program and attain skills. Physical condition is one of the requirements to achieve achievement. Limb muscles are an integral part of generating strength, so they are an important component for athletes to express high levels of strength in dynamic movements (power = Force velocity) (Falch et al., 2022; Haff & Stone, 2015).

Strength training can induce neuromuscular adaptation, with increased sprint, and agility, in both adolescents and adults (Hammami et al., 2018; Brito et al., 2014; Keiner et al., 2014). Plyometric training usually involve stopping, starting, and changing direction explosively. This movement is a component that can help in developing agility (Miller et al. 2006; Craig 2004; Miller et al., 2001). Several studies have confirmed that plyometrics can improve muscle strength and power, speed, and agility (Slimani et al., 2016; Ramírez-Campillo et al., 2015; Michailidis et al., 2013). Therefore, this study aims to prove the effectiveness of a plyometric jumping jack, countermovement jump, and tuck jump training in increasing speed, strength, and limb muscle power in adolescent males.

Materials and Methods

Research design

This research is a quasi-experimental research design with factorial designs. A total of 33 Santri Pondok Pesantren An-Nur 2 Al-Murtadlo Malang Regency, males, aged 18-22 years, have a normal body mass index (19-24 kg/m^2), blood pressure (systolic and diastolic) normal (110/70-120/80 mmHg), normal resting heart rate (60-80 bpm), normal oxygen saturation (SpO_2)(95-100%) voluntarily participated in the study. Subjects were divided into 3 intervention groups, namely PJJ (n = 11, plyometric – jumping jacks), PCJ (n = 11, plyometric – countermovement jump), and PTJ (n = 11, plyometric – tuck jump). Our research protocol complies with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects.

Study participants

Plyometric jumping jacks, countermovement jump, and tuck jump training are conducted for 30 minutes/session, intensity 70-90% 1-RM, frequency 3x/week for 6 weeks, so the total training is 18 meetings. Warming up and cooling down are each carried out for 5 minutes with an intensity of 50-60% HRmax (Sugiharto et al., 2022; Rejeki et al., 2022). Heart rate monitoring during training using a polar heart rate monitor (Polar H10 Bluetooth Heart Rate Sensor & Fitness Tracker, Polar, Kempele, Finland) (Andarianto et al., 2022).

The data collection process was carried out by taking anthropometric measurements which included height using a Stadiometer (Seca Corporation, CHINO, California, USA) (Rejeki et al., 2021), body weight using a digital scale (OMRON HN-289, Osaka, JAPAN) (Sugiharto et al., 2022). The calculation of body mass index (BMI) uses the formula of body weight (kg) divided by height (m^2) (Raharjo et al., 2021). Blood pressure (systolic and diastolic) was measured using an OMRON Deluxe Model HEM-8712 BASIC digital blood pressure meter (Puspodari et al., 2022). Measurement of limb muscle power using the Jump Meter Digital (MD) Test, measuring limb muscle strength using the Back & Leg Dynamometer, and measuring speed using the 30 m running test. Measurements of speed, strength, and limb muscle power were carried out before the intervention and after the last intervention for 6 weeks.

Statistical Analysis

The data analysis technique used the Statistical Package for Social Science (SPSS) version 23 software. The normality test used the Shapiro-Wilk test, while the homogeneity test used the Levene Test. Different tests using Paired Sample T-Test and One-way ANOVA then followed by Least Significant Difference (LSD) post-hoc test. All statistical analyzes used a significant level of 5%. All data displayed Mean ± Standard Deviation (SD).

Results

Based on the results of the One-way ANOVA analysis showed that there was no significant difference in the characteristics of the subjects between groups ($p \geq 0.05$). The results of the analysis of the average speed, strength, and limb muscle power between pretest and posttest in each group is shown in Figure 1-3 below.

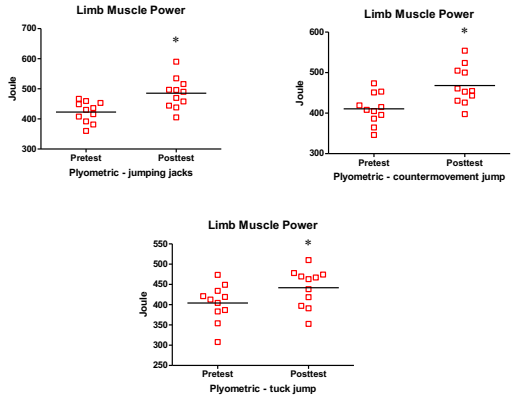

Fig. 1. The results of the analysis of the average limb muscle power between the pretest and posttest in the three groups. Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test.

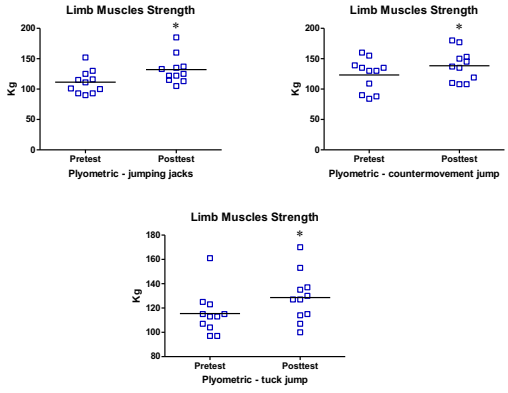

Fig. 2. The results of the analysis of the average limb muscle strength between the pretest and posttest in the three groups. Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test.

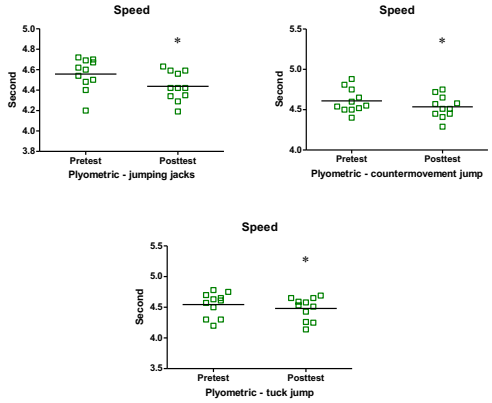

Fig. 3. The results of the analysis of the average speed between the pretest and posttest in the three groups. Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test.

Based on the results of the Pearson's Correlation Coefficient Test analysis in Figure 4 shows a strong correlation between limb muscle power and limb muscle strength (r = 0.552, p-value=0.001) and speed (r = 0.516, p-value=0.001) with a positive correlation direction.

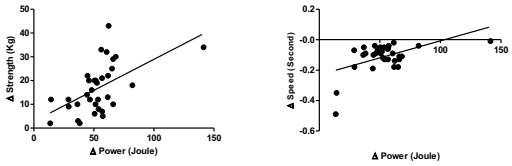

Fig. 4. Results of correlation analysis between limb muscle power with limb muscle strength and speed. Description: p-value was obtained by pearson's correlation coefficient test ($p \leq 0.001$).

Discussion

This study aims to prove the effectiveness of a plyometric jumping jack, countermovement jump, and tuck jump training on increasing speed, strength, and limb muscle power in adolescent males. Based on the results of the study, it was found that there was a significant increase in the level of speed, strength, and limb muscle power after plyometric jumping jack, countermovement jump, and tuck jump training. These results are in line with the results of the meta-analysis by Ramirez-Campillo et al. (2022) revealed a significant effect of plyometric training on increasing muscle mass, total limb muscle volume, thigh muscle volume, thigh circumference, calf circumference, and muscle pennation angle without intervention-related side effects and injuries. Results by Kim

Table 1. The characteristics of research subjects

Parameter	PJJ (*n* = 11)	PCJ (*n* = 11)	PTJ (*n* = 11)	*p*-value
Age (yrs)	19.64±1.12	19.73±1.11	19.55±1.04	0.926
Body height (m)	1.66±0.05	1.64±0.03	1.65±0.06	0.395
Body weight (kg)	58.73±6.69	57.36±5.12	57.27±3.58	0.772
Body mass index (kg/m^2)	21.19±1.37	21.43±1.65	20.85±0.73	0.582
Systolic blood pressure (mmHg)	115.64±3.56	114.36±7.71	115.55±4.37	0.834
Diastolic blood pressure (mmHg)	75.82±3.43	75.45±4.55	75.00±4.56	0.901
Resting heart rate (bpm)	63.91±5.22	64.36±4.88	65.09±5.96	0.874
Oxygen saturation (%)	97.36±1.43	97.18±1.54	97.09±1.58	0.912

Description: PJJ: Plyometric – jumping jacks; PCJ: Plyometric – countermovement jump; PTJ: Plyometric – tuck jump. Presentation of data with mean±SD. p-value obtained by analysis of One-way ANOVA.

Table 2. Results of pre, post, delta (Δ) analysis of speed, strength, and limb muscle power in the three groups

Parameter	PJJ (n = 11)	PCJ (n = 11)	PTJ (n = 11)	p-value
Pre-Speed (second)	4.56±0.16	4.61±0.15	4.55±0.19	0.636
Post-Speed (second)	4.36±0.15*†	4.54±0.14	4.48±0.18	0.038
Δ-Speed (second)	-0.20±0.12*†	-0.07±0.04	-0.06±0.02	0.000
Pre-Limb muscle strength (kg)	111.45±18.94	117.73±21.03	115.46±17.66	0.744
Post-Limb muscle strength (kg)	139.27±20.23	129.55±19.24	125.91±18.62	0.263
Δ-Limb muscle strength (kg)	27.82±7.63*†	11.82±6.34	10.46±5.59	0.000
Pre-Limb muscle power (joule)	422.86±34.61	410.70±38.25	404.20±45.63	0.542
Post-Limb muscle power (joule)	493.12±49.24*	462.20±38.55	441.78±46.90	0.039
Δ-Limb muscle power (joule)	70.26±24.83*†	51.50±7.99*	37.58±15.00	0.001

Description: (*) Significantly different from PCJ ($p \leq 0.05$). (†) Significantly different from PTJ ($p \leq 0.05$). p-value was obtained by One-way ANOVA analysis and followed by Least Significant Difference (LSD) post-hoc test. Presentation of data with mean±SD.

et al. (2022) showed that plyometric training for 8 weeks had a positive impact on increasing physical fitness, such as strength, agility, and muscle power, and reducing the risk of muscle damage. Most of the previous studies discussed the effects of plyometric training on adolescent athletes, such as baseball, soccer, and basketball (Kim et al. 2022; Beato et al., 2018; Arede et al., 2019). Marzouki et al. (2022) found that a plyometric training program induces improvements in physical fitness, which may have a transfer to health status during childhood therefore, in this study we will discuss the benefits of plyometric training on increasing speed, strength, and leg muscle power and the benefits that will be obtained in improving the quality of daily life in adolescents who are in school. Regular physical exercise has a very positive impact on the body (Pranoto et al., 2020), while a lack of physical activity can cause a decrease in muscle mass (Distefano & Goodpaster, 2018). Low muscle mass is associated with a risk of cognitive impairment and dementia (Oudbier et al. 2022).

Plyometric training has been shown to improve strength, speed, and agility performance (Hariyanto et al., 2022). Plyometric training use a stretch-shortening cycle that involves eccentric stretching to the muscle and is directly followed by concentric contraction (Munshi et al., 2022). Examples of plyometric training, such as explosive jumps, hops, bounds, and skips (Morris et al., 2022). Plyometric training shows that strength training under unstable conditions results in a significant performance increase in a measure of muscle strength, possibly due to higher muscle activation when exercising on an unstable surface (Negra et al., 2017; Behm & Colado, 2013). There are as many strength and conditioning programs as there are individual doctors who develop programs. Rehabilitation programs have changed dramatically over the last few years. Regardless of program objectives, whether they are used in the final phase of rehabilitation, for strength and conditioning, or performance enhancement, plyometric training should play an integral part in the program (Davies et al., 2015; Chmielewski et al., 2006).

Plyometrics is a very popular form of physical conditioning of healthy individuals which has been studied extensively over the last few decades (Slimani et al., 2016). Marzouki et al. (2022) explained that the application of a four-week plyometric program during physical education sessions instead of some physical education training led to higher jumps, linear running speed, agility, balance, and endurance than non-plyometric training among untrained schoolchildren. In particular, short-distance sprinting ability, agility, and vertical jump are discriminatory in terms of elite and sub-elite youth soccer players (Aloui et al., 2022; Reilly et al., 2000). In many courts and field sports such as basketball, rugby, and football, elite versus sub-elite athletes are characterized by better muscle strength and power, balance, linear sprints, and reactive change of direction (COD) appearance (Makhlouf et al., 2018; Asadi et al., 2017). Regular physical activity and training can improve an individual's quality of life (for example, having more energy reserves in muscles, better mood, feeling more relaxed, sleeping more soundly, improving cognitive function, and improving body metabolism) (Park & Park, 2022). Therefore, plyometric training as a form of physical training has many health benefits and regular plyometric training in this study has been shown to significantly increase limb muscle power, limb muscle strength, and speed.

Conclusion

In general, our findings show that plyometric jumping jacks, countermovement jumps, and tuck jumps performed for 30 minutes/session, with an intensity of 70-90% 1-RM, frequency 3x/week for 6 weeks is effective in increasing limb muscle power, strength and speed. limb muscles, and speed. However, jumping jacks plyometric training is more optimal in increasing limb muscle power, limb muscle strength, and speed compared to countermovement jump and tuck jump plyometric training.

Conflict of interest

The authors do not have any conflicts of interest.

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ПОЗИТИВНИЙ ВПЛИВ ПЛІОМЕТРИЧНИХ ТРЕНУВАНЬ НА ЗБІЛЬШЕННЯ ШВИДКОСТІ, СИЛИ ТА ПОТУЖНОСТІ М'ЯЗІВ КІНЦІВОК У МОЛОДИХ ЧОЛОВІКІВ

Шадкі Хамді Пратама Путера[1ABD], Харі Сетіджоно[1ABD], Оче Віріаван[1ABD], Нурхасан[1ABD], Херьянто Нур Мухаммад[1BD], Агус Харіянто[1BD], Аніндья Маркатус Шоліхах[1BD], Аді Праното[2CD]

[1]Сурабайський державний університет
[2]Університет Айрланга

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

Реферат. Стаття: 7 с., 2 табл., 1 рис., 66 джерел.

Метою дослідження було довести ефективність пліометричного тренування з виконанням стрибка на місці ноги разом, ноги нарізно, стрибка у висоту з присіду та стрибка у висоту з підтягуванням колін до грудей у збільшенні швидкості, сили та потужності м'язів кінцівок у молодих чоловіків.

Матеріали та методи. У дослідженні добровільно взяли участь загалом 33 чоловіки віком 18-22 років зі студентів церковної школи Сантрі Пондок Песантен, Ан-Нур 2 Аль-Муртадло, регентство Маланг (Індонезія). Учасників розділили на 3 експериментальні групи: PJJ (n = 11, пліометрика – стрибки на місці ноги разом, ноги нарізно), PCJ (n = 11, пліометрика – стрибок у висоту з присіду) та PTJ (n = 11, пліометрика – стрибок у висоту з підтягуванням колін до грудей). Тренування з виконанням стрибків на місці ноги разом, ноги нарізно, стрибка у висоту з присіду та стрибка у висоту з підтягуванням колін до грудей проводили по 30 хвилин/заняття, з інтенсивністю 70-90%, 1 повтор максимум, із частотою 3 рази/тиждень протягом 6 тижнів. Для вимірювання потужності м'язів кінцівок використовували цифровий вимірювач висоти стрибка, для вимірювання сили м'язів кінцівок використовували динамометр для спини та ніг, а для вимірювання швидкості використовували біг на 30 метрів. У методиці аналізу даних використовували t-критерій Стьюдента для парних вибірок із рівнем значущості 5%.

Результати. Одержані результати були такими: порівняння середньої швидкості між результатами попереднього та підсумкового тестування для PJJ (4,56±0,16 проти 4,36±0,15 секунди, ($p \leq 0,001$)), PCJ (4,61±0,15 проти 4,54±0,14 секунди, ($p \leq 0,001$)), PTJ (4,55±0,19 проти 4,48±0,18 секунди, ($p \leq 0,001$)), сили м'язів кінцівок між результатами попереднього та підсумкового тестування в PJJ (111,45±18,94 проти 139,27±20,23 кг, ($p \leq 0,001$)), PCJ (117,73±21,03 проти 129,55±19,24 кг, ($p \leq 0,001$)), PTJ (115,46±17,66 проти 125,91±18,62 кг, ($p \leq 0,001$)), потужності м'язів кінцівок між результатами попереднього та підсумкового тестування в PJJ (422,86±34,61 проти 493,12±49,24 джоуля, ($p \leq 0,001$)), PCJ (410,70±38,25 проти 462,20±38,55 джоуля, ($p \leq 0,001$)), PTJ (404,20±45,63 проти 441,78±46,90 джоуля, ($p \leq 0,001$)).

Висновки. На підставі результатів дослідження було зроблено висновок, що пліометричні стрибки на місці ноги разом, ноги нарізно, стрибки у висоту з присіду та стрибки у висоту з підтягуванням колін до грудей, які виконували по 30 хвилин/заняття з інтенсивністю 70-90%, 1 повтор максимум, із частотою 3 рази/тиждень протягом 6 тижнів, є ефективними для збільшення потужності м'язів кінцівок, сили та швидкості.

Ключові слова: пліометричні тренування, швидкість, сила м'язів кінцівок, потужність м'язів кінцівок.

Information about the authors:

Putera, Shidqi Hamdi Pratama: shidqi.20002@mhs.unesa.ac.id; https://orcid.org/0000-0001-6811-3130; Doctoral Program of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Setijono, Hari: harisetijono@yahoo.co.id; https://orcid.org/0000-0001-8305-4933; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Wiriawan, Oce: ocewiriawan@unesa.ac.id; https://orcid.org/0000-0003-1830-9519; Department of Sport Coaching Education, Faculty of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Nurhasan: nurhasan007@unesa.ac.id; https://orcid.org/0000-0002-9192-2072; Postgraduate, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Muhammad, Heryanto Nur: heryantomuhammad@unesa.ac.id; https://orcid.org/0000-0001-8878-3991; Department of Physical Education, Health and Recreation, Faculty of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Hariyanto, Agus: agushariyanto@unesa.ac.id; https://orcid.org/0000-0002-7927-8827; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Sholikhah, Anindya Mar'atus: anindyasholikhah@unesa.ac.id; https://orcid.org/0000-0003-4783-6182; Department of Health Education and Recreation, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Pranoto, Adi: adipranoto83@gmail.com; https://orcid.org/0000-0003-4080-9245; Doctoral Program of Medical Science, Faculty of Medicine, Universitas Airlangga, Jl. Mayjen Prof. Dr. Moestopo No.47, Pacar Kembang, Kec. Tambaksari, Kota SBY, Jawa Timur 60132, Indonesia.

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PHYSICAL ACTIVITY LEVEL AMONGST UNIVERSITY STUDENTS AND LECTURERS ACROSS MAJORS AND PROGRAMS IN INDONESIA

Agus Hariyanto[1ABE], Yetty Septiani Mustar[1ABCD], Anindya Mar'atus Sholikhah[1ABCD], Afif Rusdiawan[1ABCD], Indra Himawan Susanto[1ABC] and Mochammad Purnomo[1ABC]

[1]Universitas Negeri Surabaya

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

Corresponding Author: Agus Hariyanto, E-mail: agushariyanto@unesa.ac.id
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Abstract

Background. Physical inactivity is the fourth leading risk factor contributing to the rapid increase in global mortality. The number is increasing in all sectors, with higher education institutions no exception. As university lecturers and students' issues related to health and well-being are becoming more prevalent, the need to engage more time in doing physical activity becomes more important.

The purpose of this study is to estimate the current physical activity level of students and lecturers across faculties and majors.

Materials and methods. A cross-sectional study was conducted among 2698 students and 355 lecturers in November 2021. They completed an online Global Physical Activity Questionnaire (GPAQ) and reported the number of days and duration of activities they spent on studying or working, travelling, and recreational activities. All responses as to the duration were converted from hours into METs. Statistical analysis and data entry was performed using SPSS version 21.

Results. A significant difference was found in METs scores between lecturers and students in three majors: Economics, Sports Science, and Science Education ($p < 0.05$). Other findings showed that the PA level among students and lecturers was found in the moderate category, although the low level of physical activity was also higher. Lack of physical activity is a major risk factor for non-communicable diseases and has a negative effect on the quality of life and mental health.

Conclusions. Therefore, the university needs to carefully design policies and strategies to promote and enhance the physical activity and well-being of students, lecturers, staff, and all people involved.

Keywords: physical fitness, METs, lecturer, student, college.

Introduction

Previous studies have well-documented numerous health benefits of physical activity (PA) and exercise, with participation in moderate-intensity of physical activity on a daily basis is proved to enhance both the physical (Lee, Shiroma, Lobelo, Puska, Blair, Katzmarzyk, et al., 2012) and mental health (Chu et al., 2014; Kim et al., 2012), besides maintaining fitness level to improve quality of life (Rodríguez-Fernández & Ramos-Díaz, 2017). It is reiterated with a study conducted by Elmagd (2016), which states that physical activity and exercise can reduce anxiety and stress, increase self-confidence, sharpen brain memory and increase muscle and bone strength. Regular physical activity is also found to lower the risk of non-communicable diseases such as type 2 diabetes, cardiovascular diseases, musculoskeletal disorders, prevent depression, and cancers (Anderson & Durstine, 2019; Harvey et al., 2018; Moore et al., 2016; Safi et al., 2021) genders, and ethnicities. Most chronic disease deaths occur in middle-to low-income countries but are also a significant health problem in developed nations. Multiple chronic diseases now affect children and adolescents as well as adults. Being physically inactive is associated with increased chronic disease risk. Global societies are being negatively impacted by the increasing prevalence of chronic disease which is directly related to rising healthcare expenditures, workforce complications regarding attendance and productivity, military personnel recruitment, and academic

success. However, increased physical activity (PA. Despite the many positive impacts of physical activity, nearly 60% of the world's population fails to meet the recommended duration (Guthold et al., 2020; Rajappan et al., 2015; Van Dyck et al., 2015), which is accumulated at least 150 minutes of moderate to vigorous PA (MVPA) every week as suggested by WHO (2020). Inadequate physical activity contributes to the rapid-growing proportion of chronic diseases (WHO, 2009), which account for almost half the total global burden of diseases (Mathers, 2020).

There is notable evidence reported the decreased participation in physical activity through adolescence, and this trend continues with the increase of age throughout adulthood (Calestine et al., 2017). In the university setting, the number of people who did not participate in regular physical activity was also seen to rise (Calestine et al., 2017; Safi et al., 2021), with many undergraduate students (Alkhateeb et al., 2019) and staffs (Fountaine et al., 2014) were found to be inactive. A previous study conducted by Pengpid & Peltzer (2021) on undergraduate students in 23 countries found that 41.4% failed to meet the recommended physical activity (PA) levels based on a thorough assessment of the overall PA (Acebes-Sánchez et al., 2019). In compliance with the findings, recent WHO reported that 15% of adults of all types of jobs, including teachers in the South-East Asia region, were not compliant with the WHO recommended levels of PA (Uddin et al., 2017).

Previous studies provide several explanations that may suggest why many students, teachers, and adults do not actively engage in regular physical activity. For instance, evidence suggests that "time availability" is the primary barrier that prevents adults from fulfilling the recommended guideline of physical activity (Brown et al., 2014; Edmunds et al., 2013; Joseph et al., 2015), such as lack of free time due to tight schedule at school or university or obligation in social and family life (Kljajević et al., 2022). Long periods of sedentary time has also been found to be the major cause of the decline in physical activity among the university community, especially during the pandemic situation as it led them to be confined to their homes (Fountaine et al., 2014; Legido-Quigley et al., 2020; Romero-Blanco et al., 2020).

A suggestion from a previous study proposed that research must focus on the level of physical activity amongst staff in the workplaces who are likely being overlooked (Jackson et al., 2014). However, despite of the suggestion, only a few studies have focused on students and employees within the higher education sector, especially the college or university (Safi et al., 2021). Most of the previous research mainly focused on PA levels of one specific university member and classified them as a homogeneous group. Whereas, due to the cultural differences across departments or majors, it is essential to know that a university has a diverse range of members or communities with its own characteristics. Therefore, this study was conducted to measure and evaluate the current level of physical activity amongst the university community.

Materials and methods

Study participants

This study used a cross-sectional design with 2698 university students and 355 lecturers across seven faculties, one postgraduate program, and one vocational program at Universitas Negeri Surabaya involved as participants. Study inclusion criteria common to both samples included: (1) current enrolment as an active undergraduate student or an active lecturer at the university, based on data retrieved from Republic of Indonesia's Higher Education Database (PDDIKTI); (2) completing a self-administered questionnaire comprised of a number of measures during November 2021.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Universitas Negeri Surabaya.

Study organization

The online survey comprised of two sections which assessed subjective characteristics of participants and a structured questionnaire modified from the WHO Global Physical Activity Questionnaire (GPAQ) that has been translated into Indonesian, to measure the level of physical activity. Respondents were asked to report the number of days and duration of activities spent on studying or working, transporting, and leisure or recreational activities, comprising of 16 items in total and 1 question on sedentary behaviour. Participants were excluded if data pertaining to each item of GPAQ was not reported. MET-minutes/week METs or Metabolic Equivalents were used to express the intensity of physical activity and were also used for the analysis of the GPAQ data. The level of PA was then classified into three categories: (a) low PA (METs value less than 600); (b) moderate PA (METs value 600 – 3000); and (c) high PA (METs value more than 3000) (Uddin et al., 2017).

Statistical analysis

All statistical tests were carried out using SPSS 21 for Windows. The standard univariate statistic was used to describe the study population; means and standard deviation were used for continuous variables, while frequency and percentage were used for categorical variables. The difference in the characteristic of participants was analysed using Chi-Square. Mann-Whitney test was conducted to determine the difference in and the level of physical activity between students and lecturers. In all instances, the level of significance was set at $p < 0.05$.

Results

This research aimed to measure the level of physical activity of lecturers and university students across majors and programs. Most of the student participants were female (71.39%) with average bodyweight, height, and BMI was 54.65 ± 11.00 kg, 159.25 ± 7.00 cm, and 22.08 ± 5.55 kg/m^2, respectively. While the majority of lecturer participants comprised of male (52.68%), with an average of age was 48.99 ± 102.28 years and had higher bodyweight (69.25 ± 15.74 kg), height (161.55 ± 13.14 cm), as well as BMI (34.52 ± 5.38 kg/m^2) compared to the students. In terms of BMI, most of the students had normal BMI (58,82%), while almost half of the lecturers had BMI in the overweight category (42.82%). Both students and lecturers in all majors

and programs did physical activity at least once a week, did not smoke, had a moderate level of PA, and only a few of them had NCD's comorbid (Table 1).

Mann Whitney test shows that age (p = 0.001), bodyweight (p = 0.023), body mass index (p = 0.015), and METs score (p = 0.011) were significantly different between students and lecturers. Analysis of categorical data using the Chi-Square test shows that only the frequency of physical activity in a week differs statistically (p = 0.047).

The MET values of lecturers and students across different majors and study programs based on the results of the GPAQ questionnaire. Students from the Sports Science major had the highest METs scores, 3922.61 minutes/week and students from Vocational programs had the lowest level of METs (918.48 minutes/week). Meanwhile, the lecturers obtained the highest and lowest MET scores from Vocational programs and Social Sciences and Law majors with a score of 1753.20 and 895.50 minutes/week. Furthermore, to determine the difference between the METs scores of lecturers and students in each major and program, a different test was carried out using the Mann Whitney as the data was not normally distributed (Figure 1).

Table 2 presents there was a significant difference in the METs scores between lecturers and students in three majors, which were Economics, Sports Science, and Science Education (p < 0.05). The percentage of physical activity level category was then calculated based on the METs values. The results are presented in the figure below.

The majority of respondents had moderate physical activity levels with a percentage of 45.0% for students and 52% for lecturers. The second-largest percentage is in the low category for both lecturers and students. Then the smallest percentage is in the high category for both the lecturers and students. It shows that the academic community's overall

Table 1. Socio-demography characteristic of study participants

Characteristics	Student	Lecturer	P (sig)
Gender (n, %)			
Male	772 (28.61)	187 (52.68)	0.214
Female	1926 (71.39)	168 (47.32)	
Age (year; mean ± SD)	20.41 ±3.41	48.99 ± 102.28	0.001*
Bodyweight (kg; mean ± SD)	54.65 ± 11.00	69.25 ± 15.74	0.023*
Height (cm; mean ± SD)	159.25 ± 7.00	161.55 ± 13.14	0.156
Body mass index (BMI) (kg/m^2; mean ± SD)	22.08 ± 5.55	34.52 ± 5.38	0.015*
BMI category (n, %)			
Underweight	588 (21.79)	9 (2.54)	
Normal	1587 (58.82)	147 (41.41)	
Overweight	383 (14.20)	152 (42.82)	
Obese	140 (5.19)	47 (13.24)	0.412
Frequency of PA (n, %)			
Never	456 (16.90)	43 (12.11)	
Once a week	1036 (38.40)	117 (32.96)	
Twice a week	520 (19.27)	73 (20.56)	
Three times a week	331 (12.27)	60 (16.90)	
Almost everyday	255 (13.16)	62 (17.46)	0.047**
Levels of PA (n, %)			
Low	1109 (41.10)	132 (37.18)	
Moderate	1214 (45.00)	185 (52.11)	
Vigorous	375 (13.90)	38 (10.70)	0.360
METs (min/week, mean ± SD)	1612.81 ± 542.21	1178.0 ± 694.54	0.011*
Smoking status (n, %)			
Yes	965 (35.77)	95 (26.76)	
No	1733 (64.23)	260 (73.24)	0.214
Present of NCD (n, %)			
Hypertension	49 (1.82)	23 (6.48)	
Hypotension	196 (7.26)	11 (3.10)	
Asthma	83 (3.08)	5 (1.41)	
Diabetes mellitus type II	25 (0.93)	7 (1.97)	
Vision disorder	99 (3.67)	16 (4.51)	
Osteoporosis	10 (0.37)	40 (11.27)	
Others	481 (17.83)	45 (12.68)	
None	1755 (65.05)	208 (58.59)	0.335

*significantly different using Mann Whitney (p<0.05); **significantly different using Chi-Square test (p<0.05)

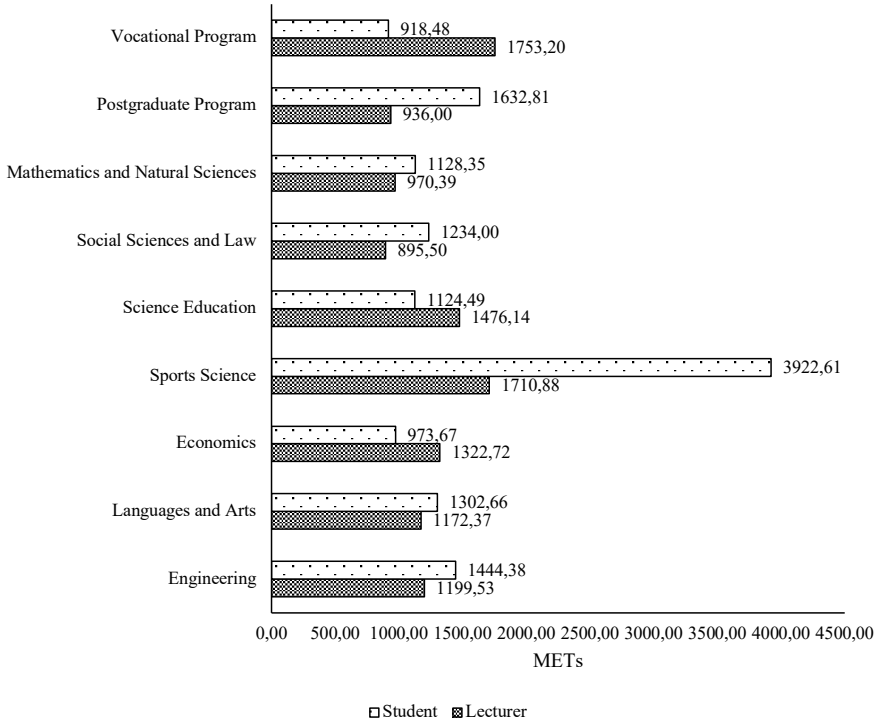

Fig. 1. The results of the MET scores of lecturers and students across different majors and programs

Table 2. Differences in METs between lecturers and students across majors/programs

Major / Program	n	Mean ± SD	P (sig)
Engineering	Lecturer = 58	1199.53 ± 1531.37	0.946
	Student = 436	1444.38 ± 2002.68	
Languages and Arts	Lecturer = 50	1172.37 ±1308.26	0.757
	Student = 289	1302.66 ±1833.73	
Economics	Lecturer = 43	1322.72 ±1345.29	0.023*
	Student = 195	973.69 ±1318.17	
Sports Science	Lecturer = 53	1710.88 ± 1474.63	0.000*
	Student = 292	3922.61 ± 3594.54	
Education	Lecturer = 65	1476.14 ± 1640.34	0.011*
	Student = 861	1124.49 ± 1606.07	
Social Sciences and Law	Lecturer = 24	895.50 ± 721.08	0.714
	Student = 227	1234.00 ± 2393.47	
Mathematics and Natural Sciences	Lecturer = 42	970.39 ± 969.84	0.977
	Student = 189	1128.35 ± 1307.38	
Postgraduate Program	Lecturer = 5	936.00 ± 545.97	0.836
	Student = 87	1632.81 ± 2072.53	
Vocational Program	Lecturer = 15	918.48 ± 1234.13	0.082
	Student = 122	1753.20 ± 2197.25	

*significantly different using the Mann Whitney test ($p<0.05$)

physical activity tends to be at a moderate level, as seen from the percentage of categories (Figure 2).

Discussion

There is a lack of research that comprehensively assesses the PA levels for students and lecturers in all majors and programs at the University, especially in Indonesia. Identifying particular populations such as students and lecturers is very interesting because they are a specific and busy population with a regular timetable who spend most of their time studying and teaching for lecturers during their weekdays (Arias-Palencia et al., 2015). This present study has several noteworthy findings that could be highlighted. In general, the level of physical activity of students and lecturers was mainly in the moderate category. However, the category of low physical activity level was also in high percentage. These findings showed that the level of physical activity of all participants in general still tends to

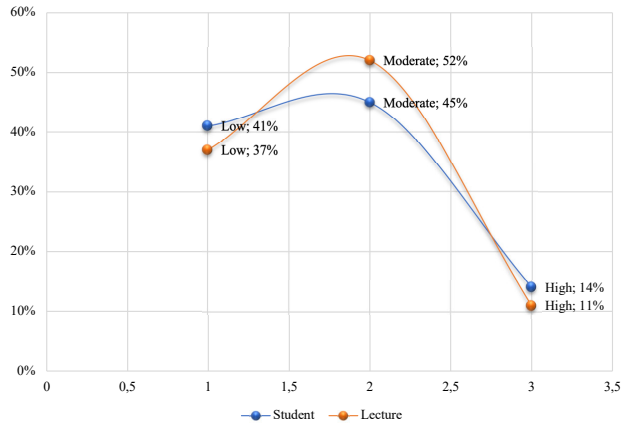

Fig. 2. The physical activity level of students and lecturer

be low. Low physical activity is a major risk factor for many adverse health conditions (Lee, Shiroma, Lobelo, Puska, Blair, & Katzmarzyk, 2012), especially the world's major non-communicable diseases, and has a negative effect on the quality of life and mental health (Guthold et al., 2018). Physical activity is one way to prevent and reduce the risk of non-communicable diseases such as obesity (Ekelund et al., 2016), which is the prevalence continues to increase due to changing lifestyles with technological advances and the increasingly widespread use of machines, thereby reducing a person's physical activity (Peyman et al., 2018; Safi et al., 2021).

In conformity with the METs scores obtained from the participants, students of the Sports Science major got the highest average METs scores. This is also conformable with findings reported by Alkatan et al., (2021) which is shown that the PA level among physical education college students in Kuwait was relatively high. It is due to the lecture process, students are taught to exercise and do physical activities. They demonstrate the lecture material by doing sports activities so that their physical activity is high enough to have an average MET of 3922.61 minutes per week. Besides, many Sports Science students are collegiate student-athletes who are still active or former athletes who joined many sports clubs. Hence, their participation in sports activities is greater than their peers in other majors' (Gayles & Hu, 2009).

Additionally, during the learning activities, both lecturers and students of Sports Science are mainly involved in discussions or interactive dialogues about the importance of sports, physical activity, and a healthy lifestyle. Therefore, Sport Science students tend to have better sports literacy and physical activity (Bulqini et al., 2021). With good physical literacy, students will have the results of motor skills, environmental context, and a broader affective social learning process. Students who receive physical education-related courses at college or university are more likely to exhibit positive social life perceptions and have a better-coping stress mechanism (Beaudoin et al., 2018; Choi et al., 2021). Good physical and health literacy also plays a role in positive health behaviours (Cairney et al., 2019; Klinker et al., 2020; Zhang et al., 2021), as stated by a previous study that health literacy enables people to build their knowledge, skills, and potential to make positive behavioural changes. Improving health literacy is more likely to lead to sustainable behaviour change given that lower levels of health literacy are associated with poorer health outcomes (Visscher et al., 2018) and academic performance (Bulqini et al., 2021).

Based on the findings, lecturers' METs scores tend to be lower than students' (see Table 1 and Figure 1). One of many possible reasons that could explain this finding was related to age. Sun et al. (2013) stated in their research that older people tend to have lower levels of physical activity than young people. While the lecturers may be more knowledgeable about the health benefits of physical activity, it does not mean that their knowledge will always equate to action. Time availability, fatigue, motivation, and the increased use of technology are some of the barriers applicable to this population (Whipple et al., 2008). Time availability that lecturers specifically allocate to their works appears to cause a major impact upon the declining engagement of physical activity on a daily basis (da Silva et al., 2018). It was reiterated by other studies which reported that adults across workplaces spent as much as 60% - 70% of their waking time to work, with more than 75% of it being sedentary (Edge et al., 2017; Headley et al., 2018; Waters et al., 2016), which is most of their time is engaged in prolonged sitting (Mustar et al., 2021). Several cross-sectional studies reported that the increase in sedentary activity at work was linked to lower productivity (Puig-Ribera et al., 2015) and fatigue (Rosenkranz et al., 2020). Therefore, it is suggested that the university should implement appropriate interventions to increase physical activity, especially for the lecturers and staff, to ensure they are provided with opportunities to stay active during working hours (Safi et al., 2021) and increase their work performance.

Being an academic includes a busy work schedule and a long duration of scientific activities. Because of this, lecturers are pushed into being more physically inactive and spend more time sitting (Cinar & Bavli, 2014). Nevertheless, the present study found that the lecturers working in the Vocational and Sport Science program had the highest METs score. There is a need for more studies to discuss this finding, but some explanations that may elucidate this finding are that Vocational and Sport Science programs comprise more practical teaching that urges both lecturers and students to actively move rather than just sit. It is in agreement with a previous study which indicated that teachers who teach practical courses or lectures tend to be more physically active and spend more time doing leisure physical activity compared to other peers (Bogaert et al., 2014; Erick & Smith, 2011). However, a more detailed analysis regarding the relationship between physical activity level and teaching subject area is needed to confirm this finding.

Despite revealing the results that impact physical activity levels in both lecturers and students, this present study has some limitations that can be highlighted. First, the data collected through GPAQ and self-reported methods are prone to human error, such as overestimating or vice versa. Nonetheless, this can be prevented by using tools to monitor PA, such as accelerometers, so that the results obtained can be more accurate. Second, the limitation of this study included the use of a convenience sample that was limited to only students and lecturers who filled out the questionnaire. Geographic location and the lack of variability of the socio-demographic factors would also limit the ability to generalize the findings to other populations.

Conclusions

Most of the students and lecturers had a low level of PA, with the highest METs was found in students coming from Sport Science majors and lecturers working in Vocational programs. Findings from this study led as the reference in developed strategies and policies aimed at promoting and improving physical activity and the welfare of the university community. Furthermore, the university needs to advocate and motivate the academic community to increase awareness of a healthy lifestyle, mainly engaging in light physical activity during working days to maintain health, fitness, well-being, and quality of life. Additional population-based studies, preferably longitudinal studies with representative samples from state and private universities and objective measurement of physical activity, are needed to understand the factors associated with physical activity in the university

community, particularly among students and lecturers who spent most of their time with students and lecturers at university.

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Conflict of interest

No conflict of interest to declare.

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РІВЕНЬ ФІЗИЧНОЇ АКТИВНОСТІ СТУДЕНТІВ І ВИКЛАДАЧІВ УНІВЕРСИТЕТІВ ЗА РІЗНИМИ СПЕЦІАЛЬНОСТЯМИ ТА ПРОГРАМАМИ В ІНДОНЕЗІЇ

Агус Харіянто[1ABE], Єтті Септьяні Мустар[1ABCD], Аніндья Маркатус Шоліхах[1ABCD], Афіф Русдьяван[1ABCD], Індра Хімаван Сусанто[1ABC], Мохаммад Пурномо[1ABC]

[1]Сурабайський державний університет

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

Реферат. Стаття: 9 с., 2 табл., 2 рис., 54 джерел.

Історія питання. Відсутність фізичної активності є четвертим провідним фактором ризику, що сприяє швидкому зростанню глобальної смертності. Ця кількість зростає в усіх секторах, і заклади вищої освіти не є винятком. Оскільки проблеми зі здоров'ям і самопочуттям викладачів і студентів університетів стають дедалі поширеними, потреба приділяти більше часу фізичній активності стає все більш важливою.

Метою цього дослідження є оцінка поточного рівня фізичної активності студентів і викладачів різних факультетів і спеціальностей.

Матеріали та методи. У листопаді 2021 року було проведено перехресне дослідження серед 2698 студентів та 355 викладачів. Вони заповнили глобальну онлайн-анкету з фізичної активності (GPAQ) і повідомили кількість днів і тривалість діяльності, яку вони витратили на навчання або роботу, подорожі та активний відпочинок. Усі відповіді щодо тривалості були конвертовані з годин у метаболічні еквіваленти (METs). Статистичний аналіз і введення даних здійснювали з використанням програмного забезпечення SPSS версія 21.

Результати. Була виявлена статистично значуща різниця в балах метаболічних еквівалентів між викладачами та студентами трьох спеціальностей: економіка, наука про спорт та наукова освіта ($p < 0,05$). Інші результати показали, що рівень фізичної активності серед студентів і викладачів належав до середньої категорії, хоча низький рівень фізичної активності також був вищим. Відсутність фізичної активності є основним фактором ризику розвитку неінфекційних захворювань і негативно впливає на якість життя та психічне здоров'я.

Висновки. Таким чином, університету потрібно ретельно розробляти політики та стратегії для заохочення та покращення фізичної активності та гарного самопочуття студентів, викладачів, членів персоналу та всіх залучених осіб.

Ключові слова: фізична підготовленість, метаболічні еквіваленти, викладач, студент, коледж.

Information about the authors:

Hariyanto, Agus: agushariyanto@unesa.ac.id; https://orcid.org/0000-0002-7927-8827; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Mustar, Yetty Septiani: yettymustar@unesa.ac.id; https://orcid.org/0000-0003-0079-3795; Department of Health Education and Recreation, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Sholikhah, Anindya Mar'atus: anindyasholikhah@unesa.ac.id; https://orcid.org/0000-0003-4783-6182; Department of Health Education and Recreation, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Rusdiawan, Afif: afifrusdiawan@unesa.ac.id; https://orcid.org/0000-0001-5388-7061; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Susanto, Indra Himawan: indrasusanto@unesa.ac.id; https://orcid.org/0000-0001-6132-9051; Department of Health Education and Recreation, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Purnomo, Mochammad: mochamadpurnomo@unesa.ac.id; https://orcid.org/0000-0003-0348-7531; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

CORRELATION OF BODY MASS INDEX, PHYSICAL ACTIVITY, AND PHYSICAL FITNESS IN ELEMENTARY SCHOOL STUDENTS

Ilmul Ma'arif[1ABDE], Nurhasan[1AC], Suroto[1AD], Risfandi Setyawan[2ADE], Basuki[2BC], Mohammad Zaim Zen[2BD], Rahayu Prasetiyo[2BCE], Yudi Dwi Saputra[2CD] and Novita Nur Synthiawati[2BCE]

[1]Universitas Negeri Surabaya
[2]STKIP PGRI Jombang

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

Corresponding Author: Ilmul Ma'arif, E-mail: ilmulmaarif16070946012@mhs.unesa.ac.id
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Abstract

The purpose of this study was to determine the conditions and the relationship between body mass index (BMI), physical activity, and physical fitness.

Materials and methods. This type of research was a cross-sectional study which was an observational study that analyzes data with predetermined variables and respondents. The number of respondents was 191 elementary school students in Kecamatan Ploso, Kabupaten Jombang, East Java, Indonesia. BMI was calculated by dividing weight in kilograms (kg) by height in meters squared (m^2), measurement of physical fitness used 20-meter Multi-Stage Fitness Test (MSFT) test, whilst physical activity test used a Physical Activity Questionnaire for Older Children (PAQ-C). The data analysis used the Pearson product-moment model using SPSS version 21.0 with a significance level of 5%.

Results. The correlation analysis results in this study indicate that there was a positive correlation between BMI and physical activity (r=0.176; p-value=0.015), BMI and physical fitness (r=0.151; p-value=0.037), and physical activity and physical fitness (r=0.142; p-value=0.049).

Conclusions. Based on the study results, it was showed that there was a positive correlation in each variable (body mass index, physical activity, and physical fitness).

Keywords: physical activity, physical fitness, body mass index, elementary school students.

Introduction

Physical activity is said to be an activity carried out by every human being described in daily life so as to produce a muscle reaction that can increase the energy expended including sports activities (Rejeki et al., 2021). When moving actively and regularly with a low to high intensity pattern used will have an impact on the body in removing calories in the body (Sugiharto et al., 2022). Each individual is different in the level of physical activity carried out because it is influenced by gender, nutrition and also socio-economic status, can benefit for physical and social health when children do physical activity and are well documented (Janssen & LeBlanc, 2010; Lubans et al., 2016), when children's active participation in physical activity can provide assistance to improve cognitive, emotional abilities, build strong muscles and bones and can be protected from several diseases and health (Hallal et al., 2006; Watson et al., 2017). Therefore physical activity is very important for elementary school children (Basuki et al., 2021).

Coronavirus Disease 2019 (COVID-19) pandemic and restrictions on gatherings have led to online classes and their impact on children's physical activity restrictions – with an increase in body weight and sedentary activities (Ługowska et al., 2022). The COVID-19 pandemic has also limited activities in schools, especially in the subjects of Physical Education, Sports and Health. The objective of Physical Education, Sport and Health subjects for elementary school children is not only to develop physical abilities, but also to develop intellectual, mental, social and emotional dimensions. However, this goal is certainly experiencing obstacles due to the COVID-19 pandemic in the world

(Basuki et al., 2019). So that it also has an impact on the cardiorespiratory condition of the child's fitness being less, obesity has increased in all age groups, overweight and low fitness are interrelated so that it has an impact on low physical activity (Dencker et al., 2006). When obesity in children later in life there is an increase it has a negative impact on health (Freedman et al., 2001). To lead a healthy life children must be able to increase movement activities to identify changes in overall fitness and get used to doing physical activity to show positive effects in home and family based activities (Brown et al., 2017).

Physical activity provides benefits for elementary school-aged children by increasing physical activity accompanied by healthy food, so that it can overcome health problems that have been developing in the community and show that physical activity as a tool to reduce obesity, as parents should also be able to know when at home that children's fitness must be maintained and keep moving so that the condition of the body can still carry out daily activities. When a children's fitness level decreases, it will result in a child being less mobile and obese, because good fitness is a picture of good physical activity, fitness and obesity are always related to gender (Li et al., 2008), so that every group including health can provide a description of an activity based on age and gender can reduce and be a solution to the problem of childhood obesity.

Physical activity is important for children who are more active and have better fitness than inactive ones (Aires et al., 2011; Boddy et al., 2012). Physical activity has a good impact on improving fitness and is integrated into physical activity. when children are active, the fitness condition will be better than children who are not active. Children who are involved in physical activity can help maintain their appearance (Muñoz-Vera et al., 2017). Each individual must have the motivation and desire to be active on a regular basis, but each individual must be able to maintain movement activities effectively because they will definitely face various things and challenges, each individual must have the skills, knowledge, motivation to overcome these challenges. The purpose of this study is how the condition of physical activity, body mass index and physical fitness to get a picture of the condition of children in elementary school.

Materiald and Methods

Study participants

A total of study pasticipants 191 elementary school students in Kecamatan Ploso, Kabupaten Jombang, East Java, Indonesia. This data collection has been approved by teachers, parents and students as the basis for the code of ethics in research and also respondents get directions before conducting the research orally, respondents fill out a willingness form to participate in this study and give sign a statement to be willing as a respondent.

Study organization

This type of research was a cross-sectional study which was an observational study that analyzes data with predetermined variables and respondents. Body mass index (BMI) was measured using standard norms by dividing the weight of the participant by his/her height in squared meters (Gerver & de Bruin, 2001; Raharjo et al., 2021; Andarianto et al., 2022; Sugiharto et al., 2022)and may not be appropriate for the Chinese population. More data among Chinese are needed to address this issue. We aimed to identify cut-offs for body mass index (BMI, measurement of physical fitness using 20-meter Multi-Stage Fitness Test (MSFT) test (Sugiharto et al., 2022; Paradisis et al., 2014)and may not be appropriate for the Chinese population. More data among Chinese are needed to address this issue. We aimed to identify cut-offs for body mass index (BMI, whilst physical activity test used a Physical Activity Questionnaire for Older Children (PAQ-C) (Kowalski et al., 1997; Kowalski et al., 2004; Moore et al., 2007).

Statistic analysis

Statistic analysis used descriptive statistics, namely the calculation of the mean, standard deviation to determine the results of BMI, physical fitness, physical activity, for BMI and fitness are calculated according to gender categories, after that used Pearson product-moment model to determine the correlation of each variable from BMI, physical activity, fitness physical analysis was performed with SPSS version 21.0, and the significant level 5%.

Results

The results of measurements made to research respondents regarding physical activity, physical fitness, body mass index (BMI) can be shown as follows in Table 1 below. Based on Table 1, it shows that regarding physical activity, physical fitness, BMI shows that the minimum value for physical activity is 10.00 a maximum of 46.00, the average is 31.09 and the standard deviation is 7.38. For the minimum physical fitness value 18.50 maximum 38.50, the average is 38.30 and the standard deviation is 38.0. For a minimum BMI value is 11.50, a maximum of 30.20, an average of 18.54 and a standard deviation of 3.59, based on the values obtained can be seen in Table 1.

Based on Table 2, which explains the characteristics of respondents with a total of 191 primary school student respondents with male and female gender regarding physical activity carried out in 1 week in a row that meets the very less, less, moderate, high, very high categories.

Based on the Table 2, it can be seen about the physical activity of elementary school student respondents based on gender with very less categories 4, less 14, moderate 42, high 26, very high 3. While for women with very less categories 4, less 17, moderate 51, high 24, very high 6. So based on these data it is known that physical activity for 1 week is on average in the moderate category, it can be seen from the calculation results, namely for male 42 students and female 51 students.

In Table 3 explains the physical fitness condition of elementary school students seen from 20-meter Multi-Stage Fitness Test (MSFT) test, so that it can be seen that the data about the categories are very less, less, moderate, good, very good, very very good. The data obtained from male and female respondents are as follows.

The Table 3 above shows that there were differences in the results of the respondents' physical fitness between men

and women, which can be seen based on the gender of men who get the number in the moderate category, namely the number of 35 respondents, while for the physical fitness of women it is in the less category with a total of 37 respondents.

Table 4 explains the condition of the body mass index of elementary school students as seen from the calculation of BMI (height and weight), so that it can be seen data about the categories of respondents, namely thin, normal, overweight, obesity. The data obtained from male and female respondents are as follows.

The Table 4 above shows that the body mass index of male respondents is in the thin category with a total of 56 respondents, while for female respondents it can be seen that it is in the normal category with a total of 50 respondents.

Based on the results of the Pearson correlation analysis (Figure 1), it shows that there is a positive correlation between BMI with physical activity (r=0.176; p-value=0.015), BMI with physical fitness (r=0.151; p-value=0.037), physical activity with physical fitness (r=0.142; p-value=0.049).

Table 1. Description of research variable data

Category	n	Min	Max	Mean	SD
Physical activity	191	10.00	46.00	31.09	7.38
Physical Fitness	191	18.50	38.50	38.30	38.0
BMI	191	11.50	30.20	18.54	3.59

Table 4. Characteristics of respondents BMI

Gender	Category	n	Min	Max	Mean	SD
Man	Underweight	56	12.10	18.40	15.96	1.87
	Normal weight	32	18.10	25.40	21.10	1.86
	Overweight	3	27.30	28.50	27.96	0.61
	Obesity	0	0.00	0.00	0.00	0.00
Woman	Underweight	47	11.50	23.90	16.29	2.53
	Normal weight	50	16.80	32.80	21.34	2.60
	Overweight	3	26.10	29.80	27.53	1.98
	Obesity	0	0.00	0.00	0.00	0.00

Discussion

The study conducted on respondents from elementary school students showed that the physical activity of boys and girls showed a moderate category so that conditions at school positively affected the fitness of boys, as seen from the results of the data obtained in the moderate category for girls in the category less even though the results are slightly different from male respondents. Another important factor impacting the risk of being overweight and obese is diet. It was evident that regular food consumption by female respondents shows a normal category so that the resulting

Table 2. Characteristics of physical activity respondents

Gender	Category	n	Min	Max	Mean	Std. Deviation
Man	Very less	4	14.30	16.80	15.6 7	1.10
	Less	14	18.00	24.00	20.57	2.24
	Moderate	42	24.00	34.00	29.35	2.35
	High	26	35.00	44.00	37.50	2.80
	Very high	3	46.00	46.80	46.43	0.40
Woman	Very less	4	13.20	17.50	15.37	1.93
	Less	17	15.00	24.00	20.35	2.62
	Moderate	51	25.00	34.00	30.09	2.80
	High	24	35.00	44.00	38.45	2.85
	Very high	6	45.00	46.00	45.50	0.54

Table 3. Characteristics of physical fitness respondents

Gender	Category	n	Min	Max	Mean	Std. Deviation
Man	Very less	16	27.50	38.30	31.24	4.16
	Less	6	36.20	38.50	37.76	1.13
	Moderate	35	34.80	39.80	38.87	0.82
	Good	0	0.00	0.00	0.00	0.00
	Very good	27	45.20	48.60	46.02	0.89
	Very very good	0	0.00	0.00	0.00	0.00
Woman	Very less	34	18.50	24.90	21.45	2.04
	Less	37	24.60	29.70	26.37	1.26
	Moderate	36	31.10	35.70	33.03	1.14
	Good	0	0.00	0.00	0.00	0.00
	Very good	0	0.00	0.00	0.00	0.00
	Very very good	0	0.00	0.00	0.00	0.00

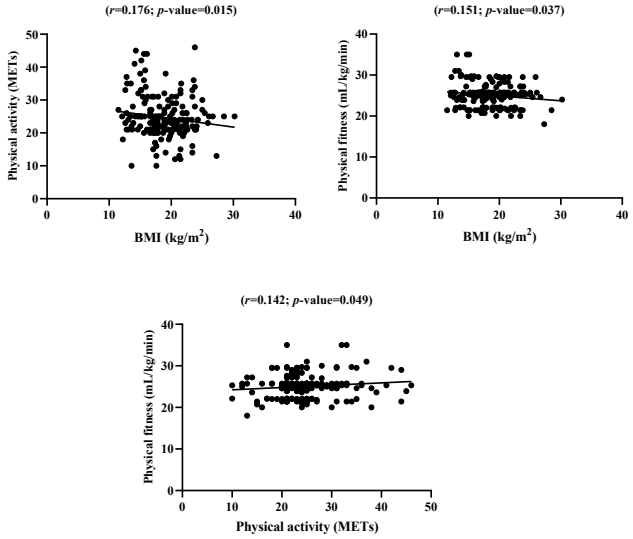

Fig. 1. Results of correlation analysis between body mass index, physical activity, and physical fitness. Pearson correlation coefficients (r) and p-values are shown in graph.

benefits increase in time for physical activity, while men enter the thin category due to irregular eating patterns and physical activity patterns because the portion of food intake that enters the body was not a lot, even though food was a source of energy to carry out activities. Although some variables show categories that were not good, at the level of a correlation, each variable illustrates that all variables influence each other or there was a correlation.

Elementary school was a place where children can gain knowledge about how to do physical activity which is an important element in a healthy lifestyle (Messing et al., 2019). High obesity rates and related diseases have made physical activity promotion a politically relevant topic. In order to form the basis for political decision making, evidence is required regarding the efficacy and effectiveness of interventions for physical activity promotion. In contrast to previous research, this systematic review of reviews targets three key settings (family and home, childcare, schoolIn addition, a less active lifestyle in moving should be reduced, including playing mobile phones and watching television, all of these activities are replaced by regular physical activity because regular physical activity can be associated with a healthy lifestyle. However, a small proportion of primary school age really understand how to carry out daily activities (Guthold et al., 2020).

Children's physical activity carried out with high intensity will have an impact on reducing the risk of being overweight and obese, and increasing the composition of physical fitness (Ng et al., 2019). This impact can be seen in Figure 1 showing that between physical activity and physical fitness there was a correlation with each other, so it can be said that every active physical activity carried out regularly and regularly will have an impact on a person's physical fitness level. Physical activity provides many benefits for children's health as a result of a physically active lifestyle. Also provides an increase in cardiorespiratory and muscle fitness, and also has a positive effect on body weight. According to Florido et al. (2017) explained that when active and increased in physical activity the possibility of a fat body condition will decrease.

Children are always involved in daily activities with physical activity will be able to maintain the condition and appearance of the body and also have an impact on the child's physical fitness, when everyone with a lifestyle that does not carry out moving activities will result in increased body fat conditions and have condition status. fat body, in contrast to an active lifestyle, because fat in the body has a negative correlation with energy expenditure (Fonseca et al., 2018). Energy activity, diet-induced thermogenesis, or a combination of all of these components. It thus contributes to positive energy balance and subsequent weight gain. Obesity, therefore, can be considered, among other aspects, the consequence of an energy imbalance; that is, energy intake greater than that spent in a certain period. In order to have stability of body weight and body composition it would be necessary for energy intake to correspond to energy expenditure. Regarding the comparison of energy expenditure between non-obese and obese individuals, the results point to a differentiated behavior of obese individuals. However, it has not yet been possible to identify which specific energy expenditure component contributes most to this differentiated behavior can (resting energy expenditure, energy expenditure during physical activity or food thermogenesisPhysical activity affects BMI values and body composition (Lakoski et al., 2011). We examined the nonmodifiable and modifiable determinants of CRF within a large healthy Caucasian population of men and women. The study included 20,239 patients presenting to Cooper Clinic (Dallas, Texas The most important thing is having a good BMI status and always being physically active. Students must have self-awareness for the importance of physical activity in daily activities so that it brings positive things and reduces obesity status and needs to be remembered that physical activity was a necessity as a lifestyle.

Conclusion

Based on the results of the study, it showed that the average student had a moderate level of physical activity and physical fitness, while the average student had a BMI with a normal weight category. However, based on the results of the analysis for each gender, on average, man had a BMI in the underweight category and women in the normal weight category. Meanwhile, the main finding of our study was the relationship between BMI and physical activity and physical fitness, and found a relationship between physical activity and physical fitness in a positive direction.

Conflict of interest

No conflict of interest to declare.

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ВЗАЄМОЗВ'ЯЗОК ІНДЕКСУ МАСИ ТІЛА, ФІЗИЧНОЇ АКТИВНОСТІ ТА ФІЗИЧНОЇ ПІДГОТОВЛЕНОСТІ В УЧНІВ ПОЧАТКОВОЇ ШКОЛИ

Ілмул Макаріф[1ABDE], Нурхасан[1AC], Сурото[1AD], Рісфанді Сетьяван[2ADE], Басукі[2BC], Мохаммад Зейм Зен[2BD], Рахаю Прасентійо[2BCE], Юді Дві Сапутра[2CD], Новіта Нур Синсьяваті[2BCE]

[1]Сурабайський державний університет

[2]Джомбангський педагогічний коледж Асоціації вчителів Індонезії

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

Реферат. Стаття: 7 с., 4 табл., 1 рис., 30 джерел.

Метою цього дослідження було визначити умови та зв'язок між індексом маси тіла (ІМТ), фізичною активністю та фізичною підготовленістю.

Матеріали та методи. Цей тип дослідження був перехресним дослідженням, яке було спостережним дослідженням, у якому аналізують дані з попередньо визначеними змінними та респондентами. Кількість респондентів становила 191 учень початкової школи в окрузі Плосо, регентство Джомбанг, Східна Ява, Індонезія. ІМТ розраховували шляхом поділу ваги в кілограмах (кг) на квадрат зросту в метрах (м2), для вимірювання фізичної підготовленості використовували човниковий біг на 20 метрів, а для тестування фізичної активності використовували опитувальник із фізичної активності для дітей старшого віку (PAQ-C). Для аналізу даних використовували коефіцієнт кореляції Пірсона з використанням програмного забезпечення SPSS версія 21.0 за рівня значущості 5%.

Результати. Результати кореляційного аналізу в цьому дослідженні вказують на наявність позитивної кореляції між ІМТ та фізичною активністю (r=0,176; p-значення=0,015), ІМТ та фізичною підготовленістю (r=0,151; p-значення=0,037) та між фізичною активністю й фізичною підготовленістю (r=0,142; p-значення=0,049).

Висновки. На підставі результатів дослідження було показано наявність позитивної кореляції в кожній змінній (індекс маси тіла, фізична активність і фізична підготовленість).

Ключові слова: фізична активність, фізична підготовленість, індекс маси тіла, учні початкової школи.

Information about the authors:

Ma'arif, Ilmul: ilmulmaarif16070946012@mhs.unesa.ac.id; https://orcid.org/0000-0002-8360-4760; Doctoral Program of Sport Science, Postgraduate Program of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Nurhasan: nurhasan007@unesa.ac.id; https://orcid.org/0000-0002-9192-2072; Postgraduate, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Suroto: suroto@unesa.ac.id; https://orcid.org/0000-0002-8186-1210; Doctoral Program of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Setyawan, Risfandi: risfandi@stkipjb.ac.id; https://orcid.org/0000-0001-5343-4601; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Basuki: basuki.stkipjb@gmail.com; https://orcid.org/0000-0003-3250-3334; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Zen, Mohammad Zaim: zenzaim994@gmail.com; https://orcid.org/0000-0002-3789-7443; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Prasetiyo, Rahayu: prasetiyo.rahayu07@gmail.com; https://orcid.org/0000-0002-4853-3362; Study Program of Physical Education, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Saputra, Yudi Dwi: yudids31@gmail.com; https://orcid.org/0000-0002-5181-7032; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Synthiawati, Novita Nur: novitanurs.stkipjb@gmail.com; https://orcid.org/0000-0002-5726-1178; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

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EFFECT OF COMPLEX TRAINING ON AEROBIC AND ANAEROBIC POWER ON AMATEUR ATHLETES

Gopal Kumar[1ABCD] and Vivek Pandey[1ABCD]

[1]Lakshmibai National Institute of Physical Education

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Corresponding Author: Gopal Kumar, E-mail: gopalk.kumar8@gmail.com
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Abstract

The study purpose was to investigate the effect of complex training on aerobic and anaerobic power of amateur athletes.

Materials and methods. The study included 30 amateur athletes in soccer and hockey, which were equally divided into two groups, namely an Experimental group who underwent 6 weeks of complex training along with regular training in their sports and a Control Group who only performed their regular sports training. Anaerobic power was assessed by Running-based Anaerobic Sprint Test (RAST) and aerobic power (VO_2max) was assessed by 12-min Cooper run/walk test. The study used the Pre-test Post-test Randomized Group Design, and Paired t-test was used as the statistical technique for data analysis at a significance level of 0.05.

Results. At the end of six weeks, the Experimental group showed significant improvement in anaerobic power and VO_2max, while only VO_2max was improved in the Control group ($p<0.05$). No significant improvement was observed in anaerobic power for the Control group ($p>0.06$). Therefore, this shows that complex training has significant effect on anaerobic power, while it does not produce significant improvements in aerobic power.

Conclusions. Six weeks of complex training integrated with regular sports training can improve anaerobic power. Coaches and athletes, specifically in soccer and hockey, can implement the complex training program in their regular training.

Keywords: complex training, amateur, anaerobic power, aerobic power.

Introduction

Strength and conditioning experts, strength coaches, and researchers are all very interested in the best training methods that maximise strength. It is now well researched and accepted by most professionals that the combination of resistance training and plyometric training results in greater muscular power gains (Faude et al., 2013; Hammami et al., 2017; Ebben et al., 1997). This combination is termed as complex training (Fleck & Kontor, 1986). This regime comprises of performing an exercise set that includes a high-load resistance training exercise, then performing a low-load plyometric power exercise right after. In this training style, two biomechanically comparable exercises are typically combined, with the high-load resistance exercise coming first. [e.g., squat at 80% of one repetition maximum (1RM)], followed by the low-load power exercise (e.g., squat jumps) (Fleck & Kontor, 1986; Docherty et al., 2004).

Since the last few decades, the area of complex training has been well researched and numerous researchers had investigated the effect of complex training on various components of physical fitness on athletes of different sports such as soccer, basketball, volleyball, rugby etc. (Christopher et al., 2012; Wallenta, C et al., 2016; Alves et al., 2010). Meta-analyses had tried to convene the vast literature of complex training and findings revealed that complex training has positive effect on physical fitness variables such as countermovement jump, sprints, agility, repeated sprint ability etc. (Christopher et al., 2012; Wallenta et al., 2016; Alves et al., 2010). But there is scarcity of studies related effect of complex training on aerobic and anaerobic power.

It is a well-accepted fact that aerobic and anaerobic power are important physical fitness attributes that contribute in the overall performance of various sports and thus players should have well developed aerobic and anaerobic fitness (Modric et al., 2020; Reilly et al., 2000). Maximal aerobic

power (VO_2max) is defined as the highest oxygen uptake that can be achieved during dynamic exercise with the involvement of large muscle groups (Wagner, 1996). Well-developed VO_2max helps in maintaining repetitive high-intensity runs and accelerating recovery process during a soccer game (Slimani et al. 2019). Anaerobic capacity is the maximal amount of ATP resynthesized via anaerobic metabolism (by the whole organism) during a specific type of short duration, maximal exercise (Green, 1994). Whether complex training can improve VO_2max is a question of debate. Meta-analyses by Ramirez-Campillo, Andrade, et al. (2021) and Thapa et al. (2022) reported small or moderate improvements in time-trial endurance performance. Similarly, the effect of complex training on anaerobic power has not been well-researched. Study conducted by Ingle et al. (2006) reported small increases (≤5.5%) in peak and mean power, while Perez-Gomez et al. (2008) found no improvements in anaerobic power.

Therefore, it is evident that area of aerobic and anaerobic power has not been congruously studied and the studies which are conducted reported contrasting results. Thus, the purpose of the present study was to investigate the effect of complex training on aerobic and anaerobic power on amateur athletes.

Materials and Methods

Study Participants

For the purpose of the study, a total of 30 male, amateur players were selected as subjects. The subjects belonged to Hockey (n=14) and Soccer (n=16) sport. The participants were randomized into one of the two groups – Experimental Group (n=15) and Control Group (n=15) (using an online randomization tool; www.randomizer.org). The physical characteristics of the subjects (Mean ± Standard Deviation) are presented in Table 1.

The inclusion criteria for the participants were – free from any musculo-skeletal or neuromuscular injury or disorder that could limit their ability to perform the training or tests, represented their institute at the inter-university level, training age of at least 4 years and had experience of doing weight training. All the participants were informed about the purpose of the study, benefits and risks involved with the training. Informed consent forms were signed by all the participants. The study was approved by the institutes Departmental Research Committee with considerations regarding ethical issues reported in Helsinki Declaration.

Study Organization

The study used pre-test post-test randomized group design with a training period of six weeks. Experimental Group underwent six weeks of complex training (three times a week i.e. on Mondays, Wednesdays and Fridays) while Control Group was not given any sort of complex training or traditional resistance training. Along with this, both the groups were involved in their regular training of respective sports. Complex training protocol is presented in Table 1.

Two familiarization sessions were conducted for participants before baseline testing. 1-RM testing and demographic data was also collected before the baseline testing. Participants were asked to abstain from any strenuous physical activity 24-hours and take proper rest before the baseline testing. Baseline testing was conducted on a standard track of 400 meters. Participants were tested for anaerobic power and maximal aerobic power (VO_2max) using Running-based Anaerobic Sprint (RAST) Test and 12-Minute Cooper Run/Walk Test respectively.

RAST Test involves six sprints of 35 meters, with a recovery period of 10 seconds between each sprint (total five 10-sec recovery periods) (Andrade et al., 2015). The timing of all six sprints was noted and power (P) in each effort (P = total body mass × distance2)/time3) was calculated (Zagatto et al., 2009). As variables of RAST, the peak power (PP), defined as the greater power achieved among the 6 efforts, the mean power (MP), defined as mean power among the 6 efforts, and minimum power (Pmin), defined as minimum power achieved among the 6 efforts, were determined relative to body weight. For VO_2max, participants were asked to run

Table 1. Protocol for complex training

Indicator	High-load resistance activity		Low-load high-velocity activity	
	Exercise	Sets × repetitions	Exercise	Sets × repetitions
Week 1-2 65% 1RM	Squat	3 × 10	Squat jump	3 × 6
	Romanian deadlift	3 × 10	Kettlebell swing	3 × 10
	Barbell lunge	3 × 10	Barbell high knees	3 × 15 sec
	Bench press	3 × 10	Plyo-push up	3 × 6
Week 3-4 70% 1RM	Squat	3 × 10	Squat jump	3 × 8
	Romanian deadlift	3 × 10	Kettlebell swing	3 × 10
	Barbell lunge	3 × 10	Barbell high knees	3 × 20 sec
	Bench press	3 × 10	Plyo-push up	3 × 8
Week 5-6 75% 1RM	Squat	3 × 10	Squat jump	3 × 10
	Romanian deadlift	3 × 10	Kettlebell swing	3 × 10
	Barbell lunge	3 × 10	Barbell high knees	3 × 25 sec
	Bench press	3 × 10	Plyo-push up	3 × 10

1RM: one repetition maximum.

continuously for twelve minutes and cover as much distance as possible. At the end of twelve minutes, distance covered by the participant was recorded in kilometres. VO_2max was calculated using the formula VO_2max = (22.351 x kilometres) – 11.288 (Cooper, 1968).

Statistical Analysis

With the help of IBM SPSS version 20.0 (IBM, New York, USA) data was analysed. Normality of the data was tested by Shapiro-Wilk test. Data was found to be normally distributed. Data are presented as means and standard deviations in Table 3. Further analysis was carried out at 0.05 level of significance. Paired t-test was used to investigate the effect of intervention by comparing the baseline testing with the post-test.

Results

All the participants of the study received the training as planned and designated. None of the participant reported any adverse effect or injury and also none of the participant left the study without completion. Demographic characteristics of both the groups i.e. age, height, weight and BMI are presented in Table 2 and there was no significant difference found between experimental and control group. Descriptive statistics (means and standard deviations) are presented in Table 2 during pre-test and post-test for both groups for the following variables – VO_2max, average anaerobic power, maximum power, minimum power and fatigue index.

Paired t-test analysis, as presented in Table 4, found that there is significant increase in VO_2max in experimental and control group ($p<0.05$); while significant effect is observed only in experimental group in case of average anaerobic power ($p<0.05$). No significant effect of complex training was observed for average anaerobic power in control group ($p>0.05$).

Discussion

The present study was conducted with the purpose to investigate the effect of complex training on aerobic and anaerobic power among amateur athletes. 30 subjects, equally divided into two groups (Experimental and Control) underwent six weeks of intervention period. The results of the study showed a significant improvement in VO_2max and average anaerobic power in experimental group, while only VO_2max improved in control group.

Soccer and hockey matches consists a lot of high-intensity runs. Strength, power and endurance have proven to be of importance for players of both the games. According to this study research, a 6-weeks complex training program along with regular training of respective games, significantly improved the anaerobic power while significant improvements were not observed in VO_2max. VO_2max was seen improved in both the groups, while the improvements were not significantly different in Experimental and Control Group, while led to the interpretation that improvement in VO_2max among the subjects was because of the regular training of their respective sports, and not because of complex training. Average VO_2max in post-test observation in Experimental and Control Group was 49.42 mL/kg/min and 47.25 mL/kg/min respectively. It shows that VO_2max improvements were slightly higher in Experimental Group than Control Group. These findings are in line with the results

Table 2. Demographic Characteristics of the Participants (Mean ± SD)

Group	Age	Height	Weight	BMI
Experimental Group	21.33 ± 1.83	172.5 ± 5.75	67.04 ± 5.04	21.17 ± 1.03
Control Group	21.06 ± 1.87	171.86 ± 8.20	65.69 ± 6.06	22.56 ± 1.79

Table 3. Descriptive Statistics (Mean ± SD)

Indicator	Experimental Group		Control Group	
	Pre-test	Post - test	Pre - test	Post - test
VO_2max	45.82 ± 3.55	49.42 ± 3.94	44.01 ± 3.30	47.25 ± 3.49
Average Anaerobic Power	448.48 ± 74.44	490.02 ± 66.65	464.48 ± 54.99	458.96 ± 40.68
Maximum Power	531.43 ± 92.45	558.75 ± 84.51	518.67 ± 60.58	510.65 ± 56.60
Minimum Power	365.68 ± 57.48	429.14 ± 60.54	409.01 ± 47.66	420.11 ± 40.45
Fatigue Index	4.95 ± 2.11	3.99 ± 1.53	3.25 ± 1.01	2.67 ± 1.09

Table 4. Paired t-test

Group	Variable	t-value	df	p-value
Experimental Group	VO_2max_Pre – VO_2max_Post	-11.26	14	0.000
	AAP_Pre – AAP_Post	-6.34	14	0.000
Control Group	VO_2max_Pre – VO_2max_Post	-9.75	14	0.000
	AAP_Pre – AAP_Post	0.702	14	0.494

AAP – Average Anaerobic Power

reported where improvements are observed for VO_2max in the intervention group, but the change in score did not differ significantly from that of the control group (Beattie et al., 2017; Ferrauti et al., 2010; Pellegrino et al., 2016).

Since for assessing VO_2max, 12-min Cooper Run/Walk test was used, literature has shown that strength training – induced neuromuscular adaptations including maximum strength, jumping power, and Post-activation potentiation (PAP) response, has beneficial effect on running performance, such as such as improved running economy and force production during running in endurance runners (Mikkola et al., 2011; Ramírez-Campillo et al., 2014; Blagrove et al., 2017). Running Economy (RE), which has been defined as oxygen uptake required at a given submaximal velocity (Ferrauti et al., 2010), has some neuromuscular characteristics such as muscle force and stiffness, fiber-type distribution, elasticity, or neural input (Guglielmo et al., 2009). These factors could also be improved by strength training (Jung, 2003; Laursen et al., 2005; Sunde et al., 2010), increasing the muscle work efficiency, and permitting aerobic activity at a lower oxygen consumption at submaximal intensities (Guglielmo et al. 2009; Millet et al., 2002; Paavolainen et al., 1999; Sunde et al., 2010; Taipale et al., 2010). Complex training elicits PAP response, which allows the athletes to produce more power on subsequent exercises (Carter & Jeremy, 2014). The specific mechanisms include stimulating high order motor unit recruitment and excitability, increasing phosphorylation of the myosin light chain, and changes in limb stiffness (Blagrove, Howatson & Hayes, 2018; Tillin & Bishop, 2009). These neuromuscular adaptations may also benefit long-distance performance such as improvement in RE and maximal running speed (Beattie et al., 2014; Blagrove, Howatson & Hayes, 2018). A study conducted by Li et al. (2019) to investigate the effect of complex training and heavy resistance training on running economy, neuromuscular and 5-km running performance concluded that 8-weeks of complex training as well as heavy resistance training did not improved VO_2max, but 5-km running performance was significantly improved. The author speculated that the 5-km performance improvements were due to the comprehensive effects of neuromuscular adaptations and running economy increase (Li et al., 2019).

Some of the researches conducted with longer intervention period has shown some improvement in VO_2max. Study conducted by Sporis, G. et al. (2011) had shown that 12 weeks of strength training may improve aerobic power by 4.6 percent among female soccer players (Sporis et al., 2011). Similar results have been reported by Gettman and Pollock (1981), Hickson (1980) and Hurley et al. (1984). No statistically significant changes were reported in VO_2max for any group in the majority of studies that assessed this parameter (Karsten et al., 2016; Vikmoen et al., 2016; Giovanelli et al., 2017; Johnston et al., 1997).

In a study on volleyball players, the impact of eight weeks of strength training on aerobic and anaerobic power was examined. The results showed that the experimental group, which included strength training in addition to regular volleyball training, significantly improved their anaerobic and aerobic power, while the control group, which included only traditional volleyball training, showed no differences (Bicer, 2021). Another study showed that after twelve-weeks of complex training, experimental group showed small increases in anaerobic power (less than 5%) among early pubertal boys (Ingle et al., 2006). This is in line with previous research that has reported absolute peak power between 400 and 420 W in trained 11- to 13-year-old boys (Docherty et al., 1987). Following complex training, mechanisms for improving anaerobic performance may involve greater force generation and neural adaptation. Mahon (2000) proposed that improved coordination and increased motor neurone firing rate were the causes of higher performance. Similar results were obtained by Ozmun, Mikesky, and Surburg (1994), who suggested that better contractile activity efficiency in young children was the product of neurological changes by measuring increased muscle activation using integrated electromyography after training. Because of this, complex training may improve the transfer of force between the concentric and eccentric phases of muscle activity and bestow a positive transfer of neuromuscular demands, leading to better coordination and synchronisation of active muscle groups (Chu, 1996).

Six weeks of complex training has significant effect on anaerobic power while it has lacks potential to produce significant increases in VO_2max. Resistance Training can be expected to improve concurrently both muscular and cardiovascular fitness within a single mode of resistance training when young and old persons have initially low fitness levels (Ozaki et al., 2013). Therefore, complex training can be integrated with regular training of respective sports to improvement of anaerobic power. Further research can be conducted with a longer intervention period or different participants to investigate its effect on aerobic power.

Conclusion

Based on the results of the study, it can be concluded that six weeks of complex training integrated with regular games training, can significantly improve anaerobic power, while it does not produce significant improvements in aerobic power among amateur athletes. Coaches and athletes can implement the complex training program in their training for improving their anaerobic power.

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Conflict of Interest

All authors declare no conflict of interest.

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ВПЛИВ КОМПЛЕКСНИХ ТРЕНУВАНЬ НА АЕРОБНУ ТА АНАЕРОБНУ ПОТУЖНІСТЬ СПОРТСМЕНІВ-ЛЮБИТЕЛІВ

Гопал Кумар[1ABCD], Вівек Пандей[1ABCD]

[1]Національний інститут фізичного виховання імені Лакшмі Бай

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

Реферат. Стаття: 7 с., 4 табл., 53 джерела.

Метою дослідження було вивчення впливу комплексних тренувань на аеробну та анаеробну потужність спортсменів-любителів.

Матеріали та методи. Учасниками дослідження були 30 спортсменів-любителів – гравців у футбол і хокей, яких порівну розділили на дві групи, а саме: експериментальну групу, яка проходила 6 тижнів комплексних тренувань разом зі звичайними тренуваннями у своїх видах спорту, і контрольну групу, яка виконувала лише свої звичайні спортивні тренування. Анаеробну потужність оцінювали за допомогою анаеробного спринт-тесту на основі бігу (RAST), а аеробну потужність (максимальне споживання кисню – VO_2max) оцінювали за допомогою 12-хвилинного тесту Купера на біг/ходьбу. У дослідженні використовували план попереднього та підсумкового тестування на двох групах із випадковим розподілом учасників, а для аналізу даних як статистичний метод використовували парний t-критерій Стьюдента за рівня значущості 0,05.

Результати. Після завершення шести тижнів експериментальна група продемонструвала статистично значуще покращення анаеробної потужності та показника VO_2max, тоді як у контрольній групі покращився лише показник VO_2max ($p<0,05$). Статистично значущого покращення анаеробної потужності для контрольної групи не спостерігалося ($p>0,06$). Таким чином, це показує, що комплексні тренування мають значний вплив на анаеробну потужність, але не спричиняють значного покращення аеробної потужності.

Висновки. Шість тижнів комплексних тренувань у поєднанні зі звичайними спортивними тренуваннями можуть покращити анаеробну потужність. Тренери та спортсмени, зокрема в таких видах спорту, як футбол і хокей, можуть реалізувати програму комплексних тренувань у своїх звичайних тренуваннях.

Ключові слова: комплексні тренування, любитель, анаеробна потужність, аеробна потужність.

Information about the authors:

Kumar, Gopal: gopalk.kumar8@gmail.com; https://orcid.org/0000-0002-4764-3690; Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Pandey, Vivek: pandey_vivek61@yahoo.com; https://orcid.org/0000-0003-2247-0671; Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

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ORIGINAL SCIENTIFIC ARTICLE

IMPACT OF NEW LIVING ENVIRONMENT ON REACTIVE STRESS TOLERANCE IN PREADOLESCENT SPORTS TRAINEES OF JHARKHAND

Mnaohar Kumar Pahan[1,2ABCD], Vikrant Malhan[3ABD] and Yendrembam Nepoleon[4AD]

[1]Lakshmibai National Institute of Physical Education
[2]Ramakrishna Mission Vivekananda Educational and Research Institute
[3]Sai Nath University
[4]Lovely Professional University

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

Corresponding Author: Manohar Kumar Pahan, E-mail: contrapahan@gmail.com
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Abstract

Study purpose. The purpose of the study was to examine the effect of background experience related to family demography on the selected parameters of reactive stress tolerance in athletes who strictly lived in a training academy for a minimum of two years.

Materials and methods. A total of 200 male sports cadets were chosen by the Jharkhand State Sports Promotion Society in Ranchi, with chronological age ranging from 11 to 14 years and 4 years of training. The demographic information (the size of the family, the type of family, the order of birth, the family monthly income, and the location of the home) were considered as independent variables. Stress tolerance parameters (PR correct, PR incorrect, PR omitted, and median reaction time) were chosen as dependent variables. The Shapiro-Wilk test was used to determine data normality, while Levene's test was used to determine homogeneity. The Mann-Whitney U and Kruskal-Wallis tests were used to draw comparisons. For post-hoc comparison, Dunn's test with Holm correction was employed. The threshold for significance was set at $p = 0.05$.

Results. The percentile rank of correct responses ($p = 0.005$) and median reaction time ($p = 0.033$) related to birth orders showed significant results. Other factors related to family information and reactive stress tolerance were not significant.

Conclusions. According to the findings, it was concluded that being in new environment for a long duration reduced the early living experience related to family demography but effect of birth order still continued.

Keywords: reactive stress tolerance, family type, family size, birth order, family monthly income, housing location, preadolescent sportsperson, Jharkhand.

Introduction

Performance analysis, training, and research are all distinct fields of sports science. These are a subset of sports science concerned with enhancing an athlete's ability to compete at a high level (Donoghue, 2010). Performance analysis studies are useful in predicting real performance prior to the main competition. Although it is generally recognised that actual performance can only be achieved during the main competition (Chahal, Ghildyal, & Chahal, 2012), the degree of performance of athletes may be evaluated prior to competition. Athletes' reactions to competition may be seen on the surface by looking at their technique, physiological responses, and behaviour patterns (Pahan & Singh, 2021). The way an athlete sees his or her surroundings has an impact on his or her reactions. Raglin (2001) argues that changes in the cognitive process are the most essential aspect that influences athletes' reactions to competition. As a result, it's crucial to look into information processing in the context of sports psychology's cognitive domain.

The most prevalent item that people notice and occasionally ignore is an athlete's behaviour. The demands of training and competition are not the same. Every competition produces stress in the competitors, so being successful in managing that stress is vital (Hanton, et. al., 2005; Kristiansen & Roberts, 2010).

The ability to function and react under stressful conditions has a significant impact on sporting performance (Jones, et. al., 2007; Craft, et. al., 2003; Anshel, et. al., 2002). The most important factor in sporting success is not the athlete's skill, but their ability to perform the skill under stressful conditions (Patmore, 1986). Stress places additional demands on athletes that can tax their resources to cope and respond during various competitive situations (Sheldon, et. al., 2009). Attentional concentration (Krohne & Hindel, 1988), motor coordination (Anshel, et. al., 2001), and decision-making ability are all sport-related characteristics that have been demonstrated to be influenced by stress.

While the majority of Indian literature on athletes' researchers has focused on investigating areas such as stress and sports performance (Singh, 2017), stress level of athletes and non-athletes (Singh & Pardhi, 2021), anxiety level and gender differences (Parveen, 2013), anxiety in college athletes (Assefa, 2014), anxiety in archers (Malik & Singh, 2015), burnout and competition anxiety (Bawa, 2010), and coping strategy (Acharya, 2017). Only a few studies related to reactive stress tolerance have been conducted in India (Pahan & Singh, 2021; Abhaydev, Bhukar, & Thapa, 2020). The potential of a person to respond immediately and correctly in a scenario when he or she is overstretched is known as reactive stress tolerance (Schuhfried, 2016). The construct looks at how well someone can stay focused and respond correctly when they're in a stressful situation.

In the domain of sport, there is a lack of research pertaining to the factors that might impact reactive stress tolerance in athletes. In accordance with past studies other than sports on family background, a few factors can be potentially related to cognitive functions. Place of residence and cognitive function (Xu, et. al, 2018), family type, family size, rural-urban background, and cognitive impairment (Sengupta, et. al, 2014), home situation and cognitive ability (Kaushal & Singh, 2021), birth size and cognitive function (Chandrashekarappa, et al., 2020), and poverty and cognitive function (Mani, et. al, 2013). Several studies have been conducted on socioeconomic status, environmental factors, and individual factors on sports participation (Kamphuis, et. al, 2008) (Verma & Verma, 2016). However, very few studies were conducted on socioeconomic status and psychological measures in sports.

The family structure, including family size, family type, birth order, family income, and house location, has not been studied in the Indian population. Therefore, the current study aims to compare the level of reactive stress tolerance with different family structures. The study will give us a better idea of how certain aspects of family structure and one of the sports-related cognitive abilities (reactive stress tolerance) work on. This may help us to find and develop sporting talents.

The current *study aims* to measure the performance of reactive stress tolerance and investigate whether living in a new environment for at least two years reduces the athletes' early life experience related to family demography.

Materials and Methods

Study Participants

Selection of Samples: 200 male subjects aged 11–14 years were selected from Jharkhand State Sports Promotion Society, Ranchi. Samples having 4 years of training, 2 years of living experience in academy and average performance on quarterly physical assessments were selected by simple random sampling.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Lakshmibai National Institute of Physical Education.

Study Organization

Variables and Test Selection: As dependent variables, the determination test (DT) form S1 was used to measure percentile ranks (PR) like PR correct, PR incorrect, PR omitted, and median reaction time. Family information was selected as an independent variable which consists of demographic information e.g. family size (small ≤ 5, large > 5), family type (nuclear = single parent family, joint = more than one parent) the order of birth, monthly income of the family as determined by the SES Scale (Wani, 2019), and the location of the house (urban, semi-urban, and rural).

Selection of Instrument and Scoring: Reactive stress tolerance was administered by a computerised testing system (the Vienna Test System by Schuhfried GmbH). For scoring percentile ranks, the correct, incorrect, omitted, and median reaction times as well as the median reaction time were chosen.

Informed Consent: The subjects were minors, therefore informed consent were taken from the administration, coach, and athlete in-charge of the academy. Subjects were briefed about the study and their consents were also taken.

Test Procedure: The test was administered between 9 a.m. and 5 p.m. Subjects were well informed about the date and time of their test. Before the start of the test, the programme offered a practise set. Once the subject acknowledged the practise test, the real tests were conducted. Introspective reports were gathered at the end of the test.

Statistical Analysis

The Shapiro-Wilk test was employed to ensure the normality of the data. Mann-Whitney U test was employed to compare two group variables, e.g. size of family and type of family. For comparing differences between three or more grouping variables, the Kruskal-Wallis test was employed. Dunn's Post-Hoc analysis was done for the variables showing the main difference in the Kruskal-Wallis test. As the sample sizes were unequal, so Holm's post-hoc correction was used for testing the significance at $p < 0.05$ level.

Results

For the purpose of analysing the data, the scores of reactive stress tolerance were arranged according to the parameters of family demographic information shown in Table 1. The normality of the data was checked where the output of Shapiro-Wilk confirmed that, independent variable order of birth with the dependent variable percentile rank of correct response and median reaction time were the only variables that demonstrated the normal distribution. After conducting Levene's test, it was observed that in a few categories of birth order, between both median reaction

Table 1. Family Information, Sample Distribution and Descriptive Statistics of Scores under Reactive Stress Tolerance

Family		PR Correct			PR Incorrect		PR Omitted		Median Reaction Time	
		N	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Size	Small	67	20	11	20	28	8	9	0.84	0.10
	Large	133	20	21	20	40	11	14	0.84	0.14
Type	Joint	54	18.5	17	22	38	11.5	14	0.86	0.12
	Nuclear	146	21	12.75	17	35	10	13.25	0.84	0.12
Birth Order	1st	52	21.5	16.25	18	37	11	11.75	0.85	0.09
	2nd	54	23	9	15	20.25	9	13.25	0.83	0.11
	3rd	47	13	14	24	42.5	9	16	0.88	0.14
	4th	29	22	19	15	26	13	16	0.83	0.15
	5th	11	21	14.5	17	14	8	12.5	0.83	0.09
	6th	7	13	9	37	30.5	11	5.5	0.94	0.12
Monthly Income	2641-7886	158	21	16.75	20	35	11	14	0.84	0.11
	7887-13160	23	20	10.5	13	26.5	8	8	0.85	0.13
	13161-19758	9	22	31	13	38	8	10	0.83	0.13
	19759-26354	7	17	11.5	15	26.5	8	6.5	0.85	0.10
	26355-52733	3	19	13.5	71	9	7	2.5	0.89	0.13
Location	Rural	53	23	18	16	28	9	14	0.82	0.10
	Semi-Urban	134	19	12.75	22	36	11	14	0.85	0.14
	Urban	13	18	10	13	10	8	5	0.88	0.15

time and percentile rank of correct response, the data were homogenous. Therefore, non-parametric tests were utilized for comparison.

Table 1, the descriptive statistics, e.g., sample distribution in each section of family demography, their mean ranks and interquartile ranks (IQR) associated with parameters of reactive stress tolerance and family demography are displayed in Table 1. The box-plots in Figure 1 to 5 illustrate the distribution of scores on each parameter of reactive stress tolerance and family information. Information on gender was not measured.

Table 2 shows the output table of comparative statistics. To compare categorical variables, e.g., size of family and type of family, the Mann-Whitney U test were applied. The results show mean ranks, Mann-Whitney U statistics (^), and p-values. For other categorical variables, e.g., order of birth, family monthly income, and location of house, the Kruskal-Wallis tests were applied to find a difference in scores of

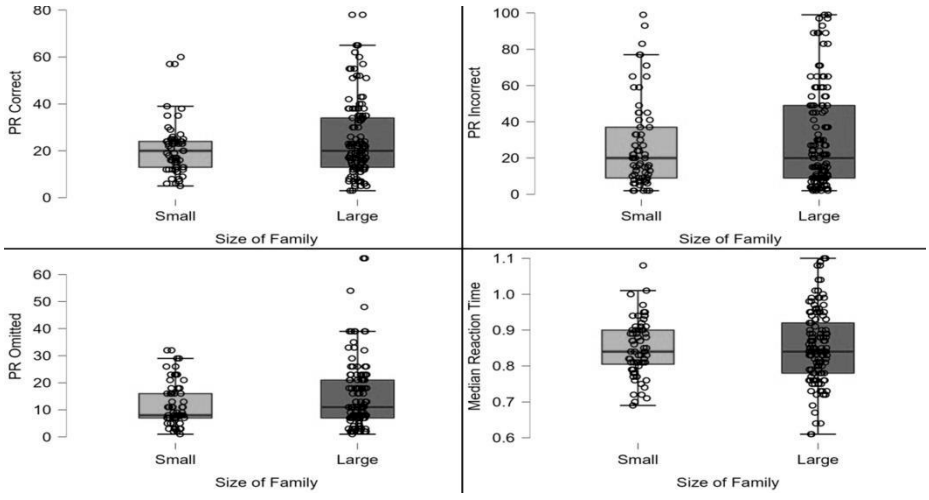

Fig. 1. Data Distribution of Reactive Stress Tolerance by Size of Family

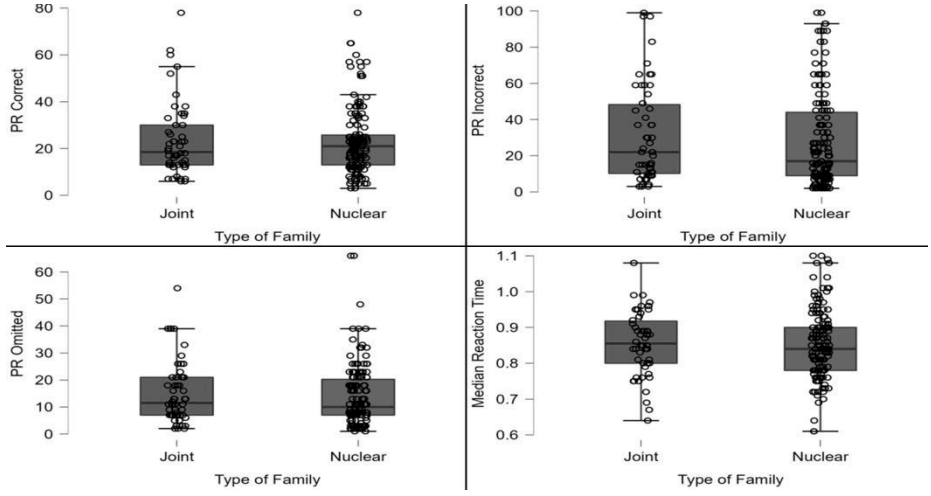

Fig. 2. Data Distribution of Reactive Stress Tolerance by Type of Family

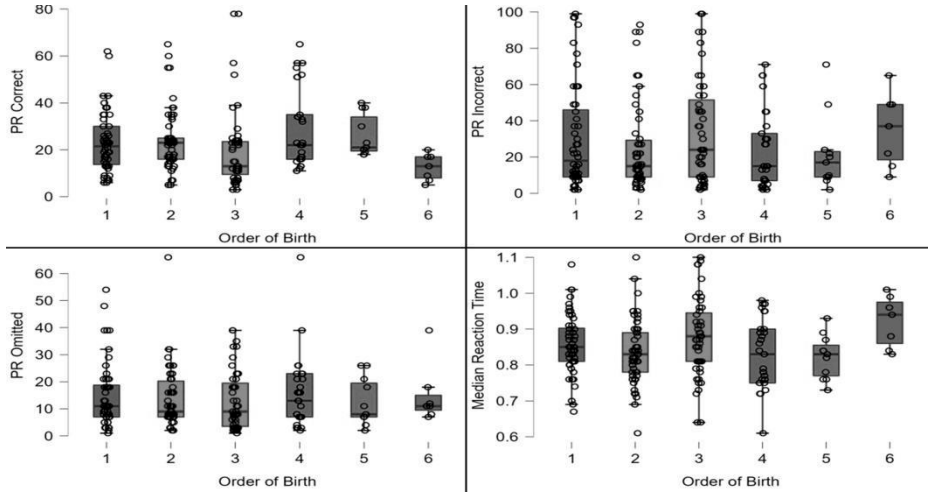

Fig. 3. Data Distribution of Reactive Stress Tolerance by Order of Birth

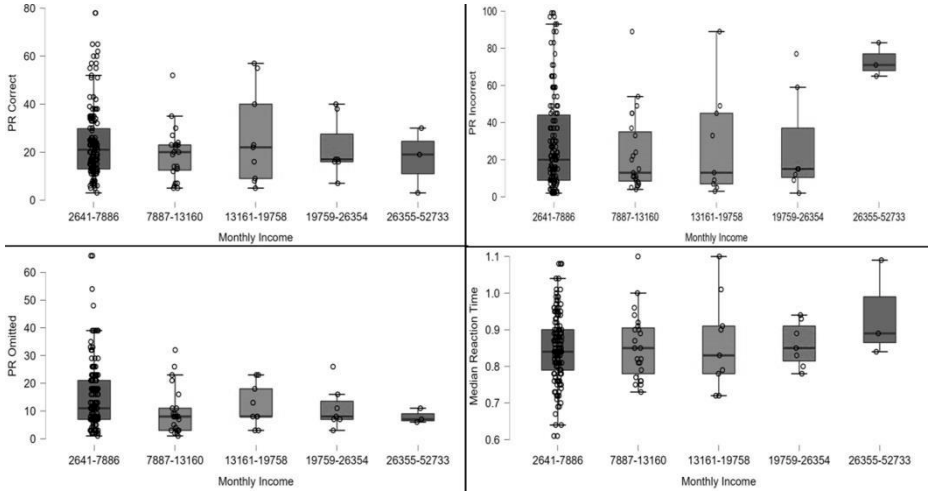

Fig. 4. Data Distribution of Reactive Stress Tolerance by Monthly Income

Table 2. Comparative Statistics of Variables under Reactive Stress Tolerance with Different Family Information

			PR Correct			PR Incorrect			PR Omitted			Median Reaction Time		
Family		**N**	**MR**	**Statistics**	**p**	**MR**	**Statistics**	**p**	**MR**	**Statistics**	**p**	**MR**	**Statistics**	**p**
Size	Small	67	96.68	4199.5^	0.507	99.78	4407.5^	0.901	90.34	3774.5^	0.077	99.25	4372^	0.829
	Large	133	102.42			100.86			105.62			101.13		
Type	Joint	54	100.85	3923^	0.958	108.1	3531.5^	0.258	106.29	3629.5^	0.388	105.72	3660^	0.437
	Nuclear	146	100.37			97.69			98.36			98.57		
Birth Order	1st	52	104.67	16.957†	0.005**	102.8	5.202†	0.392	104.22	1.632†	0.897	104.5	12.104†	0.033*
	2nd	54	108.06			94.08			100.44			89.61		
	3rd	47	79.17			110.96			93			114.78		
	4th	29	116.5			89.29			105.83			87.22		
	5th	11	124.5			89.41			94.32			80.45		
	6th	7	50.43			126.57			111.36			145.43		
Monthly Income	2641-7886	158	103.13	2.095†	0.718	100.97	6.903†	0.141	105.91	7.736†	0.102	99.63	1.735†	0.784
	7887-13160	23	86.17			91.17			74.54			99.61		
	13161-19758	9	101.33			93.56			94.89			99.11		
	19759-26354	7	94.79			94.29			86.29			106.71		
	26355-52733	3	82.67			182.83			64.33			142.83		
Location	Rural	53	112.57	3.799†	0.15	97.31	0.857†	0.651	99.73	0.777†	0.678	89.65	2.583†	0.275
	Semi-Urban	134	97.35			102.84			102.07			104.1		
	Urban	13	83.73			89.42			87.42			107.65		

MR: Mean Rank, ^Mann-Whitney U Statistics, †Chi-square: Kruskal-Wallis, *Significant at 0.05, **Significant at 0.01

reactive stress tolerance. The information in Table 2 contains mean ranks, chi-square value (†), and p-value from the Kruskal–Wallis tests on these variables.

Kruskal-Wallis H test showed that there were statistically significant difference in percentile rank of correct response χ^2 (5) = 16.957, p = <0.01, and median reaction time χ^2 (5) = 1.632, p = 0.033, between the orders of birth Table 2, and Figure 3.

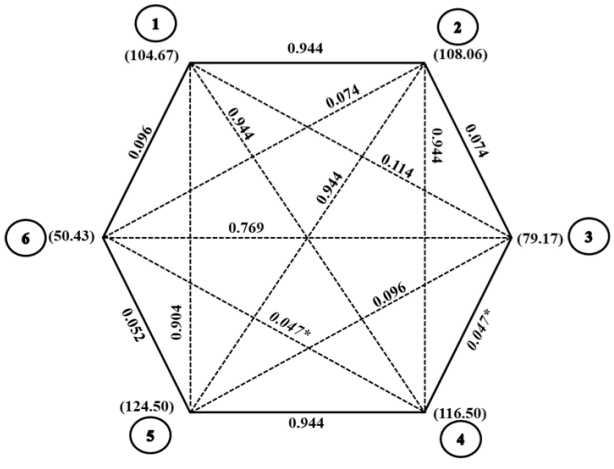

Fig. 6. Dunn's Post-Hoc Analysis between Percentile Rank of Correct Response and Orders of Birth

Figure 6 depicts the post-hoc comparison of the percentile rank of correct response and birth orders. Statistical significance was found between two groups, group 1; 3rd and 4th child, p = 0.047, and group 2; 4th and 6th child, p = 0.047.

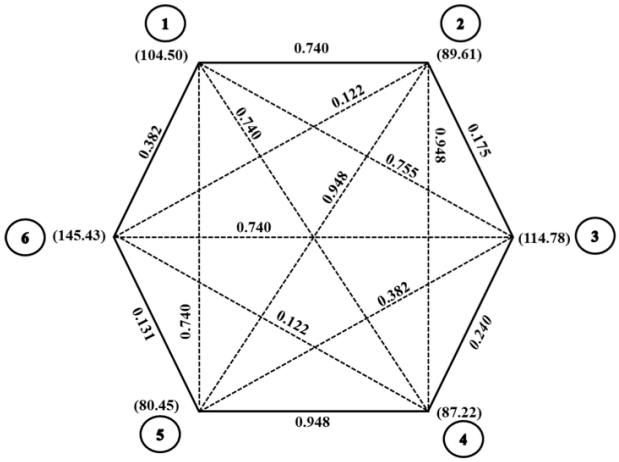

Fig. 7. Dunn's Post-Hoc Analysis between Median Reaction Time and Orders of Birth

Figure 7 depicts the post-hoc comparison of the median reaction time and birth orders. Though the Kruskal-Wallis test showed a significant difference but, no statistical significance was observed in the result of Dunn's post-hoc analysis.

Discussion

As it is well known that athletes resides in academies for several years to train and achieve their optimal performance, the current study lays stress to find out whether living in sports academy for the minimum of two years reduces the effect of family demography such as family size, family type, birth order,

family monthly income and house location. Reactive stress tolerance, one of the dimensions of cognitive ability required in sports was tested to understand the research problem. The subjects lived in same academy and had similar training experience for the minimum of two years were selected for the study. Food style, living style, daily schedule, e.g., sleep-wake, academic and training time were similar for all participants.

Starting with the visual presentation of data on Figure 1 to 5, all data in each factor of family information related to parameters of reactive stress tolerance were widely distributed and found to be non-normal, with the exception of percentile rank of correct response and median reaction time related to birth order. The two parameters relating to birth order were found to be normally distributed yet homogenous in character. The age group chosen for the research, 11-14 years, is assumed to be the reason of non-normal findings. According to the previous findings, different psychological, physical, and physiological changes occur throughout this age (IGNOU, 2010; Allen & Waterman, 2019). Some children's growth begins early or late, while others develop in a predictable way according to their age (Thompson, 2009). The living experience at the academy and the hours when the tests conducted are two further aspects that may be identified. Cadets aged 11 had two years of living experience, while those aged 12, 13, and 14 had three, four, and five years of living experience, respectively. Findings of relevant literature also indicate that an individual's cognitive and physical performance is influenced by time of day, time of test, and their circadian rhythm (Facer-Childs, et. al, 2018).

Adaptation to New Environment

In connection to measures of reactive stress tolerance, such as percentile rank of incorrect response and omitted stimuli related to birth order, components of family information, such as size, type, monthly income, and location, were shown to be non-significant in Table 2. It is possible to infer that when a sportsperson is exposed to a new environment for a lengthy period of time, their early life experience linked to the specified reactive stress tolerance decreases.

Effect Still Continued

Table 2 shows that birth order is associated with two metrics of reactive stress tolerance: percentile rank of correct response and median reaction time, both of which were determined to be statistically significant. It may be inferred that the birth order has an impact on one's capacity to make accurate decisions and react quickly in a stressful scenario. The influence of birth order was not lessened by spending at least two years in a different setting. A detailed examination of the results of the post-hoc analysis is essential for reaching this conclusion. Figure 6 shows the post-hoc pairwise comparison of birth order and percentile rank of correct responses, which indicates two pairs of significant differences: 1) fourth and third order, and 2) fourth and sixth order. Figure 7 shows no significant differences in birth order and median response time after a post-hoc pairwise comparison. Figure 7 shows that the fifth kid has the greatest mean rank, followed by the fourth, second, first, third, and fifth. In general, children of one or two-child family size have strong cognitive capacity (Polit, 1982; Dandes & Dow, 1969), and when the birth order rises, cognitive ability reduces (Blake, 1981). The individuals' living experience at the academy, developmental age, and age-truncation may have contributed to the catastrophic finding. The participants who were 11 years old had less training experience than the individuals who were 14 years old. In the sports sector, age truncation is a serious concern that may have affected the result. It's also possible that the findings are correct, but that the child's development must be investigated in order to arrive at a meaningful conclusion.

Conclusion

On the basis of the current study, it can be inferred that the ability to quickly and appropriately react to ever changing stimuli in sporting events is affected by the birth order of an individual. Because psychological characteristics can distinguish between high and low performers who meet the same physical and physiological standards, personnel from talent identification and development programmes may consider cognitive ability tests to identify long-term athletes. For better understanding, samples from a particular age group that have similar background information may be chosen for the study.

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Conflict of Interest

The author declares that there is no conflict of interest.

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ВПЛИВ НОВОГО ЖИТТЄВОГО СЕРЕДОВИЩА НА СТІЙКІСТЬ ДО РЕАКТИВНОГО СТРЕСУ В ПІДЛІТКІВ-ВИХОВАНЦІВ СПОРТИВНИХ ШКІЛ У ШТАТІ ДЖХАРКХАНД (ІНДІЯ)

Манохар Кумар Пахан[1,2ABCD], Вікрант Малхан[3ABD], Єндрембам Неполеон[4AD]

[1]Національний інститут фізичного виховання імені Лакшмі Бай
[2]Місія Рамакрішна Вівекананда Навчально-дослідний інститут
[3]Університет імені Саї Ната
[4]Прекрасний професійний університет

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

Реферат. Стаття: 8 с., 2 табл., 7 рис., 38 джерел.

Мета дослідження. Метою дослідження було вивчення впливу попереднього досвіду, пов'язаного із сімейною демографією, на вибрані параметри стійкості до реактивного стресу у спортсменів, які суто жили в спортивній академії протягом мінімум двох років.

Матеріали та методи. Для участі в дослідженні Товариством сприяння спорту штату Джхаркханд у місті Ранчі (Індія) були відібрані загалом 200 спортсменів-курсантів чоловічої статі хронологічним віком від 11 до 14 років із досвідом тренувань 4 роки. Демографічну інформацію (кількість членів сім'ї, тип сім'ї, порядок народження, місячний дохід сім'ї та місце розташування житла) розглядали як незалежні змінні. Параметри стійкості до стресу (процентильний ранг правильних реакцій, неправильних реакцій, пропущених реакцій і середнього часу реакції) були обрані як залежні змінні. Для визначення нормальності розподілу даних використовували критерій Шапіро-Уілка, а для визначення однорідності дисперсій – критерій Левена. Для порівнянь використовували U-критерій Манна-Уітні та критерій Краскела-Уолліса. Для апостеріорних порівнянь застосовували критерій Данна з поправкою Холма. Поріг значущості був заданий на рівні p = 0,05.

Результати. Процентильний ранг правильних реакцій (p = 0,005) і середній час реакції (p = 0,033), пов'язані з порядками народження, показали статистично значущі результати. Інші фактори, пов'язані з інформацією про сім'ю та стійкістю до реактивного стресу, не були статистично значущими.

Висновки. Відповідно до результатів дослідження було зроблено висновок, що перебування в новому середовищі протягом тривалого часу скорочувало ранній життєвий досвід, пов'язаний із сімейною демографією, але вплив порядку народження все-таки зберігався.

Ключові слова: стійкість до реактивного стресу, тип сім'ї, кількість членів сім'ї, порядок народження, місячний дохід сім'ї, місце розташування житла, спортсмен передпідліткового віку, штат Джхаркханд (Індія).

Information about the authors:

Pahan, Manohar Kumar: contrapahan@gmail.com; https://orcid.org/0000-0003-2087-5456; Department of Sport Psychology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India &

Assistant Professor, Department of Sports Science and Yoga, Ramakrishna Mission Vivekananda Educational and Research Institute, Belur Math, Howrah, 711202, India.

Malhan, Vikrant: vikrantmalhan@gmail.com; https://orcid.org/0000-0002-8953-4740; Department of Management, Sai Nath University, Chandway, Kuchu Road, Jirabar, Ormanjhi, Jharkhand 835219, India.

Nepoleon, Yendrembam: nepoyeng1559@gmail.com; https://orcid.org/0000-0002-9919-8429; School of Physical Education, Lovely Professional University, Jalandhar - Delhi, Grand Trunk Rd, Phagwara, Punjab 144001, India.

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ORIGINAL SCIENTIFIC ARTICLE

THE INJURY INCIDENCE AND TREATMENT EXPERIENCE AMONG ELITE AND BEGINNER THAILAND BODYBUILDERS

Potchara Chinnasee[1ABCDE], Thanatpong Sukwong[1ABCDE], Pranee Liamputtong[2ABCDE], Dusanee Suwankong[3ADE], Nur Ikhwan Mohamad[4ADE] and Ali Md Nadzalan[4ADE]

[1]Chandrakasem Rajabhat University
[2]VinUniversity
[3]Thaksin University
[4]Universiti Pendidikan Sultan Idris

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

Corresponding Author: Dusanee Suwankhong, email: dusanee.s@tsu.ac.th
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Abstract

Background. Bodybuilding is a sport where a person should do a lot of weight training while in the same time having a strict diet control. Due to this, they are believed to have higher chances of getting injured. However, lack of research has been conducted on the incidence of injuries and the treatment history among bodybuilders in Thailand. Therefore, the purpose of this study was to investigate and compare the incidence of injuries and treatment experience between elite and beginner Thailand bodybuilders.

Material and methods. 157 bodybuilders who were registered as members of the Thailand Bodybuilding and Physique Sports Association (since 2020-2021) were recruited as participants in this study. They were divided in to two groups, namely elite (more than 5 years of sports training) and beginner (less than 5 years of sports training). A valid and reliable questionnaire was used to collect the data from the participants.

Results. There was no significant difference in the most common period of injury between the beginner and elite groups. The most common period of injury for both groups was found to be during diet period (beginner 55.43%; elite 55.38%) followed by bulk period, off season and competition period, respectively. For the injury area, there was no difference between the groups, with the lower back (beginner 63.04%; elite 52.31%) being the most common area of injury, followed by shoulder, chest, finger and wrist. There was also no significant difference in treatment between the groups in the first 48 hours after injury. Most of the athletes in both groups had rest (beginner 80.43%; elite 81.53%) and applied cold (beginner 61.96%; elite 73.85%) to their injury area. Additionally, the beginner group of Thai bodybuilders visited the physical therapist more often than the elite group did ($p < 0.01$). At the same time, there was no significant difference in medical doctor, sports scientist, coach and self-treatment and rehabilitation between both groups. However, most of athletes from both groups mainly resorted to self-treatment.

Conclusions. The study findings are expected to be valuable for the bodybuilding association, coaches and athletes to take extra precautions regarding injury in the future.

Keywords: bodybuilder, injury, treatment, athlete status, rehabilitation.

Introduction

Bodybuilding is a sport that relies on resistance training especially weight training with appropriate diet control for building muscles and burning fat. Bodybuilders must follow their strict training and nutrition orders in order to make sure they can achieve the best physical condition during competition. In all around the world, including Thailand specifically, there are competitions at different levels around the world every year. In addition to training for competitions, there are also quite a few practicing for recreation and health so bodybuilders were at risk for various injuries from training programme (Lewis, Purushotham, & Power, 2005). Athletes who train with high levels of resistance were at risk for both acute and chronic injuries during training and competition. These includes injuries to the lower back, shoulders, upper

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arms, knees, with up to 38 per cent of the muscles and 23 per cent of the ligaments involved (Winwood, Hume, Cronin, & Keogh, 2014). In addition, the risk factors and incidence of injury in athletes undergoing high-intensity training were also studied. The risk was reported to occur up to 7.1 times per person per 1,000 hours of training, and experienced athletes were 3.77 times more likely to injure than novices, with most occur in the shoulder and lumbar region (Teixeira et al., 2020).

Bodybuilding is a sport that requires resistance training to increase muscle mass and decrease fat mass to generate muscle definition. There was research report that elite bodybuilders had larger muscle group and lesser fat mass when compare to novice group (Sukwong et al., 2022). The bodybuilding athletes from clubs in Germany got injury from training at the shoulder, elbow, lumbar and knee (Siewe et al., 2014). Injury from resistance training caused by an intrinsic factor from the muscle contraction mechanism to develop acute muscle, tendon, and ligament damage. However, it can lead to chronic injuries when not treated properly and eventually bring to problems for training program and daily life (Lavallee & Balam, 2010). There have been reports that injured bodybuilders take self-treatment more than any other method (Winwood et al., 2014) but self-treatment must be carried out properly according to the principles of sports medicine in order to recover from re-injuries or chronic injuries lead to future medical expenses. However, self-treatment methods have not been reported.

Despite being a popular sport across many levels, lack of research has been conducted especially among Thailand bodybuilders. The incidence of injury in bodybuilders and the treatment history will be crucial information that can be used by bodybuilding associations, officials, coaches and athletes to take more extra precautions in the future. The purpose of this study were to investigate and compare the incidence in injuries and treatment between elite and beginner Thailand bodybuilders.

Materials and Methods

Study Participants

The population of this study was 257 bodybuilders who were registered as members of the Thailand Bodybuilding and Physique Sports Association (from 2020-2021). We recruited 157 individuals who had the competition organized by the association during February 2021 – February 2022 by volunteer sampling. This sample size was used as a calculation method for prevalence study provided by Naing et al. (2006) which a precision of 0.05 and bodybuilding injury rate data from previous study (Keogh & Winwood, 2017). The participants were divided into elite (over 5 years of bodybuilding experience) and beginner groups (less than 5 year for bodybuilding experience) (Sukwong et al., 2022). All participants read and signed inform consent that approved by Institutional Review Board (No. 030/2564).

Instrument and Data Collection

The questionnaire was conducted to collect the data. It was developed by the researcher and adapted from previous studied (Siewe et al., 2014) to determine the injury incidence and treatment experience. Content validity of questionnaire was examined by 5 sports medicine experts (IOC = 0.68) and reliability was examined by Cronbach's alpha coefficient (a = 0.73) from the results of 60 bodybuilders who were registered as members of the Thailand Bodybuilding and Physique Sports Association but did not participate in the competition that organized by the association during February 2021 February 2022. The researchers asked for the permission from Thailand Bodybuilding and Physique Sports Association to perform the data collection.

Statistical Analysis

Descriptive (Frequency, percentage, mean and standard deviation) and Inferential (Chi-square test at statistical significance at 0.05) statistics were used for analyzing the data. All the data analysis was conducted using Statistical Package for Social Science (SPSS) version 23.

Result

Table 1 showed the characteristics of 157 Thai bodybuilders which were divided into beginner group (92 subjects) and elite group (65 subjects).

Table 1. Characteristics of Thai bodybuilders

Characteristics	Beginners (n = 92)		Elite (n = 65)	
	mean	SD	mean	SD
Age (Years)	24.36	4.53	28.06	5.77
Weight (kg)	76.20	10.80	77.48	9.95
Height (cm)	172.47	5.03	170.38	6.95
BMI (kg/m^2)	25.55	3.11	26.63	2.67
Experience (Years)	3.04	0.98	5.93	2.87

Table 2. The comparison of injury incidence between elite and beginner Thailand bodybuilders

Incidence	Beginners (n = 92)	Elite (n = 65)	χ^2	p
	Frequency (%)	Frequency (%)		
The most period of injury				
Bulk period	23 (25.00)	17 (26.15)	0.28	0.96
Diet period	51 (55.43)	36 (55.38)		
Competition period	6 (6.52)	3 (4.62)		
Off season	12 (13.04)	9 (13.85)		
Injury site				
Shoulder	24 (26.09)	23 (35.38)	2.83	0.41
Finger and wrist	6 (6.52)	3 (4.62)		
Lower back	58 (63.04)	34 (52.31)		
Chest	4 (4.35)	5 (7.69)		
Body structure of injury				
Bone	2 (1.27)	3 (4.62)	4.36	0.35
Muscle	38 (41.30)	23 (35.38)		
Ligament/Tendon	41 (44.57)	34 (52.31)		
Joint	4 (4.35)	0 (0)		
Others	7 (7.61)	5 (7.69)		
Current symptoms				
Recovered	59 (64.13)	38 (58.46)	0.51	0.47
Injured	33 (35.87)	27 (41.54)		

Table 3. The comparison of treatment between elite and beginner Thailand bodybuilders

Treatment	Beginner (n= 92)	Elite (n=65)	χ^2	p
	Frequency (%)	Frequency (%)		
The first 48 hours after injury				
Rest				
Yes	74 (80.43)	53 (81.53)	0.03	0.86
No	18 (19.57)	12 (18.46)		
Cold				
Yes	57 (61.96)	48 (73.85)	2.43	0.11
No	35 (38.04)	17 (26.15)		
Massage				
Yes	12 (13.04)	15 (73.85)	2.69	0.10
No	80 (86.96)	50 (26.15)		
Medication				
Yes	4 (4.35)	3 (4.62)	0.006	0.93
No	88 (95.65)	62 (95.38)		
No treatment				
Yes	22 (23.91)	11 (16.92)	1.12	0.28
No	70 (76.09)	54 (83.08)		
See the medical doctor/ Physical therapist				
Yes	26 (28.26)	26 (40.00)	2.36	0.12
No	66 (71.74)	39 (60.00)		
Surgery				
Yes	0 (0)	0	-	-
No	92 (100)	65 (100)		
After 48 hours of treatment				
HEAT technique				
Yes	41 (44.57)	26 (40.00)	0.32	0.56
No	51 (55.43)	39 (60.00)		
Massage technique				
Yes	64 (69.57)	44 (67.69)	0.06	0.80
No	28 (30.43)	21 (32.31)		
Medication				
Yes	39 (42.39)	25 (38.46)	0.24	0.62
No	53 (64.13)	40 (61.54)		
Others technique				
Yes	16 (17.39)	10 (15.38)	0.11	0.73
No	76 (82.61)	55 (84.62)		

Using Chi-squared test. *Significant difference (p<0.01)

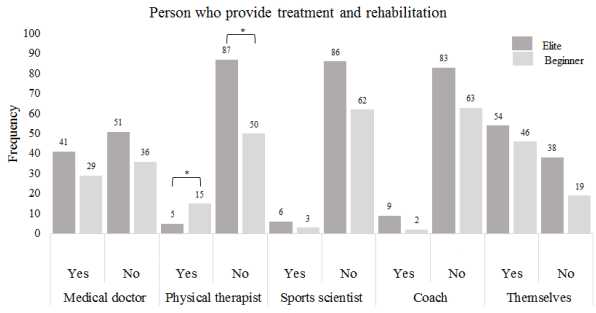

Fig. 1. Person who provide treatment and rehabilitation

Table 2 showed the comparison of injury incidence between elite and beginner Thailand bodybuilders. There was no significant difference of the most period of injury between beginner and elite group. We found that the most period of injury from both group was diet period (beginner 55.43%; elite 55.38%) followed by bulk period, off season and competition period respectively. Like the injury site, there was no difference between groups, with the lower back (beginner 63.04%; elite 52.31%) being the most common site of injury, followed by shoulder, chest, finger and wrist. While, ligament/tendon was the most commonly injured body structure in both group (beginner 44.57%; elite 52.31%), followed by muscle, bone, joint and others (skin). Most of them could recovered from their injuries (beginner 64.13%; elite 58.46%), but some remain.

Table 3 showed the comparison of treatment between elite and beginner Thailand bodybuilders. There was no significant difference between groups in the first 48 hours after injury for treatment. Most of the athletes in both groups get rest (beginner 80.43%; elite 81.53%) and used cold (beginner 61.96%; elite 73.85%) on their injury site. A small percentage of both groups were found to use massage, take pills, see the medical doctor or physical therapist after injury. We also found that all of them never get surgery when they injured. After 48 hours of treatment, they mainly used massage techniques (beginner 69.57%; elite 67.69%). Some of them use HEAT technique, medication, and others technique (PT and Thai traditional medicine) respectively.

The results from figure 1 showed the person who provide treatment and rehabilitation after injury. We found that beginner Thailand bodybuilders met the physical therapist more than elite athletes group (p<0.01). While most of the elite Thailand bodybuilders did not meet a physical therapist when compared to a beginner group (p<0.01). At the same time, medical doctor, sports scientist, coach and themselves treatment and rehabilitation were not significant difference between both groups however, most of athletes from both group mainly took self-treatment.

Discussion

This study aims to investigate and compare the incidence of injuries and treatment between elite and beginner Thailand bodybuilders. The findings showed diet period followed by bulk period were frequently found to be injured in both groups. This is the period that requires resistance training at different levels of intensity and others training such as cardiovascular training (Helms, Fitschen, Aragon, Cronin, & Schoenfeld, 2014), but the diet may affect the energy system used in the muscle contraction during training that effect mechanism of micro-tears and generated in the muscle fibers as protein synthesis, repairs, and rebuilds result in muscles return larger and stronger.

For the injury sites, it was found that lower back injury occur most frequently followed by shoulder. The selection of exercises and its biomechanics might be the reason for these, as most exercises will involve the activation of these parts (Fares et al., 2020; Mostaham & Salehia, 2019). Besides that, muscle, ligament and tendon are the most common structure of injuries. This is in line with what was found by Keogh and Winwood (2017) with reported that strain, tendinitis and sprains were the most common injury in bodybuilders. Our finding also similar to previous study

which report that muscle, ligament, and tendon were injured frequently (Xiaojun & Taotao, 2008; Xie, 2022).

We also found that most of the injured participants did not see medical doctor and completely not severe until surgery after injury. The findings differ from those in Saudi bodybuilders who found about 6 percent of surgery after injury (Almalki et al., 2022) and most of them received treatment by physiotherapy.

For the treatment during the first 48 hours after injury, most athletes take a rest from training and apply a cold compression to the injury site. This is consistent with the application of PRICE principles (Bleakley, Glasgow, & MacAuley, 2012). In addition, most of the athletes in both groups did not have themselves massaged, did not use medication, did not see a medical doctor, and did not underwent surgery. High level of confidence to recover and did not want to spend time for these might be the reason of their action. After the first 48 hours, both groups of bodybuilders used massage techniques. However, the injury of the bodybuilder group may not be a serious injury. Therefore, it can be massaged for rehabilitation purposes.

Most of the person who provide cured were self-treatment, they did not meet doctors, physical therapists, sports scientists or even a coaches. In contrast, young Saudi bodybuilders received medication, physiotherapy and surgery (37%, 57%, and 6% respectively) (Almalki et al., 2022). We couldn't find the exact reason for this condition in previous literature, but this condition can be contributed by the costs and time that would be spent, which might cause them to chose self-treatment. Besides, there are many websites and books found on the internet regarding self-treatment that they can refer. A more critical studies need to be conducted in the future.

Conclusion

Although many of the comparison made were found not to be significantly difference, the each data in this study should be used carefully to become the reference point for the coaches and athletes. More care should be given to the diet period as most of the injuries happened at that time. Besides, selection of exercises and the exercise techniques should also be given attention on the most injury part to reduce the injury cases. Coaches and athletes should be educated on the first aid, treatment and rehabilitation methods so that it will not disturb their competition planning. Findings of this study is expected to be valuable for the bodybuilding association, coaches and athletes to take extra precautions regarding injury in the future.

Acknowledgement

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Conflict of interest

Authors declare that there are no conflict of interest exist in this study.

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РІВЕНЬ ТРАВМАТИЗМУ ТА ДОСВІД ЛІКУВАННЯ СЕРЕД ТАЇЛАНДСЬКИХ БОДІБІЛДЕРІВ ВИСОКОГО ТА ПОЧАТКОВОГО КЛАСІВ

Чіннасі Почара[1ABCDE], Суквонг Танапонг[1ABCDE], Прані Лямпуттонг[2ABCDE], Дусані Суванконг[3ADE], Нур Іхван Мохамад[4ADE], Алі Мд Надзалан[4ADE]

[1]Університет Чандракасем Раджабхат

[2]ВінУніверситет

[3]Таксінський університет

[4]Університет освіти імені Султана Ідріса

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

Реферат. Стаття: 5 с., 3 табл., 1 рис., 15 джерел.

Історія питання. Бодібілдінг – це такий вид спорту, у якому людина має багато тренуватися з обтяженнями, водночас суворо контролюючи дієту. Через це у них, як вважають, вищі шанси отримання травм. Однак досліджень щодо частоти травм та історії лікування серед бодібілдерів у Таїланді було проведено недостатньо. Таким чином, метою цього дослідження було вивчення та порівняння рівня травматизму та досвіду лікування між таїландськими бодібілдерами високого та початкового класів.

Матеріали та методи. Учасниками цього дослідження були 157 бодібілдерів, зареєстрованих членами Таїландської спортивної асоціації бодібілдингу та атлетизму (з 2020-2021 року). Їх розділили на дві групи: високого класу (понад 5 років занять спортом) і початкового класу (менше 5 років занять спортом). Для збору даних учасників використовували валідну та надійну анкету.

Результати. Статистично значущої різниці в найпоширенішому періоді травмування між групами початкового та високого рівнів не було. Встановлено, що найбільш поширеним періодом травмування для обох груп був період дієти (група початкового рівня – 55,43%; група високого рівня – 55,38%), за яким слідував період масового навантаження, міжсезоння та період змагань відповідно. Що стосується зони травми, між групами не було різниці, причому найпоширенішою зоною травми була нижня частина спини (група початкового рівня – 63,04%; група високого рівня – 52,31%), за якою йшли плече, грудна клітка, палець і зап'ястя. Також між групами не було статистично значущої різниці в лікуванні в перші 48 годин після травми. Більшість спортсменів в обох групах відпочивали (група початкового рівня – 80,43%; група високого рівня – 81,53%) і прикладали холод (група початкового рівня – 61,96%; група високого рівня – 73,85%) до зони травми. Крім того, група таїландських бодібілдерів початкового рівня частіше зверталася до фізіотерапевта, ніж група спортсменів високого класу ($p < 0,01$). Водночас, між обома групами не було статистично значущої різниці в лікарях, спортивних учених, тренерах і самолікуванні та реабілітації. Проте більшість спортсменів в обох групах переважно вдавалися до самолікування.

Висновки. Очікується, що результати цього дослідження будуть цінними для асоціації бодібілдингу, тренерів і спортсменів, щоб уживати додаткових запобіжних заходів щодо травм у майбутньому.

Ключові слова: бодібілдер, травма, лікування, стан спортсмена, реабілітація.

Information about the authors:

Chinnasee, Potchara: pchinnasee@gmail.com; https://orcid.org/0000-0002-5380-3988; Sports Science Division, Faculty of Science, Chandrakasem Rajabhat University, 39/1 Ratchadaphisek Rd, Chan Kasem, Chatuchak, Bangkok 10900, Thailand.

Sukwong, Thanatpong: thanatpongsw@gmail.com; https://orcid.org/0000-0001-5235-6824; Sports Science Division, Faculty of Science, Chandrakasem Rajabhat University, 39/1 Ratchadaphisek Rd, Chan Kasem, Chatuchak, Bangkok 10900, Thailand.

Liamputtong, Pranee: pranee.l@vinuni.edu.vn; https://orcid.org/0000-0003-0673-4497; College of Health Science, VinUniversity, Gia Lam District, Hanoi, 100000, Vietnam.

Suwankhong, Dusanee: dusanee.s@tsu.ac.th; https://orcid.org/0000-0002-9210-4282; Department of Public Health, Faculty of Health and Sports Science, Thaksin University, Chankasem, Chatuchak, Bangkok, 10900, Thailand.

Mohamad, Nur Ikhwan: nur.ikhwan@fsskj.upsi.edu.my; https://orcid.org/0000-0001-8392-8274; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, 35900, Malaysia.

Md Nadzalan, Ali: ali.nadzalan@fsskj.upsi.edu.my; https://orcid.org/0000-0002-0621-2245; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, 35900, Malaysia.

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ORIGINAL SCIENTIFIC ARTICLE

SURVEY ON LOW BACK PAIN AMONG CYCLISTS: PREVALENCE, RISK FACTORS AND KNOWLEDGE OF INJURY PREVENTION STRATEGIES

Vinosh Kumar Purushothaman[1ABCD], Wei Vvy Chen[1ABCD], Ambusam Subramaniam[2ACD], Arun Vijay Subbarayalu[3ACD], Nithiyah Maruthey[1ABCD] and Mohanraj Kandasamy[4ACD]

[1]INTI International University
[2]Universiti Tunku Abdul Rahman
[3]Imam Abdulrahman Bin Faisal University
[4]Vinayaka Missions Research Foundation

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

Corresponding Author: Vinosh Kumar Purushothaman, E-mail: vinoshmpt@yahoo.com
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Abstract

The study aimed to determine prevalence of low back pain (LBP), risk factors, and knowledge of injury prevention strategies in recreational cyclists.

Materials and methods. This cross-sectional quantitative study included 141 adult recreational cyclists aged 18 to 70. LBP prevalence was determined using a standard Nordic questionnaire. In addition, a validated self-developed questionnaire was used to assess knowledge level, with a high score representing the highest level of knowledge. Frequencies and percentages were used to report the descriptive variables, whereas the Chi-square test was used to determine the association between risk factors and LBP.

Results. The study identified that 55.3% of cyclists had a lifetime prevalence of LBP, and 35.5% reported LBP in the past 12 months. However, no significant association ($p>0.05$) was found between the risk factor and the LBP. Despite this, a low level of knowledge of injury prevention strategies for recreational cyclists was found.

Conclusions. This survey found that recreational cyclists have a low level of understanding about crucial bicycle characteristics such as seat height, saddle tilt, and handlebar position to maintain optimal body biomechanics. Recreational cyclists should be educated on the need for appropriate bicycle modifications and ergonomics, effective warm-up, stretching, and cool-down techniques, and some critical injury prevention strategies, especially in the low back.

Keywords: cyclist, low back pain, knowledge, risk factors, injury prevention.

Introduction

Cycling is one of the most popular activities worldwide due to its physical and mental health advantages (Decock et al., 2016; Oja et al., 2011). Additionally, cycling has been linked to a decreased risk of type 2 diabetes, cardiovascular disease, cancer, and obesity (Antequera-Vique et al., 2022; Nordengen et al., 2019). Cycling also offers the extra benefit of not being connected to repetitive joint impact.

Despite the fact that cycling is considered a safe and low-impact activity, a number of acute, chronic and overuse injuries have been linked to its practice (Dinu et al., 2019; Rasmussen et al., 2016). In regard to overuse injuries, low back pain (LBP) has been reported as one of the areas with a high prevalence of injuries in recent studies among recreational cyclists (11.5%) (Francois Du Toit et al., 2020), mountain bikers (23%) (Lebec et al., 2014), and road cyclists (45%) (Priego Quesada et al., 2019).

Cycling is one such activity where the cyclist's stance, with a protracted flexed posture, may have an impact on the morphology of the spine and may result in greater mechanical strain on the lumbar region, resulting in low back discomfort (Antequera-Vique et al., 2022; Marsden, 2010). Furthermore, cycling requires riders to assume postures that are deemed unnatural based on the needs of trunk flexion in order to complete a specific technical move that enhances

sports performance (Antequera-Vique et al., 2022) such as adapting the spinal curvatures on the bicycle depending on the handlebar type and position on the handlebars. Another systematic review have also reported that cycling-related prolonged lumbopelvic flexion, imbalances in the activation of the core and spinal muscles, and lower handlebar posture can all induce lower back pain in cyclists (Streisfeld et al., 2017).

The bicycle's components should be adjusted to the rider's body measurements for efficient cycling such as seat height, seat tube angle, body posture, and crank length (Bini & Hunter, 2021). The handlebars, pedals, and seat are some of the points of contact where the mechanical movements of the muscles are transferred to the bicycle while cycling (Bini & Hunter, 2021; Turpin & Watier, 2020). Certain positions adopted by the cyclist may predispose to overuse injury. Nevertheless, there is little knowledge among cyclists of the appropriate cycle ergonomics to prevent injuries (Bini & Hunter, 2021). For example, one study has reported on the lack of knowledge on the saddle position in relation to pedals based on scientific knowledge as improper position of the saddle could lead to overuse injuries (Peveler et al., 2005; Wanich et al., 2007). Besides, different handle heights result in a variety of riding postures that may alter the cervical and lumbar curves (Chen & He, 2012). Thus, cyclists should be made aware of the importance of proper cycle ergonomics to prevent overuse injuries in the long term and improve overall fitness and performance during the activity.

Several studies were conducted on cyclists to identify the incidence of injury, factors affecting performance, and modifications in the components of the cycle. LBP is one of the factors causing cyclists to stop participating in the sport, which hinders them from gaining the benefits of cycling (François du Toit et al., 2020). However, there is a dearth of studies examining the prevalence of LBP and the level of knowledge of its preventative strategies among Malaysian recreational cyclists. Hence, this study aimed to determine the prevalence, association between risk factors, and knowledge level among recreational cyclists in Malaysia.

Materials and methods

Study participants

This study was a cross-sectional study conducted among 141 recreational cyclists in various cycling clubs in the Klang Valley, Malaysia. The study included participants ranging in age from 18 to 70 years old and of both genders. Participants who do not understand the English language, competitive cyclists, and bicycle commuters were excluded from the study. Prior to the study, ethical approval was obtained from INTI International University Ethics and Research committee with reference number: INTI/UEC/2021/001. Considering the population size of recreational cyclists in various running clubs in the Klang Valley, confidence level (95%), and acceptable margin of error (5%), a sample size of 200 recreational runners was selected using simple random sampling methods. Of the 200 questionnaires administered, 141 completed questionnaires were returned, demonstrating a 70% response rate. Participants were informed of the study objective, the confidentiality of their data, and their anonymity in the research. They were then required to sign an informed consent form before proceeding with the questionnaire. All participation in this research was completely voluntary, and the participants were allowed to withdraw from the research at any time without giving a reason.

Study organization

This study designed a self-structured questionnaire concerning recreational cyclists. It has four sections: i) Demographic information on recreational cyclists, ii) Risk factors for LBP among recreational cyclists, iii) Knowledge about low back pain preventive strategies adopted by the cyclists, and iv) Prevalence of LBP. Specifically, all items of the prevalence of the LBP section were retrieved by adopting the modified Nordic questionnaire. The content validity of the self-developed questionnaire has been assessed using professional judgment by experts in physiotherapy and rehabilitation. Since all recreational riders were members of various cycling groups, the data were collected using "Google forms."

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 28.0.0 was used to conduct the statistical analysis. Knowledge of LBP strategies was analysed using multiple-choice questions with one or multiple correct answers for each question. Descriptive analysis was used to evaluate demographic data and the level of knowledge of LBP prevention strategies, represented in frequency and percentage. The chi-square test was used to interpret the association between risk factors and LBP.

Results

141 respondents took part in the current survey. Table 1 provided information about the respondents demographic details.

The analysis of low back pain revealed that 55.3% of cyclists had developed back pain. Furthermore, 35.5% of people reported low back pain in the previous 12 months, and 14.2% reported it in the previous 7 days.

Table 3 shows the association between risk factors and LBP. Although, high frequencies were seen in lack of warm up and cool down, no association were found between the variables.

The study's findings addressed the cyclists' knowledge about the LBP prevention strategies and the correctness of responses to the knowledge-related variable, as shown in Table 4. Specifically, the respondents' knowledge of saddle and tilt angle was only 14.9% and 3.54%, respectively. However, 80.14% of respondents were more knowledgeable about exercise to reduce LBP. In addition, nearly half (48.93%) of them correctly recognized the perfect handlebar position to reduce LBP, and only 19.14% knew the optimal riding distance for a cyclist to prevent the incidence of LBP, as shown in Table 4.

Further exploration was carried out to ascertain whether the participating cyclists' knowledge of LBA prevention strategies is one of the factors in preventing LBA. Table 5 shows the association between the cyclists' knowledge

Table 1. Demographic Characteristics

Variables		Mean ± SD	n (%)
Age	18-30		39 (27.7)
	31-50		81 (57.4)
	51-70		21 (14.9)
Gender	Female		22 (15.6)
	Male		119 (84.4)
BMI		24.86 ± 3.97	
Riding Speed (Km/h)		27.91 ± 4.96	
Educational Level	Primary		2 (1.4)
	Secondary		14 (9.9)
	Diploma		30 (21.3)
	Pre-university		4 (2.8)
	Undergraduate		45 (31.9)
	Postgraduate		42 (29.8)
	PhD		4 (2.8)
Cycling Experience	< 6 months		5 (3.5)
	6 months - 1 year		18 (12.8)
	1 year - 2 years		23 (16.3)
	2 years - 3 years		20 (14.2)
	> 3 years		75 (53.2)

All the data presented in frequencies (percentage) except BMI and riding speed presented in mean ± SD, BMI: Body mass index, SD: Standard Deviation

Table 2. Prevalence of Low Back Pain

Variable		n (%)
Lifetime Prevalence		
	Yes	78 (55.3)
	No	63 (44.7)
LBP from cycling in the past 12 months		
	Yes	50 (35.5)
	No	91 (64.50)
LBP from cycling at present		
	Yes	20 (14.2)
	No	121 (85.8)

*LBP-Low back pain

about bicycle seat adjustment, saddle title angle, best cycle design, handlebar position, optimal cycle distance, core muscle exercises, and the annual prevalence of LBA. Except for the cyclists' knowledge about saddle tilt angle, all the other factors are significantly associated with the annual prevalence of LBA.

Discussion

The current study aimed to determine the prevalence, risk factors, and level of knowledge of LBP prevention strategies among Malaysian recreational cyclists. According to the study's statistics, 35.5% of cyclists reported having LBP in the past 12 months. The results of the current study are also concurrent with a previous study that reported a prevalence of 41% of LBP among amateur cyclists (Van der

Table 3. Association between risk factor and LBP

Risk factors		LBP in the past 12 months			χ^2	p-value
		Total	No	Yes		
		n (%)	n (%)	n (%)		
Riding terrains					6.960	0.138
	Flat with few hills	58 (41.1)	44 (31.2)	14 (9.9)		
	Downhill	1 (0.7)	1 (0.7)	0		
	Flat roads	19 (13.5)	11 (7.8)	8 (5.7)		
	Hilly roads	58 (41.1)	33 (23.4)	25 (17.7)		
	Uphill	5 (3.5)	2 (1.4)	3 (2.1)		
Smoking					0.338	0.561
	Yes	21 (15.6)	13 (9.2)	9 (6.4)		
	No	119 (84.4)	78 (55.3)	41 (29.1)		
Supplementary exercise					0.201	0.654
	Yes	104 (73.8)	66 (46.8)	38 (27.0)		
	No	37 (26.2)	25(17.7)	12 (8.5)		
Warm-up					2.754	0.097
	Yes	77 (54.6)	45 (31.9)	32 (22.7)		
	No	64 (45.4)	46 (32.6)	18 (12.8)		
Cool-down					0.603	0.806
	Yes	64 (54.6)	42 (29.8)	22 (15.6)		
	No	77 (54.6)	49 (29.8)	28 (19.9)		
Other sports					2.223	0.136
	Yes	85 (60.2)	59 (41.8)	26 (18.4)		
	No	56 (39.7)	32 (22.7)	24 (17.0)		

*LBP-Low back pain, χ^2 – Effect size

Table 4. Cyclist Knowledge on LBP prevention strategies

Item	N (%)
Knowledge on saddle angle	21 (14.89)
Knowledge on saddle tilt angle	5 (3.54)
Knowledge on best bicycle design	53 (37.58)
Knowledge on core muscle exercises	113 (80.14)
Knowledge on handlebar position	69 (48.93)
Knowledge on optimal distance for cycling	27 (19.14)

*LBP-Low back pain

Table 5. Association between Cyclists' knowledge about LBP prevention strategies and the annual prevalence of low back pain.

Risk factors	LBP in the past 12 months			
	Total	No	Yes	χ^2
	n (%)	n (%)	n (%)	(p-value)
Knowledge about Seat Adjustment				
Correct Response	21 (15)	19 (19)	2 (8)	6.6064
Incorrect Response	120 (85)	74 (81)	46 (92)	(p>0.05)
Knowledge about saddle tilt angle				
Correct Response	5	3	2	
Incorrect Response	136	87	49	0.4975 (p<0.05)
Knowledge on best bicycle design				
Correct Response	53	42	11	8.025
Incorrect Response	88	49	39	(p>0.05)
Knowledge on core muscle exercises				
Correct Response	113	80	14	52.1235
Incorrect Response	28	11	36	(p>0.05)
Knowledge on handlebar position				
Correct Response	69	79	6	73.1225*
Incorrect Response	72	12	44	(p>0.05)
Knowledge on optimal distance for cycling				
Correct Response	27	75	9	55.6013*
Incorrect Response	114	16	41	(p>0.05)

*LBP-Low back pain, χ^2 – Effect size

Walt et al., 2014). Nevertheless, the incidence of mechanical LBP was comparatively lower (13.5%) in top-level road cyclists (De Bernardo et al., 2012) and world-class cyclists (13.4%) (Barrios et al., 2015). The possible reason may be that the targeted population was different in the current study and the training pattern may vary in professional cyclists. This evidence stands to reason because, in comparison to recreational road cyclists, professional road cyclists typically have greater average cycling speeds, distances, and frequencies per week, which may decrease the risk of low back pain (Priego Quesada et al., 2018; Teyeme et al., 2019).

In the Klang Valley, 14.2% of recreational cyclists reported having LBP at the time of the survey. In a similar survey, 16% of road cyclists reported low back pain at the time of the survey (Clarsen, 2015). The point-prevalence of low back pain in the two sample populations is comparable as a result of their similarities. This supports the study's findings and shows that LBP is a common problem among recreational road cyclists. Maintaining a fixed riding posture, utilising high gears, climbing hills for a lengthy amount of time, and stressing gluteal, hamstring, and back muscles are all thought to be factors in LBP in cyclists (Mellion, 1994).

Our study found no significant association between the riding terrain and LBP. This result supports that of an earlier study that evaluated the prevalence of low back discomfort among cyclists riding on "mostly flat", "primarily hilly", and "flat with rolling hills" terrains. This study found that low back pain in recreational cyclists is not significantly linked to the different types of cycling terrain (Schultz & Gordon, 2010). Although there is no remarkable relationship between LBP and terrain, ongoing research on cycling biomechanics has revealed that uphill cycling requires a significant amount of power to defy gravity. Cycling uphill has a different posture than cycling on flat ground (Fonda & Šarabon, 2012). In this study, the majority of the participants are non-smokers and they adopt a healthy lifestyle. In contrast, recent evidence adopted from a study stated that cigarette smoking contributed to one of the risk factors for chronic LBP in university athletes (Ansari & Sharma, 2022). Another interesting finding in this study was that there was no relationship between LBP and exercise. Since a substantial number of participants in this survey do exercise to prevent LBP, this may be the possible reason for the non-significant relationship. However, a dissimilar result was illustrated in the study investigated by Rostami et al., 2015 revealed that deficiency of core stability muscles leads to LBP in bikers. Therefore, core stability exercises may be beneficial for mountain bikers.

In this survey, cyclists had a low level of knowledge about LBP prevention strategies. Only 14.9%, 3.5%, and 19.1% of the respondents provided correct answers for optimal position on saddle angle, saddle tilt, and optimal distance for recreational cyclists, respectively. Despite the low level of knowledge, the other components of the questionnaire, such as the importance of suspension in the cycle, core muscle exercise, and handlebar position, more than half of the respondents have a moderate level of knowledge of prevention strategies. Unlike previous studies, this study established a significant association between the cyclists' knowledge about bicycle seat adjustment, best cycle design, handlebar position, optimal cycle distance, core muscle exercises, and the annual prevalence of LBA. Nevertheless, our findings reveal cyclists' knowledge about saddle tilt angle does not show any association with the annual prevalence of LBP. However, an earlier study indicated that cyclists' appropriate adjustment of the saddle angle resulted in a major improvement in the incidence and magnitude of their back pain (Salai et al., 1999).

Thus, inadequate knowledge of bicycle parameters would be one of the contributing factors to the prevalence of LBP in cyclists as demonstrated through this study. No study has looked into cyclists' awareness of back pain prevention methods as of yet. The fundamental understanding of injury among cyclist varies, with some showing a higher level of understanding than others. However, cyclist' understanding tends to improve with time and with experience (Rees et al., 2022).

Some limitations of the study include inherent issues of self-reported surveys. This study's results are derived from a self-reported survey of recreational cyclists about their prevalence, risk factors, and injury prevention strategies. Therefore, independent verification of data was not possible. The study captured the prevalence, risk factors, and

injury prevention strategies from the voice of recreational cyclists in various cycling clubs in the Klang Valley, Malaysia. Therefore, the perceptions cannot be generalized to cyclists in Malaysia. Therefore, future studies should include a broader population of cyclists across Malaysia to generalize the findings.

Conclusions

In conclusion, the survey's findings indicate that recreational bikers know little about aspects of bicycles, including saddle height, saddle tilt, and handlebar position. Furthermore, there is an association between the cyclists' knowledge about LBP prevention strategies focusing on bicycle adjustments & core muscle exercises and the annual prevalence of low back pain. Therefore, it is important to emphasize the need for education on proper bicycle modifications for recreational riders to lower the prevalence of LBP. Despite the fact that the vast majority of research participants regularly strengthen their core muscles, LBP is nevertheless somewhat more common than average. Therefore, the community of recreational cyclists needs to emphasize adequate education and knowledge of bicycle adjustment and the proper method to perform core muscle exercise.

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Conflict of interest

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

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ОПИТУВАННЯ ПРО БІЛЬ У ПОПЕРЕКУ СЕРЕД ВЕЛОСИПЕДИСТІВ: ПОШИРЕНІСТЬ, ФАКТОРИ РИЗИКУ ТА ЗНАННЯ СТРАТЕГІЙ ЗАПОБІГАННЯ ТРАВМАТИЗМУ

Вінош Кумар Пурушотаман[1ABCD], Вей Вві Чен[1ABCD], Амбусам Субраманіам[2ACD], Арун Віджай Суббараялу[3ACD], Нітія Марутей[1ABCD], Моханрадж Кандасамі[4ACD]

[1]Міжнародний університет ІНТІ
[2]Університет імені Тунку Абдул Рахмана
[3]Університет імені імама Абдуррахмана ібн Фейсала
[4]Дослідницький фонд місій Вінаяки

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

Реферат. Стаття: 7 с., 5 табл., 30 джерел.

Метою дослідження було визначити поширеність болю в попереку (БП), фактори ризику та знання стратегій запобігання травмам у велосипедистів-любителів.

Матеріали та методи. У цьому перехресному кількісному дослідженні взяли участь 141 дорослий велосипедист-любитель віком від 18 до 70 років. Поширеність БП визначали за допомогою стандартного Скандинавського опитувальника. Крім того, для оцінки рівня знань використовували валідований самостійно розроблений опитувальник, при цьому високий бал представляв найвищий рівень знань. Для приведення описових змінних використовували частоти та відсотки, тоді як для визначення зв'язку між факторами ризику та БП використовували критерій хі-квадрат.

Результати. За результатами дослідження було визначено, що 55,3% велосипедистів мали БП протягом усього життя, а 35,5% повідомили про БП протягом останніх 12 місяців. Однак між фактором ризику та БП не було виявлено статистично значущого зв'язку (p>0,05). Незважаючи на це, було виявлено низький рівень знань про стратегії запобігання травматизму для велосипедистів-любителів.

Висновки. Це опитування показало, що велосипедисти-любителі мають низький рівень розуміння важливих характеристик велосипеда, таких як висота сидіння, нахил сідла та положення керма, для підтримання оптимальної біо-

механіки тіла. Велосипедисти-любителів слід навчати необхідності відповідних модифікацій велосипеда та ергономіки, ефективних технік розминки, розтяжки та охолодження, а також деяких важливих стратегій запобігання травмам, особливо попереку.

Ключові слова: велосипедист, біль у попереку, знання, фактори ризику, профілактика травм.

Information about the authors:

Purushothaman, Vinosh Kumar: vinoshmpt@yahoo.com; https://orcid.org/0000-0001-5213-3065; Faculty of Health and Life Sciences, INTI International University, Persiaran Perdana BBN Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.

Chen, Wei Vvy: weivvyyyy@gmail.com; https://orcid.org/0000-0001-6233-2762; Faculty of Health and Life Sciences, INTI International University, Persiaran Perdana BBN Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.

Subramaniam, Ambusam: ambusam_7@hotmail.com; https://orcid.org/0000-0002-5745-4084; Faculty of Medicine and Health Sciences, Universiti Tunku Abdul Rahman, Jalan Sungai Long, Bandar Sungai Long, 43000 Kajang, Selangor, Malaysia.

Subbarayalu, Arun Vijay: ausubbarayalu@iau.edu.sa; https://orcid.org/0000-0002-5758-118X; Department of Physiotherapy, Quality Assurance Department, Deanship of Quality & Academic Accreditation, Imam Abdulrahman Bin Faisal University, Dammam 31441, Saudi Arabia.

Maruthey, Nithiyah: nithiyahmaruthey@gmail.com; https://orcid.org/0000-0001-8359-3718; Faculty of Health and Life Sciences, INTI International University, Persiaran Perdana BBN Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.

Kandasamy, Mohanraj: mohaan23@gmail.com; https://orcid.org/0000-0002-9877-4420; Faculty of Physiotherapy, Vinayaka Missions Research Foundation, Sankari Main Road (NH47), Salem, Tamil Nadu 636308, India.

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ORIGINAL SCIENTIFIC ARTICLE

CIRCUIT GAME DEVELOPMENT: IMPLICATIONS ON BALANCE, CONCENTRATION, MUSCLE ENDURANCE, AND ARROW ACCURACY

Betrix Teofa Perkasa Wibafied Billy Yachsie[1ABCDE], Suharjana[1BDE], Ali Satia Graha[1BCE] and Amri Hartanto[1ABCDE]

[1]Universitas Negeri Yogyakarta

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

Corresponding Author: Amri Hartanto, E-mail: amry7766@yahoo.com
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Abstract

Study purpose. Balance, concentration, muscle endurance, and accuracy are very important for archery athletes, but there are still limited game models to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes. The aim of this research is to develop a circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in proper and effective archery athletes.

Materials and methods. The development model used in this study is based on Lee & Owens theory which uses five phases in a cycle, namely ADDIE. The effectiveness test was carried out on archery athletes aged 10-13 years, totaling 30 people. Treatment was given for 18 meetings.

Results. The conclusion of the research is that the circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes is feasible. The circuit game model is effective in improving balance, concentration, arm muscle endurance, and accuracy in archery athletes. The circuit game model consists of 6 posts.

Conclusions. For coaches, the circuit game model can be used to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes. Suggestions for further researchers are that this circuit game model needs to be developed again to be better.

Keywords: circuit game, balance, concentration, arm muscle endurance, accuracy.

Introduction

Archery has been loved by many from early childhood, teenagers, and adults. Archery is also one of the leading sports in Indonesia and as a culture from Indonesia. The hope is to be able to reach the international level through the training programs that have been planned. The characteristic of the sport of archery is releasing arrows through a certain trajectory towards the target at a certain distance (Sarro et al., 2021; Kim et al., 2021; Ortiz et al., 2020).

Archery is a precision sport that requires consistency and stability of a steady movement for accurate shooting of arrows (Simsek et al., 2019; Serrien et al., 2018; Musa et al., 2019). Archery in terms of components that affect the performance of archery athletes are physical, tactical, technical, and mental. The physical components needed in archery include: physical condition, muscle strength, muscle endurance, and technique (Taha et al., 2018).

The most basic problems for adolescents may occur in physical and psychological components, including physical, which contains arm muscle endurance and balance, and from the psychological aspect, namely concentration. One of the mental factors that determine the accuracy of archery is concentration (Savvides et al., 2020; Verawati & Valianto, 2020; DeVoe et al., 2019). Concentration is needed, especially for sports that require high concentration, one of which is archery, because this sport requires accuracy, precision, consistency, and constancy in every action of every arrow that is fired. The higher the concentration level of an archery athlete, the better and more consistent the results will be. On the other hand, the lower the concentration level of an archery athlete, the results will not be maximal and will be seen in the inconsistency of the scores he gets (Swann et al., 2017).

Archery is a statistical sport that requires good physical condition, strength, and endurance, especially in the upper body's muscles. One indication of the athlete's physical

condition that greatly influences archery achievement is the endurance of the arm muscles (Lau et al., 2020; Al-Jaber & Shandal, 2021). In the sport of archery balance is needed because it must be able to hold the body while on the other hand aim to open a shot (Kim, 2018). Several studies have shown that balance has an effect on archery outcomes (Lee et al., 2019; Ziebell et al., 2019).

Due to the lack of balance, concentration, and endurance of the athlete's arm muscles, this has implications for the low accuracy of archery. On this basis, an exercise model is needed in the form of a game that can be a stimulus for athletes to improve skills, physically (muscle endurance and balance), and mentally (concentration). Through exercises that are modified into the form of games and there are elements of play, children do not get bored quickly in doing so.

The development assumption in this study is the lack of a circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes. The goal to be achieved in this research is that the product produced in the future can add insight to the trainer as an alternative to developing an archery coaching program.

Materials and methods

Study participants

The subjects of the validation test were 6 experts with professors and doctoral degrees, and 1 archery trainer practitioner. After the product is produced in the form of a circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes, the effectiveness of the product is tested. The effectiveness test was carried out on archery athletes aged 10-13 years, totaling 30 people. Treatment was given for 18 meetings.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Yogyakarta State University.

The instrument of the feasibility test used a questionnaire. The feasibility test of the material is based on the aspects of the feasibility of the material, the feasibility of the content, and the feasibility of the language. Media feasibility test based on aspects of size, cover design, and content design.

The instrument for testing the effectiveness of the archery accuracy test is the archery accuracy test, namely by shooting at a distance of 30 meters, by means of an archer shooting 36 arrows and the total number of results for each arrow. The balance test used the stork stand test. The concentration test used the Grid Concentration Test. The arm muscle endurance test is the Holding Bow Digitec Test (Prasetyo et al., 2022).

Study organization

This type of research is research and development (Research and Development). In the research and development procedure, there are several stages that must be done in a research based on the theory of several experts. The development model used is based on Lee & Owens theory which uses five phases in a cycle, namely ADDIE (Analysis, Design, Development, Implementation, and Evaluation) (Samri et al., 2020).

Statistical analysis

The data analysis technique used in this research is quantitative analysis. The feasibility test uses descriptive analysis. Testing the effectiveness using t-test paired sample test.

Results

The results of the development of a circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes were then validated by material experts and media experts to determine the quality of the products developed. The assessment is carried out by material experts using a questionnaire. The measurement scale used is a modified Likert scale. The results of the material expert's assessment of the circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes are presented in Table 1.

Table 1. Data of material expert assessment results

Aspect	Earned Score	Maximum Score	Percentage	Category
Learning materials	53	60	88,33%	Appropriate
Contents	74	84	88,10%	Appropriate
Language	32	36	88,89%	Appropriate

Based on Table 1, the results of the material expert's assessment of the circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes, the material aspect of 88,33% is in the appropriate category. The content aspect is 88,10% in the appropriate category, and in the language aspect of 88,89% included in the appropriate category.

The results of the media expert's assessment of the circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes are presented in Table 2.

Table 2. Media expert assessment results data

Aspect	Earned Score	Maximum Score	Percentage	Category
Size	20	24	83,33%	Appropriate
Cover Design	95	108	87,96%	Appropriate
Content Design	198	228	86,84%	Appropriate

Based on Table 2, the results of the media expert's assessment of the circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes, namely the size aspect of 83,33% is in the feasible category; the cover design aspect is 87,96% in a category is appropriate, and the content design aspect of 86,84% is included in the appropriate category.

The resulting circuit game model consists of 6 posts; Pos 1 consists of walking with heels, walking tables, releasing arrows, Pos 2; climbing the block, walking bow, releasing arrows, Pos 3; toe walk, walking bottles, releasing arrows, Heading 4; bosu ball, bench push-ups, releasing arrows,

Pos 5; ankle zig-zag, take a walk hola hoop, releasing arrows, Pos 6; marble ankle, lifting bench body, releasing arrows. As in Figure 1.

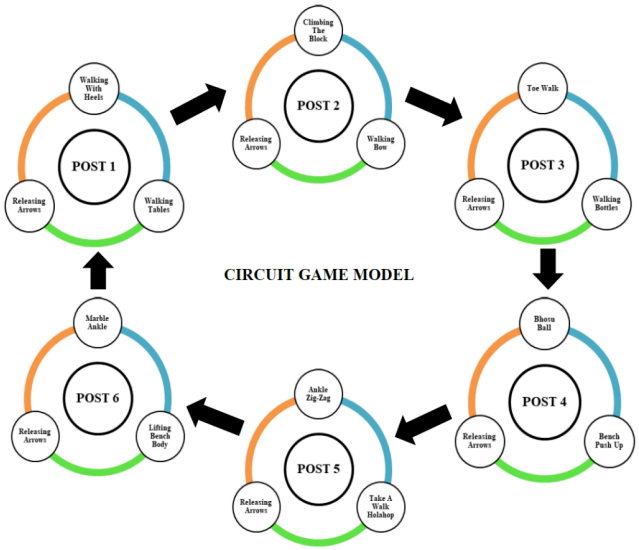

Fig. 1. Circuit game model

The effectiveness test in this study was conducted to determine the effectiveness of the circuit game model in improving balance, concentration, arm muscle endurance, and accuracy in archery athletes. The effectiveness test was carried out for 18 meetings with 30 athletes.

At each meeting, the athlete's time in completing each post is always recorded; it is hoped that with each session, there will be an increase in the time in completing each post. The training process is carried out in a fun way; the coach provides educational rewards and punishments, and always provides motivation and evaluation at the end of the exercise.

The results of the pretest and posttest data on balance, concentration, arm muscle endurance, and accuracy in archery athletes are presented in Table 3.

Table 3. Results of pretest and posttest

Variable	Pretest	Posttest
Balance	21.47±2.15	23.07±2.44
Concentration	13.63±2.25	15.90±3.29
Muscle Endurance	14.53±1.55	15.77±1.74
Archery Accuracy	243.60±10.82	249.60±11.32

Furthermore, paired sample test analysis was carried out to determine whether there was an increase in balance, concentration, arm muscle endurance, and accuracy after being given a circuit game model for 18 meetings. The results of the effectiveness test between the pretest and posttest data are in Table 4.

Based on the results of the pretest-posttest analysis in Table 4, a significance value of 0.000 < 0.05 was obtained, indicating a significant difference between the pretest and posttest. Based on the analysis results, it can be concluded that the circuit game model effectively improves balance, concentration, arm muscle endurance, and accuracy after being given a circuit game model for 18 meetings.

Table 4. Analysis of paired sample test

Data		Mean	t count	Sig
Balance	Pretest	21.47	8.339	0.000
	Posttest	23.07		
Concentration	Pretest	13.63	7.779	0.000
	Posttest	15.90		
Muscle Endurance	Pretest	14.53	7.223	0.000
	Posttest	15.77		
Archery Accuracy	Pretest	243.60	8.939	0.000
	Posttest	249.60		

Discussion

The circuit game model developed is one post that uses Bosu. Bosu is used as a stimulus in training archery athletes' balance. The flat side of the Bosu ball is often used to increase muscle tone, improve posture and improve balance. The ball side is mainly used to increase reaction speed and control the motor. Bosu exercise applications are used for the development of balance (Lubetzky-Vilnai et al., 2015; D. Badau et al., 2018), development of strength and postural control (A. Badau, 2017), and development of motor skills (Zemkova et al., 2017). In addition, Bosu, which has a large area of use, can not only be used standing on it in a vertical position but also a horizontal position (Saeterbakken et al., 2019).

The results of the study showed that training using a Bosu ball for eight weeks could improve balance (Gidu et al., 2022; Saikhanzul et al., 2022). Rebound training using a trampoline and a BOSU ball provides proprioceptive and vestibular stimulation and improves postural control and balance (Abd-Elmonem & Elhady, 2018). Exercise (BOSU ball) for ten weeks can improve the balance (static and dynamic) (Elfateh, 2016). There was a significant change in left balance in a 16-year-old basketball player after being given Bosu ball training treatment (Nugraha et al., 2022).

The circuit game model developed has several movements in the post to increase concentration. Concentration is a condition in which a person's awareness is focused on a particular object at a specific time. Concentration is needed, especially for sports that require high concentration, one of which is archery. This sport requires accuracy, precision, consistency, and constancy in every action of every arrow fired (Camus, 2020).

The circuit game model developed has several movements in the post to increase muscle endurance, such as walking tables, walking bottles, bench push-ups, taking a walk hola hoop, and lifting the bench body. This exercise is effective in increasing muscle endurance. The results of this study are supported by several studies that carried out weight training to increase muscle endurance (Grgic et al., 2020; Schoenfeld et al., 2019; Fragala et al., 2019).

The circuit game model developed is effective in increasing accuracy in archery athletes. This happens because the athlete repeats with arrows or releases arrows at the end of each post in the circuit game model. Releasing arrows is done with ever-increasing repetitions and sets. The increase in ability is due to the association of knowledge obtained by children at previous meetings with new knowledge, and the association is more robust when done repeatedly. This is

based on the law of exercise learning theory. That principle of the law of exercise shows that the main focus in learning is repetition; the more often the subject matter is repeated, the more mastered it will be (Tomporowski & Pesce, 2019). Without repeated practice, skills for mastery of technique and stability cannot become an automatic movement (Bompa & Buzzichelli, 2019).

Conclusions

Based on the study's results, it was concluded that the circuit game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes was feasible. The circuit game model improves balance, concentration, arm muscle endurance, and accuracy in archery athletes.

The product contains the procedure for implementing the exercise model, text, and images. This development product has components that allow coaches and athletes to learn it more easily because it is accompanied by: (1) instructions for use, (2) objectives to be achieved, (3) presentation of material, (4) attention-grabbing materials in the form of pictures and explanatory texts.

For coaches, the circuit game model can improve balance, concentration, arm muscle endurance, and accuracy in archery athletes. Suggestions for further researchers, namely the game model to improve balance, concentration, arm muscle endurance, and accuracy in archery athletes, need to be developed again to be better.

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Conflict of interest

We know of no conflicts of interest associated with this publication, and there has been no significant financial support for this work that could have influenced its outcome. As the corresponding author.

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РОЗРОБКА ЦИКЛІЧНОЇ ГРИ: ВПЛИВ НА РІВНОВАГУ, КОНЦЕНТРАЦІЮ, М'ЯЗОВУ ВИТРИВАЛІСТЬ І ТОЧНІСТЬ СТРІЛЬБИ З ЛУКА

Бетрікс Теофа Перкаса Вібафід Біллі Яхсі[1ABCDE], Сухарджана[1BDE], Алі Сатія Граха[1BCE], Амрі Хартанто[1ABCDE]

Джок'якартський державний університет

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

Реферат. Стаття: 6 с., 4 табл., 1 рис., 34 джерела.

Мета дослідження. Рівновага, концентрація, м'язова витривалість і точність дуже важливі для спортсменів, які займаються стрільбою з лука, але досі існує обмежена кількість ігрових моделей для покращення рівноваги, концентрації, витривалості м'язів рук і точності у спортсменів-лучників. Метою цього дослідження є розробка належної та ефективної моделі циклічної гри для покращення рівноваги, концентрації, витривалості м'язів рук і точності у спортсменів, які займаються стрільбою з лука.

Матеріали та методи. У цьому дослідженні використовували модель розробки на базі теорії Лі та Оуенса, яка використовує п'ять фаз у циклі, а саме: аналіз, проектування, розробка, впровадження, оцінка. Перевірку ефективності проводили на спортсменах-лучниках віком 10-13 років загальною кількістю 30 осіб. Процедуру проводили протягом 18 зустрічей.

Результати. За результатами дослідження було зроблено висновок, що модель циклічної гри для покращення рівноваги, концентрації, витривалості м'язів рук і точності у спортсменів-лучників є доцільною. Ця модель циклічної гри показує свою ефективність у покращенні рівноваги, концентрації, витривалості м'язів рук і точності у спортсменів, які займаються стрільбою з лука. Ця модель циклічної гри складається з 6 позицій.

Висновки. Тренери можуть використовувати цю модель циклічної гри для покращення рівноваги, концентрації, витривалості м'язів рук і точності у спортсменів-лучників. Рекомендації для подальших дослідників полягають у тому, що ця модель циклічної гри потребує повторної розробки з метою її покращення.

Ключові слова: циклічна гра, рівновага, концетрація, витривалість м'язів рук, точність.

Information about the authors:

Yachsie, Betrix Teofa Perkasa Wibafied Billy: betrixbilly@uny.ac.id; https://orcid.org/0000-0002-3908-2248; Department of Sports Science, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Suharjana: suharjana_fikuny@yahoo.com; https://orcid.org/0000-0003-0984-8086; Department of Sports Coaching Education, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Graha, Ali Satia: ali_satiagraha@uny.ac.id; https://orcid.org/0000-0001-6277-1968; Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Hartanto, Amri: amry7766@yahoo.com; https://orcid.org/0000-0002-6276-2495; Department of Sports Science, Faculty of Sport Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTS OF WAI KRU MUAY THAI TRAINING ON WELL-BEING AND PHYSICAL FITNESS OF PEOPLE OF ALL AGES

Amorntheap Wandee[1ABCDE], Ban Chabairam[1BD] and Suchart Homjan[1CD]

[1]Buriram Rajabhat University

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

Corresponding Author: Amorntheap, Wandee, E-mail: amorntheap.wa@bru.ac.th
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Abstract

Study purpose. The study aimed to investigate the social, physical, and mental well-being of people of all ages in Buriram province and developed physical activities that apply to local people of all ages.

Materials and methods. To develop social cohesion in Sai To 5 Tai, Chanthopphet district, Buriram province, the study recruited 120 participants of all ages divided into 2 groups of 60 people each: 1) an experimental group was given a training program for training in Wai Kru Muay Thai 12 positions, 15 sequences 3 days/week, 30 minutes/day for 10 weeks; and 2) a control group performed their normal routine. The participants were assessed for their well-being in all ages using a questionnaire and for their physical fitness using field tests in pre-training and after training for 5 and 10 weeks. Research data were analyzed using mean, standard deviation, normal distribution test, parametric and non-parametric statistic test.

Results. The results showed that after 10 weeks, the experimental group had social, physical, and mental well-being in all ages as well as physical fitness that developed in cardiovascular endurance, flexibility, muscle strength and endurance better than in the control group at a significance level of 0.05.

Conclusions. The training program for training in Wai Kru Muay Thai 12 positions, 15 sequences can improve the well-being and physical fitness of people of all ages.

Keywords: physical well-being, mental well-being, social well-being, physical fitness, Wai Kru Muay Thai.

Introduction

As a result of the COVID-19 situation, people were quarantined in residential areas, physical activities, social activities were reduced, and worsening mental state (Burns et al., 2020; Rider et al., 2021). After the COVID-19 pandemic rate decreases, the development of physical, social, and mental well-being, is critical for people in the community to achieve recovery of physical condition to be strong, have good mental health, and have happy coexistence in society (Morrow-Howell et al., 2020; Vigo et al., 2020; Maugeri & Musumeci. 2021).

Activities used to improve well-being should be activities that can improve physical fitness. As well as being able to practice together at all ages to achieve interaction between people in the community in the form of aerobic exercise, which affects mental development (Penedo & Dahn, 2005; Zelko et al., 2019; Van den Berg et al., 2017). In addition, many physical activities can improve well-being, such as Tai Chi, Qigong, and Yoga, which are widely found (Nontakhod et al., 2022).

However, the activity used to train the uniqueness of Thailand and still lacks research about well-being is Wai Kru Muay Thai training, which moves the body in multi-directions with large muscles in the form of aerobic exercise. As a result, the elderly can practice together safely (Phanpheng et al., 2020). Moreover, this activity also increases alternative activities for physical, social, and mental health development in people.

Materials and methods

Study participants

120 participants lived in Ban Sai Tho 5 Tai, Chanthobphet Subdistrict, Ban Kruat District, Buriram Province, di-

vided into 2 groups using a table to determine the sample size of Cohen (Cohen, 2013). Determine alpha values at the statistical significance level of .05, the effect size at .50, and the Power of the test at .75, with 57 people per group, two groups totaling 114 people. Furthermore, to prevent the mortality in participants, 6 participants were added, a total of 120 people, 60 people per group as follows: The experimental group consisted of 3 age ranges: 1) Aged 7-18 years 2) Aged 19-59 years and 3) Aged 60 years and over, 20 people per age range, was trained by Wai Kru Muay Thai. The control group was divided into the age range, and the number of people was the same as the experimental group, which was doing the routine. Criteria for inclusion of research participants 1) Have at least 6-8 hours of rest per day 2) No symptoms of heart disease 3) No relatives with heart disease 4) Blood pressure is not higher than 140/90. Criteria for exclusion of research participants 1) Involuntary participation in research 2) Participate in research less than 80% of the total training period 3) Force majeure causing not to participate, such as sickness or accidents. All participants signed the consent document to participate in the research.

Human research ethics

The research had been approved by the committee for the research ethics of Buriram Rajabhat University. The certificate issued was BRU: -rdi 002 (002/2565).

Study organization

All participants were assessed for physical, social, and mental well-being assessments with the Health Questionnaire (Ratanavilaisakul, 2015) and physical fitness test by the DPE test, consisting of body composition, flexibility, muscle strength and endurance, cardiovascular endurance, as well as agility and balance test for older people (Department of Physical Education, 2019). The experimental group conducts Wai Kru Muay Thai 12 positions, 15 sequences of training, repeating 5 rounds (Table 1) for 3 days/week, 30 minutes/day each time, including all 10 weeks in the form of group activities. While the control group is not trained. Data were collected in pre-training, after training for 5 weeks, and post-training for 10 weeks.

Statistical analysis

Quantitative data were tested for normal distribution of social, physical, and mental well-being by Kolmogorov-Smirnov's method and physical fitness by Shapiro-Wilk method. When found that 1) Normal distribution data, Analyze the difference between 2 groups by independent t-test and within the group between before, after 5, and 10 weeks of training by One-way ANOVA with Repeated Measured test. 2) Non-normal distribution data, Analyze the difference between 2 groups by Mann-Whitney U Test method and within the group between before, after 5, and 10 weeks of training with Friedman test method at the significant level .05 by SPSS17.0 (SPSS Inc. Released 2008. SPSS Statistics for Windows, Version 17.0 Chicago: SPSS Inc.).

Table 1. Wai Kru Muay Thai 12 positions, 15 sequences of training program

Day	Type of Activities	Type of Movements	Duration
	Warm up	Dynamic stretching in major muscle groups	5 minutes
Monday Wednesday Friday	Work out	1. Jarod muay 2. Tawai bangkom 3. Muan mud 5 times 4. Yang sam khum 1st 5. Hong hern 6. Yang sam khum 2nd 7. Phra mae thorani beeb muay phom 8. Yang sam khum 3rd 9. Lub hok mokasak 10. Berg fah 11. Khun phaen phan marn 12. Yang sam khum 4th 13. Phra ram plang sorn 14. Tud mai khom narm 15. Yang suk kasem	20 minutes (12 positions, 15 sequences of training) Repeat 5 rounds.
	Cool down	Static Stretching in major muscle groups	5 minutes

Results

The results of the study of Wai Kru Muay Thai training on well-being for all ages can be divided into 2 parts as follows:

1) The results of physical, social, and mental well-being conduct overall analysis of all ages by testing differences between groups by Mann-Whitney U Test and testing differences within each group by Friedman test method.

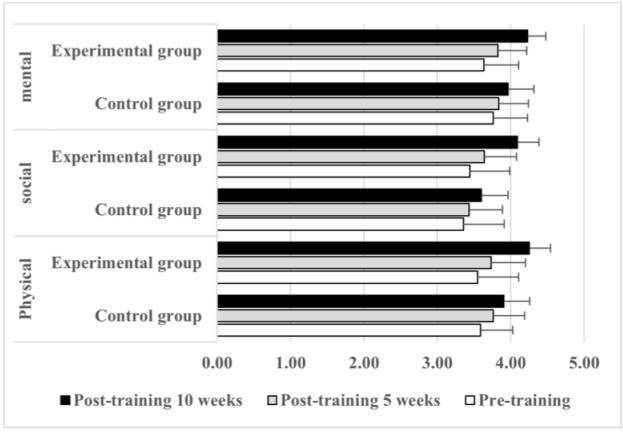

Fig. 1. The mean of physical, social, and mental well-being in the experimental group was different from the control group after 10 weeks of training. The mean was different within each group ($p<0.05^*$)

2) Physical fitness results, which were analyzed by age by testing the difference between groups with One-way ANOVA with Repeated Measured test and tested differences within each group with independent t-test as follows:

2.1) Age over 60 years old.

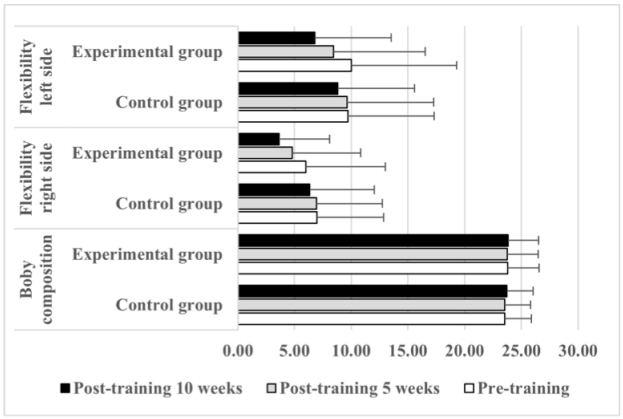

Fig. 2. The mean of body composition (p=0.88), flexibility right (p=0.10) and left side (p=0.36), after 10 weeks of training in the experimental group, there was no difference from the control group, while the mean of flexibility right and left side within the experimental group (p<0.05*)

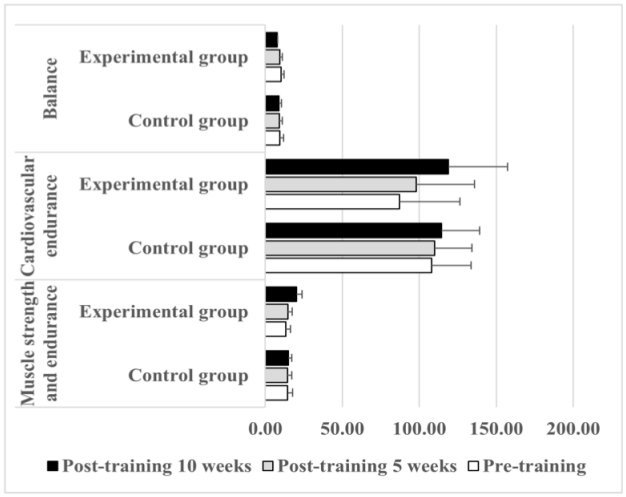

Fig. 3. The mean of muscle strength and endurance, and balance after 10 weeks of training in the experimental group was different from the control group and within the experimental group, as well as cardiovascular endurance (p<0.05*)

2.2) Between 15-59 years old

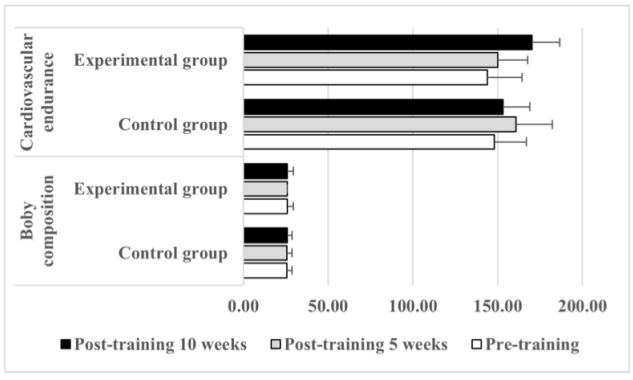

Fig. 4. The mean of body composition after 10 weeks of training in the experimental group had no difference from the control group (p=0.91), while the mean of cardiovascular endurance after 10 weeks of training in the experimental group was different from the control group (p<0.05*)

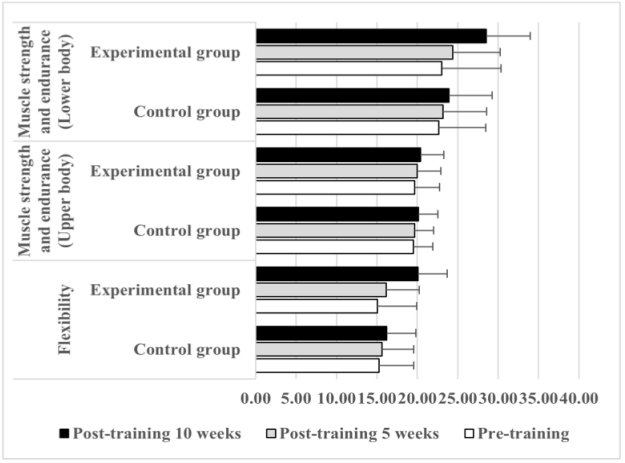

Fig. 5. The mean of flexibility, and muscle strength and endurance on lower body after 10 weeks of training in the experimental group was different from the control group and within the experimental group (p<0.05*)

2.3) Between 7-18 years old

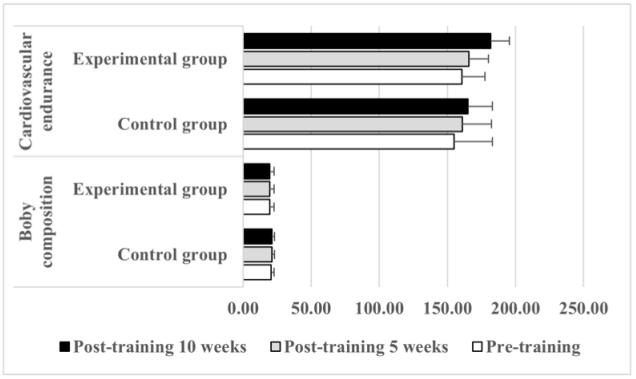

Fig. 6. The mean of body composition after 10 weeks of training in the experimental group had no difference from the control group (p = 0.07), while the mean of cardiovascular endurance after 10 weeks of training in the experimental group was different from the control group (p<0.05*)

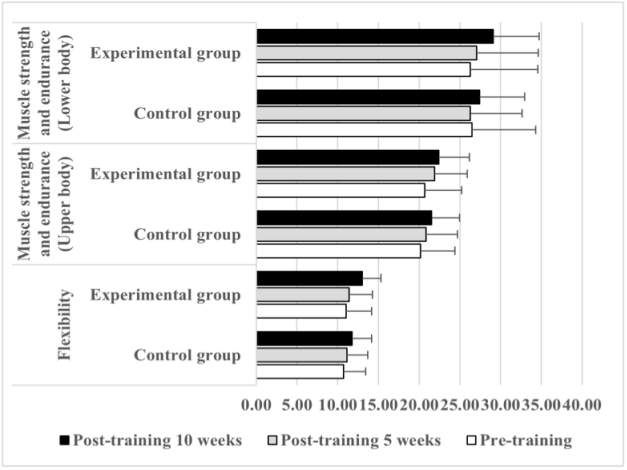

Fig. 7. The mean of flexibility (p=0.10), muscle strength and endurance on upper body (p=0.46) and lower body (p=0.34), after 10 weeks of training in the experimental group, there was no difference from the control group. However, there was also a difference within the experimental group in each variable (p<0.05*)

Discussion

The difference within the group of the average of physical, social, and mental health data in Pre-training, after Training 5 Weeks, and after Training 10 Weeks in the experimental group found that participants with Wai Kru Muay Thai. An average of variables increased from before training, after 5 weeks and 10 weeks, respectively, because the Wai Kru Muay Thai program was an activity that required the body to move on the beauty of the unique posture and perform activities together between ages in public as well. In addition, the appearance of specific gestures made participants talk and taught each other to make the right gestures. As a result, people in the community develop physical well-being. The part of the improved sense of the body used to carry out each person's daily routine along with the development of social well-being in terms of helping and caring for family members and people in the community together. Including mental well-being that made participants feel confident in themselves, control their emotions, and be happier in life (Murphy et al., 2010; Kimiecik & Horn, 2012).

The difference between the experimental group and the control group in health information consists of 1) physical well-being in terms of self-guided travel, 2) social well-being, participation in community activities, religious activities with family members, equal health insurance services, a sense of safety in life and property in the living community. After training for 5 weeks, the experimental group had an average of physical and social well-being more than the control group because the experimental group had activities that must come to exercise Wai Kru Muay Thai together, which caused more to leave their own home. Moreover, there was visit to the area around the community, and having activities together will affect social well-being, causing people in the community to persuade each other to do (Melnyk and Neale., 2018). After training for 10 weeks, the experimental group had a better average than the control group because there were easy activities to follow, suitable for all ages, and the appointment time together was evident, causing people to exercise, talk within the family, and more community (Kimiecik & Horn, 2012).

Analysis of differences within the experimental group of the average of pre-training physical fitness data, after training for 5 weeks and 10 weeks in 3 age ranges, found that 1) 7-18 years old had flexibility, strength and endurance of muscles. Cardiovascular endurance increased, respectively. 2) 19-59 years old, body composition, flexibility, strength and endurance of muscles, and cardiovascular endurance. 3) 60 years old and over, there was flexibility, strength and endurance of muscles and balance. All participants developed higher from before training, after 5 weeks and 10 weeks, respectively. Wai Kru Muay Thai was an activity that requires the body to move at a moderate speed with rhythm and stretch the knee joint, and continue for about 30 minutes, which affects on the body of all ages to develop strength and endurance of muscles, flexibility, balance from shortening and stretching with body weight in Wai Kru Muay Thai and cardiovascular endurance (Widjaja et al., 2012).

Conclusions

Wai Kru Muay Thai 12 postures, 15 sequences of training program are activities that can be done together in the community and are safe for all ages. Wai Kru Muay Thai training sets can also develop physical, social, and mental well-being. Therefore, it is an alternative for community leaders or exercise leaders to be used as an engaging activity for people in the community to improve their well-being. Furthermore, practicing until proficient will affect the development of physical fitness as cardiovascular endurance, flexibility, muscle strength and endurance for all ages, and balance for the elderly.

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Conflict of interest

The author declares that there have no of interest.

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ВПЛИВ ТРЕНУВАНЬ ІЗ ВИКОНАННЯ РИТУАЛЬНОГО ТАНЦЯ «ВАЙ КРУ МУАЙ ТАЙ» НА САМОПОЧУТТЯ ТА ФІЗИЧНУ ФОРМУ ЛЮДЕЙ УСІХ ВІКОВИХ ГРУП

Аморнтхіап Ванді[1ABCDE], Бан Чабайрам[1BD], Сухарт Хомян[1CD]

[1]Університет Бурірам Раджабхат

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

Реферат. Стаття: 5 с., 1 табл., 7 рис., 17 джерел.

Мета дослідження. Метою цього дослідження було вивчення соціального, фізичного та психічного самопочуття людей усіх вікових груп у провінції Бурірам (Таїланд), і в його рамках було розроблено фізичні навантаження, які застосовуються до місцевого населення усіх вікових категорій.

Матеріали та методи. З метою розвитку соціальної згуртованості в населеному пункті Сай То 5 Тай, округ Чантоппхет, провінція Бурірам, для участі в дослідженні було набрано 120 учасників різного віку, розділених на 2 групи по 60 осіб у кожній: 1) експериментальна група отримувала тренувальну програму для тренувань із виконання ритуального танця «вай кру муай тай» із 12 позицій, 15 послідовностей 3 дні/тиждень, 30 хвилин/день протягом 10 тижнів; і 2) контрольна група виконувала свої звичайні повсякденні справи. Самопочуття учасників усіх вікових категорій оцінювали за допомогою опитувальника, а їхню фізичну форму оцінювали за допомогою польових тестів у період до початку тренувань і після проходження тренувань протягом 5 і 10 тижнів. Аналіз даних дослідження здійснювали за допомогою середнього, стандартного відхилення, перевірки нормальності розподілу, параметричних і непараметричних статистичних критеріїв.

Результати. Результати показали, що через 10 тижнів експериментальна група в усіх вікових групах мала кращі показники соціального, фізичного та психічного самопочуття, а також фізичної форми, яка розкрилась у витривалості серцево-судинної системи, гнучкості, м'язовій силі та витривалості, ніж у контрольній групі, за рівня значущості 0,05.

Висновки. Тренувальна програма для тренувань із виконання ритуального танця «вай кру муай тай» із 12 позицій, 15 послідовностей може покращувати самопочуття та фізичну форму людей усіх вікових категорій.

Ключові слова: фізичне самопочуття, психічне самопочуття, соціальне самопочуття, фізична форма, ритуальний танець «вай кру муай тай».

Information about the authors:

Wandee, Amorntheap: amorntheap.wa@bru.ac.th; https://orcid.org/0000-0003-1581-8457; Faculty of Education, Buriram Rajabhat University, 439 Jira Road, Nai Mueang, Buriram, 31000, Thailand.

Chabairam, Ban: ban.cb@bru.ac.th; https://orcid.org/0000-0002-5889-0363; Faculty of Education, Buriram Rajabhat University, 439 Jira Road, Nai Mueang, Buriram, 31000, Thailand.

Homjan, Suchart: Suchart.hj@bru.ac.th; https://orcid.org/0000-0001-8880-6436; Faculty of Education, Buriram Rajabhat University, 439 Jira Road, Nai Mueang, Buriram, 31000, Thailand.

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ORIGINAL SCIENTIFIC ARTICLE

COMPLEX PHYSICAL REHABILITATION OF WOMEN REPRODUCTIVE AGE WITH STAGE I HYPERTENSIVE HEART DISEASE

Nataliia Stratiy[1AB], Ludmila Sychova[1BCE], Iryna Kachailo[1BDE] and Vitaliy Gargin[1BDE]

[1]Kharkiv National Medical University

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

Corresponding Author: Vitaliy Gargin, E-mail: vitgarg@ukr.net
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Abstract

Background. Hypertensive heart disease (HD) is a chronic abnormality that affects various systems of the body and is especially unfavorable for women of reproductive age.

The purpose of the study was to develop a comprehensive program of physical rehabilitation for young women suffering with stage I hypertensive heart disease at the outpatient stage of rehabilitation and evaluate its effectiveness.

Materials and methods. 42 young women with a diagnosis of HD were randomly divided into two groups: one performing traditional physical rehabilitation (control group) and the other following a method based on the Pilates system. Questionnaire, Martinet-Kushelevsky test, modified Romberg test, and Deshin test were performed.

Results. Questionnaire and examination for determination of therapeutic tasks in the application of physical rehabilitation show improvement due to the use of the suggested methodology. Indicators of Martinet-Kushelevsky test improved from 2.46 points to 5.48 points ($p<0.01$) which is better ($p<0.05$) than in the case of the traditional methodology where they changed from 2.44 to 4.61 ($p<0.01$). Kotov-Deshin test results show improvement in both groups evenly but the test results of the women of the main group improved from "unsatisfactory" to "good", and those of the women of the control group improved from "unsatisfactory" to "satisfactory" with significantly better results in the main group ($p<0.05$). Distribution of the Romberg test results show improvement of vestibular stability in all participants of the main group.

Conclusions. The proposed program of complex physical rehabilitation of patients with stage I hypertensive heart disease using the Pilates method proved to be effective. Due to this program, there was a significant decrease in heart rate, systolic and diastolic pressure, an improvement in the response of the cardiovascular system to the Martinet-Kushelevsky functional test as well as in the state of the respiratory and nervous systems, as evidenced primarily by the indicators of hypoxic tests, spirometry, clino- and orthostatic tests, with the Romberg and Deshin methods.

Keywords: hypertensive heart disease, Pilates, women, blood pressure.

Introduction

Hypertensive heart disease (HD) is a chronic abnormality that affects various systems of the body, characterized by an increase in blood pressure above normal (Shalimova et al., 2020; Shepherd et al., 2016). The disease is underlain by arterial hypertension, which is one of the main risk factors for the development of coronary heart disease, cerebral stroke and other disorders (Shalimova et al., 2019; Rzymski et al., 2021). All available means and forms of exercise therapy should be used in the system of motor activity of a patient with stage I hypertension, taking into account the use of certain methodological guidelines and rules (Shalimova, 2022; Krivenko et al., 2021). An important problem is the development of a comprehensive program of physical rehabilitation for this category of patients (Maksymenko et al., 2020; Schenström, Rönnberg, Bodlund, 2006), the need for a deeper study of the pedagogical basis for the use of physical exercises in rehabilitation treatment in stressful conditions in Ukraine especially (Awuah et al., 2022).

Hypertensive heart disease is showing a steady upward trend and this is primarily due to the fact that hypertensive heart disease is a disease of civilization (Polyvianna, Chumachenko, Chumachenko, 2019) its negative aspects (in particular, the information boom, the increased pace of life, hypokinesia, etc.).

The analysis of literary sources showed that hypertensive heart disease occupies one of the leading places among the abnormalities of the cardiovascular system (Yakovlev et

al., 2020). The prevalence of hypertension in women, the chronic course of the disease, the lack of effectiveness of the generally accepted complex therapies determine the relevance of the chosen topic and the need to search for new and effective combinations of physical rehabilitation means that would improve the rehabilitation treatment, would not cause adverse reactions and be well tolerated by women (Podrihalo et al., 2022; Gargin et al., 2019). That is very important for women of reproductive age due to common combination with other disease of genital system (Mączka, Sass, 2017; Lazko et al., 2021; Lytvynenko et al., 2022) that could be realized in later period.

The purpose of the study was to develop a comprehensive program of physical rehabilitation for young women suffering from stage I hypertensive heart disease at the outpatient stage of rehabilitation and evaluate its effectiveness.

Materials and methods

Study participants

We performed primary examination of women suffering from hypertensive heart disease. Under our supervision there were 42 young women (21-30 years old) with a diagnosis of stage I hypertensive heart disease. They were randomly divided into two groups: control (20 patients) and main (22 women). According to the diagnosis, the nature of the disease, age, gender and previous examination, both groups of patients were homogeneous. At the same stage, a program of physical rehabilitation was applied for this contingent of patients. The control group of patients was trained according to the generally accepted method, and the main group according to the method developed by us. Anthropometric data of participants are presented in table 1.

Table 1. Anthropometric data of participants.

Anthropometric data of investigated groups	Control group (N=20)		Main group (N=22)		p
	Mean	SD	Mean	SD	
Age (years)	28.47	3.48	28.13	4.02	p>0.05
Weight (kg)	67.44	5.31	69.04	5.88	p>0.05
Height (m)	1.63	0.11	1.64	0.10	p>0.05

Study organization

The complex of rehabilitation measures in the control and main groups lasted 26-28 days. After that, a second examination was carried out, which made it possible to assess the time course of the indicators of the cardiovascular and respiratory, central and autonomic nervous function, occurring under the impact of the rehabilitation means we used. The results of the re-examination were studied and the effectiveness of the proposed rehabilitation program was evaluated. Evidence-based conclusions were made and practical recommendations were given for participants.

The examined patients of the main and control groups were prescribed a complex of therapeutic exercises and massage according to the generally accepted scheme on a sparing and sparing-training motor regimen (Podrihalo et al., 2021). In the training motor mode, the patients of the control group were engaged according to the generally accepted methodology, and patients of the main group using the Pilates methods. Classes were held once a day, every day (excluding Sundays) in the hall of therapeutic physical education department. All participants were questioned before and after rehabilitation. Martinet-Kushelevsky test, modified Romberg test, and Deshin test had been performed.

Martinet-Kushelevsky test had been performed measuring blood pressure with a tonometer, determining carpal dynamometry, lung capacity, body length and weight. During its implementation, the subject performed 20 squats in 30 seconds at a pace set from the screen. After the end of the exercise, the program measures the heart rate for 3 minutes and displays the recovery time (in seconds) on the graph. According to the recovery time, the level of physical abilities was assessed: from 1 to 30 s (16-18 points) – high; from 31 to 60 s (13-15 points) - above average; from 61 to 120 s (7-12 points) – medium; from 121 to 150 s (4-6 points) – below average; from 151 to 180 s (1-3 points) – low.

The Kotov-Deshin test was carried out as follows. At rest, the pulse was determined (according to 10-second segments) and blood pressure was measured. Then the subject performed a load in the form of a 2-minute run in place at a pace of 180 steps per minute with a high hip lift. After performing the exercise, the subject sat down and during each of the 5 minutes of the recovery period, his pulse rates were recorded for the first and last 10 seconds, and in the interval between 11 and 49 seconds, blood pressure was measured.

Statistical analysis

Statistical processing of data obtained during the study was carried out using Microsoft Office Excel 2016 spreadsheets (Microsoft, USA) and Statistica 10.0 software (StatSoft, USA). The compliance of the obtained data with the normal distribution law was assessed with the Shapiro-Wilk's W-test. Student's t-test was employed to assess the significance of the difference between independent groups of parametric indicators. The assessment of the significance of differences in the signs of dependent groups with signs of normal distribution was carried out according to the even Student's test (t-test of dependent samples). Differences were determined by the significance level $p<0.05$.

Results

Results of questionnaire for participants of control and main groups are presented in table 2.

The results of Kotov-Deshin test were evaluated by the increase in pulse and pulse pressure, as well as by the nature and time of recovery and it is prezented in Table 4.

Follow-up study of the vestibular stability using the Romberg test is prezented in table 5.

Discussion

The initial stage of our work was devoted for the analysis and processing of literary sources on the problem of hypertensive heart disease. The presentation, etiology and pathogenesis of this disease were studied. We have reviewed the available programs of physical rehabilitation

Table 2. Questionnaire of participants about their feeling

Initial parameters		Control group (N=20)		Main group (N=22)		Comparison of groups after the course of rehabilitation
		After the course of rehabilitation	Initial parameters	After the course of rehabilitation		
psycho-emotional state	unsatisfactory	3(15.0%)	1(5.0%)	4(18.2%)	-	p<0.05
	satisfactory	14(70.0%)	8(40.0%)	14(63.6%)	3(13.6%)	
	good	3(15.0%)	11(55.0%)	4(18.2%)	19(86.4%)	
adaptation to physical stress	unsatisfactory	19(95.0%)	8(40.0%)	20(90.9%)	9(40.9%)	p>0.05
	satisfactory	1(5.0%)	9(45.0%)	2(9.1%)	10(45.5%)	
	good	-	3(15.0%)	-	3(13.6%)	
general strengthening of the body	unsatisfactory	16(80.0%)	12(60.0%)	17(72.3%)	3(13.6%)	p<0.05
	satisfactory	4(20.0%)	8(40.0%)	5(22.7%)	13(59.1%)	
	good	-	-	-	6(27.3%)	
activity of the cardiovascular system	unsatisfactory	20(100.0%)	9(45.0%)	22(100.0%)	9(40.9%)	p>0.05
	satisfactory	-	11(55.0%)	-	10(45.5%)	
	good	-	2(10.0%)	-	3(13.6%)	
feeling pain from time to time		17(85.0%)	14(70.0%)	18(81.8%)	9(40.9%)	p<0.05
pain in the cervical spine spine		12(60.0%)	8(40.0%)	13(59.1%)	6(27.3%)	p>0.05
pain in the thoracic spine		11(55.0%)	9(45.0%)	11(50.0%)	6(27.3%)	p>0.05
pain in the lumbar spine		11(55.0%)	8(40.0%)	12(54.5%)	3(13.6%)	p<0.01

Table. 3. Parameters of the Martinet-Kushelevsky test, points

Parameters	Initial parameters		After the course of rehabilitation		Comparison of initial parameters and after the course of rehabilitation
	Mean	SD	Mean	SD	
Control group (N=20)	2.44	0.21	4.61	0.40	p<0.01
Main group (N=22)	2.46	0.19	5.48	0.37	p<0.01
Comparison between groups	p>0.05		p<0.05		

Table 4. Distribution of the results of the Kotov-Deshin test

Parameters	Initial parameters			After the course of rehabilitation		
	unsatisfactory	satisfactory	good	unsatisfactory	satisfactory	good
Control group (N=20)	19(95.0%)	1(5.0%)	–	10(50.0%)	8(40.0%)	2(10.0%)
Main group (N=22)	20(90.9%)	2(9.1%)	–	6(27.3%)	12(54.5%)	4(18.2%)
Comparison between groups	p>0.05			p<0.05		

Table 5. Distribution of the results of the Romberg test

Parameters	Initial parameters			After the course of rehabilitation		
	unsatisfactory	satisfactory	good	unsatisfactory	satisfactory	good
Control group (N=20)	16(80.0%)	3(15.0%)	1(5/0%)	4(20.0%)	14(70.0%)	2(10.0%)
Main group (N=22)	18(81.8%)	3(13.6%)	1(4.5%)	–	9(40.9%)	13(59.1%)
Comparison of groups	p>0.05			p<0.05		

for hypertensive heart disease (Shalimova, 2022; Pulavskyi et al., 2022; Gevorkyan, Ippolitov, Bocharova 2022). As a result of the analysis of literary sources, the purpose and objectives of the study were formulated and specified, the main approaches to the physical rehabilitation of patients with hypertension were determined. At the same stage, a program of physical rehabilitation was drawn up using the Pilates health-improving methods.

The rationale for the use of the health-improving Pilates method in patients of the main group in the training motor

mode could be used as traditional therapeutic physical education involves the study of each muscle group separately (Byrnes, Wu, Whillier, 2018), however, a unique healing method developed in the beginning of the 20th century by the German fitness expert Joseph Hubertus Pilates, suggests a system of exercises based on the attitude to the body as a whole.

There are basic principles of the Pilates system: concentration; control; accuracy; breath; center; continuity, smoothness, fluidity of movements (Kashuba et al., 2020). Concentration is an element of the technique that helps to bring the body and spirit together and become calmer internally. Simultaneously with the exercise, it is necessary to create an image of its implementation. With this visualization, the muscles will be subconsciously activated. Control of exercises requires a high degree of coordination and control, since all the muscles involved in the movement must optimally interact with each other. Accuracy in this system, it is not the number of repetitions that is decisive, but the quality and awareness of their implementation. Breath in Pilates exercises, it is about making the center of the body stable. During the training it is recommended to employ thoracic lateral breathing. In this case, the lower part of the chest expands to the sides and back, and at the same time the thin muscles between the ribs are stretched. There is greater mobility in the upper body. Holding the breath during the exercise is not recommended. Center as Joseph Pilates spoke of "Powerhouse", meaning the middle of the body between the pelvis and the rib cage, with the spine as the central axis. Here, first of all, we are talking about four muscle groups: the transverse abdominal muscle, oblique muscles, and pelvic floor muscles. All of them work together and create a muscular corset, which, on the one hand, supports the spine, and on the other hand, makes the stomach taut. Each exercise starts in the center and flows through the limbs. The force that arises in the center coordinates all movements. Continuity, smoothness and fluidity of movements due to soft execution of movements is more important than a high number of repetitions and speed.

As results of our work we could insist, that the health-improving Pilates method involves the achievement of the following positive changes: normalization of blood pressure; strengthening the abdominal muscles; strengthening the muscles of the pelvic floor; improved joint mobility; improved coordination of movements; improved cell supply with oxygen; optimization of the psycho-emotional state (Sofyan, Abdullah, Hafiar, 2022). Optimization of the psycho-emotional state which we obtained in main group is especially important for patients with HD as stress-factor is one of more important in etiology of that disease and we can influent for initial link of pathogenesis.

Systematically conducted physical therapy classes based on the health-improving Pilates complex activate all physiological processes in the body and improve its vital activity. Under the impact of this complex, the activity of the autonomic nervous system increases, the activity of the endocrine glands and the psychological status of the patient improves. This effect is obtained by performing static, breathing exercises for muscle relaxation and others at a slow pace (Nechyporenko et al., 2020; Bales et al., 2020). This results in a decrease in excitation and an increase in inhibition in the central nervous system (Kolupayev et al., 2022).

Following these physical exercises patients' myocardium is found to undergo activation of metabolism and regeneration processes, an increase in blood flow, and an improvement of its nourishment. In this regard, the heart muscle is strengthened and its contractility increases (Arfanda et al., 2022). Tests which were performed, resulted that no one parameter of cardiovascular activity was decreased in comparison with traditional system of rehabilitation.

Thus, the health-improving Pilates complex is a rather specific type of health-improving gymnastics, which gives a rather high effect in the treatment and prevention of patients suffering from stage I HD, subject to specific guidelines.

The study of the cardiovascular and respiratory indicators in patients of the control and main groups showed positive time course was observed in terms of pulse and blood pressure (Mujriah et al., 2022). When comparing the obtained repeated indicators of the cardiovascular and respiratory systems between the control and the main group, no significant differences were found, which indicates a positive effect of complex physical rehabilitation on women in both groups.

Follow-up examination in patients of the control group revealed a decrease in heart rate and blood pressure at rest. After exercise, a higher systolic pressure persisted, but there was no significant decrease in the recovery time of these indicators. In the main group, there was a more pronounced positive trend in terms of heart rate, systolic pressure and recovery time according to Martinet-Kushelevsky and Deshin tests. This indicates an increase in the adaptive capacity of the cardiovascular system of patients in the main group to dosed loads. During the re-examination of the function of the autonomic nervous system after a course of physical rehabilitation, positive time course was established in the main group and slight positive changes in the control group.

Follow-up study of the vestibular stability using the Romberg test detected an improvement in the time to maintain balance, a decrease in tremor of the hands and eyelids, and a decrease in staggering mainly in women of the main group. The percentage of assessments in the performance of the test in women of the main group improved from "unsatisfactory" to "good", and in women of the control group from "unsatisfactory" to "satisfactory" with significantly better results in main group.

Significant reducing of pain feeling in spine was described previously for Pilates complex (Kashuba et al., 2020) but we proved more significant improvement in main group for lumbar area. That is important for background of HD which performs choice of anesthetic medicine not too wide in that suffering (Goncharova et al., 2020; Lyndin et al., 2019).

We could testify according performed study with questionnaire and examination for determination of therapeutic tasks in the application of physical rehabilitation improvement of many states as follows: general strengthening of the patient's body; improvement of the activity of the cardiovascular system; activation of metabolic processes; strengthening and training the heart muscle; regulation of blood pressure and functions of the vestibular apparatus; improvement of psycho-emotional state; normalization of impaired functions of the cardiovascular, respiratory and autonomic systems; increasing the body's adaptation to physical stress.

Conclusions

Thus, our proposed program of complex physical rehabilitation of patients with stage I hypertensive heart disease using the Pilates method is effective and allows healthcare workers to speed up the recovery process in the patient's body. Under the impact of this program, there was a significant decrease in heart rate, systolic and diastolic pressure, an improvement in the response of the cardiovascular system to the Martinet-Kushelevsky functional test, as well as in the state of the respiratory and nervous systems, as evidenced primarily by the indicators of hypoxic tests, spirometry, clino- and orthostatic tests, with the Romberg and Deshin methods. The rationality of the approach significantly increases the effectiveness of treatment, which contributes to an acceleration of the process of recovery of the patient and restoration of working capacity.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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КОМПЛЕКСНА ФІЗИЧНА РЕАБІЛІТАЦІЯ ЖІНОК РЕПРОДУКТИВНОГО ВІКУ З ГІПЕРТОНІЧНОЮ ХВОРОБОЮ СЕРЦЯ І СТАДІЇ

Наталія Стратій[1AB], Людмила Сичова[1BCE], Ірина Качайло[1BDE], Віталій Гаргін[1BDE]

Харківський національний медичний університет

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

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Історія питання. Гіпертонічна хвороба серця (ГХ) – це хронічне захворювання, що вражає різні системи організму і особливо несприятливою є для жінок репродуктивного віку.

Мета дослідження – розробка комплексної програми фізичної реабілітації молодих жінок, хворих на гіпертонічну хворобу серця I стадії, на амбулаторному етапі реабілітації та оцінка її ефективності.

Матеріали та методи. 42 молоді жінки з діагнозом ГХ були рандомно розподілені на дві групи: з проведенням традиційної фізичної реабілітації (контрольна група) та методикою за системою пілатес. Проводили опитування, тест Мартіне-Кушелевського, модифікований тест Ромберга, тест Дешина.

Результати. Про вдосконалення запропонованої методики свідчить анкетування та обстеження для визначення лікувальних завдань у застосуванні фізичної реабілітації. Показники тесту Мартіне-Кушелевського покращилися з 2,46 бала до 5,48 ($p<0,01$), що краще ($p<0,05$) порівняно з традиційною методикою, де він змінений з 2,44 до 4,61 ($p<0,01$). Тест Котова-Дешина свідчить про рівномірне покращення в обох групах, але тест у жінок основної групи покращився з «незадовільного» до «доброго», а у жінок контрольної групи з «незадовільного» до «задовільного» зі значно кращими результатами в основних групі ($p<0,05$). Розподіл результатів проби Ромберга свідчить про покращення вестибулярної стійкості в усіх учасників основної групи.

Висновки. Запропонована програма комплексної фізичної реабілітації хворих на гіпертонічну хворобу серця I стадії за методом пілатесу є ефективною. Під впливом цієї програми відбулося значне зниження ЧСС, систолічного і діастолічного тиску, поліпшення відповіді серцево-судинної системи на функціональну пробу Мартіне-Кушелевського, а також

стану дихальної та нервової систем, про що свідчать насамперед показники гіпоксичних проб, спірометрії, кліно- та ортостатичної проб, тестів Ромберга та Дешина.

Ключові слова: гіпертонічна хвороба серця, пілатес, жінки, артеріальний тиск.

Information about the authors:

Stratiy, Nataliia: nv.stratii@knmu.edu.ua; https://orcid.org/0000-0002-2053-6027; Department of Physical Education and Health, Kharkiv National Medical University, Nauki 4, Kharkiv, 61022, Ukraine.

Sychova, Ludmila: lv.sychova@knmu.edu.ua; https://orcid.org/0000-0003-4406-421X; Department of Sports, Physical and Rehabilitative Medicine, Physical Therapy, Ergotherapy, Kharkiv National Medical University, Nauki 4, Kharkiv, 61022, Ukraine.

Kachailo, Iryna.: ya.kachailo@knmu.edu.ua; https://orcid.org/0000-0002-9892-4353; Department of Department of Obstetrics, Gynecology and Pediatric Gynecology, Kharkiv National Medical University, Nauki 4, Kharkiv, 61022, Ukraine.

Gargin, Vitaliy: vitgarg@ukr.net; https://orcid.org/0000-0001-8194-4019; Department of Pathological Anatomy, Kharkiv National Medical University, Nauki 4, Kharkiv, 61022, Ukraine.

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ORIGINAL SCIENTIFIC ARTICLE

PSYCHOLOGICAL INDICATORS ENSURING EFFICIENCY OF A CHESS PLAYER'S COMPETITIVE ACTIVITY

Vardan Geghamyan[1ABCD] and Silvi Tarjumanyan[2ABCD]

[1]Armenian State Institute of Physical Culture and Sport
[2]European University of Armenia

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

Corresponding Author: Silvi Tarjumanyan, E-mail: silvitarjumanyan@yahoo.com
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Abstract

Background. The paper is based on the discussion of psychological problems in modern chess, which are significantly related to the rapid growth of chess competitiveness in recent years, the frequency of participation in competitions, the intensity of competition and other similar manifestations.

Study purpose. We aimed to identify the most important psychological indicators that ensure the effectiveness of a chess player's competitive activity, to describe their correlational relations and the peculiarities of their manifestation.

Materials and methods. The research process was carried out with the use of interconnected laboratory-instrumental and non-instrumental methods, which are of great practical importance in psychology: questionnaires, tests, observations, mathematical statistical methods as well as self-developed "psychodiagnostic multifactorial" equipment. The research was organized among 30 grandmasters in the National men's chess team of the Republic of Armenia through different years, winners of the World Olympiad, World team tournaments, and the World Cup. It targeted the study of the four main areas of a chess player's psyche: competitive mental reliability, individual psychological characteristics, emotional states and emotional abilities.

Results. As a result of the analysis of correlations, the following 8 patterns were singled out from 52 examined psychological indicators: resistance to internal uncertainty stressors, competitive emotional endurance, personal anxiety, energetic sphere of competitive motivation, psycho-regulation, mobilization preparedness, attention features and complex motor reaction speed. We consider the selected indicators as the leading psychological factors that ensure the competitive process of a chess player.

Conclusions. Effective manifestations of the selected psychological indicators can enable a chess player to perform in a more stable and effective way during decisive competitions. The selected indicators can also describe the level of sports training of a highly qualified chess player and serve as model characteristics of psychological service.

Keywords: model characteristics, psychological indicators, leading factors, chess player, correlations.

Introduction

In the history of world chess the significant increase in the competitive load recently is unprecedented, in terms of both quantity and quality of competitions. Recently, the competitive load in chess has undertaken an exceptional growth, increasing almost 2-3 times compared to the past. Chess players, participating in 15-20 and more international tournaments, do not have time and possibility to recover and prepare for the next plays. The intensity of the competitive struggle has reached the maximum: in the ranking presented by reliable sources (International Chess Federation; Live Chess Rating), the competitions of the grandmasters taking the 1-100th places are held in an almost equal struggle, often their own rating or 0.5 points become decisive. The professional abilities, the quality of the game and the level of training of a chess player in the 100th place do not yield the level of the chess players included in the top 10. In the same way, in every major international tournament, there is an almost equal struggle between chess players in the first and the last places (Schinke, Smith, & McGannon, 2013; Swann, Moran, & Piggott, 2015). Constantly changing regulations raise new issues like participation of chess players in

simultaneous competitions of different ages and genders, matches with different regulations: classic chess, blitz, armegeddon, etc. All this in turn increased the competitive struggle as well leading to an extremely persistent, tense chess "military" battle.

The above-mentioned and other similar manifestations set new psychological problems for the chess player, demanding maximum willpower, high emotional endurance, stress resistance, ability to self-normalize negative mental states, high degree of development of psycho-cognitive processes, as well as individual psychological peculiarities (Schinke, McGannon, & Smith, 2013; Tod, 2017).

In the manifestations of a chess player's different mental phenomena, the study of the relations of personal features unity is very important. The facts show that high competitive results in chess achieve those players, who has unique psychological traits, as targeted goals, appropriate competitive motivation, assurance of positive mental state, etc (Holding, & Pfau, 1985; Gobet, & Simon, 1998; Campitelli & Gobet, 2008).

The disclosure of psychological indicators that ensure the effectiveness of competitive activities will enable to deepen scientific and practical approaches to the mechanisms of the chess player's mental regulation and also to develop appropriate models and tools for their further development and improvement.

Research hypothesis: It is assumed that the psychological indicators ensuring the efficiency of highly qualified chess players' competitive performance have unique correlations and mechanisms of development, as the chess player's activity is highly conscious, which is expressed in solving tactical problems, analyzing situations, making effective decisions and in action plan of the game.

The study purpose is to reveal the most important psychological indicators ensuring the effectiveness of a chess player's competitive activity and to characterize their correlations and peculiarities of manifestation.

Materials and methods

Study participants

The research was organized among 30 grandmasters in the National men's chess team of the Republic of Armenia through different years, winners of the World Olympiad, World team tournaments, and the World Cup.

The studies were carried out in the laboratory of the Sports, Pedagogy and Psychology Department in the State Institute of Physical Culture and Sports of Armenia in accordance with the requirements of the Declaration of Helsinki. The research results were approved by the Ethics Committee of the State Institute of Physical Culture and Sports of Armenia.

Study organization

In order to diagnose the leading psychological indicators ensuring chess player's competitive activity and organize the research process more effectively, it is required to invest modern high sensory technologies and to do selection of methods. The current process of the chess players psychological support offers more perfect ways and interconnected methods to psychologists (Benko & Hochberg, 1991; Rowson, 2001; Stewart, 2013).

Guided by the modern applied principles of sports psychology, we have implemented interconnected and result-compensating laboratory-instrumental and non-instrumental methods during the research.

In order to make the research process more effective, we used the "Psycho-diagnostic Multifactorial" self-made complex device of modified laboratory research methods (Babayan & Geghamyan, 2010), which is designed for psychological research and is widely applied in the field of sport psychology. The device is a complex battery of diagnostic various methods of motivational indicators and mental states with modern high-sensory technical equipment.

Laboratory-instrumental researches were performed by the following methods:

1. Reactometry – types of motor reaction (Prună, & Ionescu-Tîrgovişte, 1987).
2. Tremometry – features of voluntary regulation of tremor (Eakin, Francis, & Spirduso, 2001).
3. Tapping test – This method has many varieties of application with appropriate modifications due to the goals and problems of the research. Our research includes studies of the athlete's neuropsychological concentration and the ability to voluntarily regulate the pace of motor actions (Ilyin, 2003).
4. Electro-skin resistance – emotional tension (Jyh-Jier Ho, 2002).

Non-instrumental methods were performed according to:

1. V. E. Millman Competitive Mental Reliability Questionnaire.
2. V. E. Millman's Pre-start Mental Diagnosis Questionnaire.
3. Spielberger anxiety self-assessment scale (Spielberger, 2010).
4. Eysenck Self-Assessment Test (EPI version) (Eysenck, & Eysenck, 1993).
5. Schulte's table of diagnostic features of attention.
6. Evaluation of the effectiveness of competitive activities.
7. Mathematical statistical methods – the processing of numerical data was directed to the analysis of correlational indicators, based on the results of which several psychological characteristics were given as primary indicators to ensure the effectiveness of the chess player's competitive activity. The methods of mathematical statistics were implemented by StatPlus 2009 computer program.

The research was organized and carried out with the following stages:

In the first stage professional literature sources were studied and analyzed.

In the second stage, research was carried out among 30 grandmasters, included in the National men's chess team of the Republic of Armenia through different years, winners of the World Olympiad, World team tournaments and World Cup.

In the third stage, comparative-correlational analyzes were performed based on the results of the research.

Researches targeted the study of the four main areas of the chess player's psyche:

1. Competitive mental reliability (Gould, Dieffenbach, & Moffett, 2002).
2. Individual psychological characteristics of a person (Batchelder & Bershad, 1979; McGannon & Smith, 2020).
3. Emotional states (Hanton, Neil, & Mellalieu, 2008; Groot, 2008).
4. Psychomotorik abilities (Tod, Andersen, & Marchant, 2009).

The studied indicators, according to the studies of different authors, are the main and leading indicators of showing high competitive results in sports (Dunnington, 2003; Fletcher, Hanton, Mellalieu, & Neil, 2012; Tod, 2017).

Statistical analysis

In order to reveal the primary and essential psychological indicators, out of 52 studied indicators we have selected the most closely related to each other, which can be the main psychological factors ensuring the effectiveness of a chess player's competitive activity. Mainly the indices with r = 0.50 and more eigenvalues were selected. Comparative-correlational analyzes were performed based on the results of the research.

Results

As a result of the analysis of correlations, the following 8 patterns were singled out from the whole of the examined psychological indicators, which manifested direct, mediated and reliable connections both with each other and with other examined psychological indicators. They are the following:

1. Internal uncertainty stressors, which are related to the chess player's health and mood swings, being in a good shape, failures during the competition, getting in a bad position, not being able to carry out the planned tactical task, fears and doubts about failing one's own initiatives, which reduce the level of self-confidence.
2. Competitive emotional endurance, which provides "mental freshness" in competitions, thus supporting to other mental phenomena being more effective: a chess player is able to fully express his own abilities.
3. Personal anxiety, in the presence of a high index of which, a chess player experiences fear and lack of self-confidence.
4. Energetic sphere of competitive motivation: it is manifested in a chess player's conscious and subconscious spheres, formulating desires, aspirations, motives, interests, goals, persistence tendencies for victory.
5. Psycho-regulation: the ability of self-regulation for negative emotions.
6. Neuropsychological concentration: it allows to concentrate on the game in the face of time shortness, negative mental states, various other disturbing circumstances (thoughts, fatigue, etc.).
7. Attention features: creates an opportunity to effectively distribute attention on the board, quickly transform from thoughts to chess pieces and vice versa.
8. Complex motor reaction: ensures precise, effective decision making and actions in a short period of time (blitz, tiebreak, armageddon or classic when time is running out).

We consider the following indicators as the leading psychological factors ensuring the competitive process of a chess player, which is evidenced by the reliable correlation and can be used as model characteristics.

The analysis of the correlations of the mentioned leading indicators also proves that the index of internal uncertainty stressors occupies a central place in the structure of the internal mechanisms of the highly qualified chess players' personality. This indicator manifested direct and mediated reliable correlations with competitive emotional endurance, psychoregulation, competitive motivation, attention features, neuropsychological concentration, personal anxiety and complex motor reaction indicators (see Table 1).

Analyzes of correlational relationships testify that the internal uncertainty stressors, which can arise during every competition and manifest in different nature and degree, require from a chess player high emotional endurance, cause negative mental states, manifestations of different anxiety levels, also right or wrong manifestations of different types of attention mobilization training in competitive situations, which, in its turn, can have an impact on the effectiveness of competitive activities.

Table 1. Reliable Correlations of Chess Players' Internal Uncertainty Stressors with The Main Studied Indicators

N	STUDIED INDICATORS	CORRELATIONS (R)
1.	Competitive emotional endurance	-0.87
2.	Psychoregulation	-0.80
3.	Competitive motivation	-0.75
4.	Attention features	0.72
5.	Neuropsychological concentration	0.62
6.	Personal anxiety	0.57
7.	Complex motor reaction	0.51

The above is also substantiated by our comparative analysis of competitive results, specific competition effectiveness and studied psychological indicators. It becomes clear that stable and reliable competitive results are shown especially by those chess players who have high stability to the stressors of internal uncertainty, which ensures the effective manifestation of other investigated mental indicators, leading to high competitive results.

Discussion

In modern chess, the psychological factor is pushed to the forefront (Holding & Pfau, 1985; Gobet & Simon, 1998), so it is necessary to consider it as a primary condition and regulator ensuring the effectiveness of a chess player's activity. Studies of psychological phenomena by various authors prove that they tried to consider the psychological factor in the athlete's sports training system as a complete and multifaceted manifestation (Grabner, Stern, & Neubauer, 2007), but often it remained at the functional or personal levels (Gould, Voelker, Damarjian, & Greenleaf, 2014; Geghamyan, 2021; Kaczyńska, Kołodziejczyk, & Sałabun, 2021).

The entire process of our research was considered as a complete system of formation of the level of psychological preparation of the athlete, because studies on the psy-

chological factor in chess cannot be based on one mental phenomenon – they must be implemented with complex psychological characteristics.

The leading psychological indicators ensuring the effectiveness of a chess player's competitive activity, their reliable correlative connections and formation mechanisms are clarified. They are the following: stability to the stressors of internal uncertainty, the degree of competitive emotional endurance, the index of personal anxiety, the energy field of competitive motives, the psychoregulation, the degree of mobilization readiness, as well as indicators of attention characteristics and complex motor reaction. As a result of correlation analysis, it was revealed that in the structure of the internal mechanisms of the personality of highly qualified chess players, the index of stability against the stressors of internal uncertainty occupies a central place. The high degree of stability of the latter can contribute to the effective manifestation of other mental indicators, ensuring stable competitive results. Individual indicators may be model specifications for a given sport.

These studies also showed that the above-mentioned correlative reliable connections can undergo significant changes, stabilize along with sports improvement, and new ones appear based on them, which provides an opportunity for further studies of this issue. The above mentioned supports the research hypothesis that highly qualified chess players have unique correlations of psychological indicators and development mechanisms.

Conclusions

Summing up the research results on the correlation of psychological indicators, it can be concluded:

1. The leading psychological indicators of a chess player demonstrate unique reliable correlations in the whole set of studied indicators, which reveals interconnected systems within the internal structure of a chess player's personality, the effective manifestations of which can enable him to perform in a more more stable and effectiv way during decisive competitions.
2. In order to effectively organize the competitive process of highly qualified chess players, it is necessary to take into account the level of a chess player's stress resistance, especially towards internal uncertain stressors, the stability of which will stimulate the realization of potential opportunities.
3. Demonstration of high competitive results in chess can be achieved mainly by effective manifestation of the following indicators: internal uncertainty stressors, competitive emotional resilience, personal anxiety, psycho-regulation, mobilization readiness, attention features, complex motor reaction. The selected indicators can describe the level of sports training of a highly qualified chess player and serve as model characteristics of psychological service.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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ПСИХОЛОГІЧНІ ПОКАЗНИКИ, ЯКІ ЗАБЕЗПЕЧУЮТЬ ЕФЕКТИВНІСТЬ ЗМАГАЛЬНОЇ ДІЯЛЬНОСТІ ШАХІСТА

Вардан Гегамян[1ABCD], Сільві Тарджуманян[2ABCD]

[1]Вірменський державний інститут фізичної культури і спорту
[2]Європейський університет Вірменії

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

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Історія питання. В основу цієї статті покладене обговорення психологічних проблем у сучасних шахах, які значною мірою пов'язані зі стрімким зростанням шахового духу суперництва в останні роки, частотою участі в змаганнях, гостротою суперництва та іншими подібними проявами.

Мета дослідження. У цьому дослідженні ми мали на меті виявити найважливіші психологічні показники, які забезпечують ефективність змагальної діяльності шахіста, описати їхні кореляційні зв'язки та особливості їх прояву.

Матеріали та методи. Процес дослідження здійснювали з використанням взаємопов'язаних лабораторно-інструментальних і неінструментальних методів, які мають важливе практичне значення в психології: анкет, тестів, спостереження, методів математичної статистики, а також самостійно розробленого «психодіагностичного багатофакторного» обладнання. Це дослідження було організоване серед 30 гросмейстерів Національної чоловічої збірної Республіки Вірменія із шахів різних років, переможців Всесвітньої Олімпіади, командних світових турнірів та Кубка світу. Воно було спрямоване на вивчення чотирьох основних сфер психіки шахіста: змагальної психічної надійності, індивідуально-психологічних характеристик, емоційних станів та емоційних здібностей.

Результати. У результаті аналізу кореляційних зв'язків із 52 досліджуваних психологічних показників були виокремлені 8 патернів: стійкість до стресорів внутрішньої невизначеності, змагальна емоційна витривалість, особисте прагнення, енергетична сфера змагальної мотивації, психорегуляція, мобілізаційна готовність, особливості уваги та швидкість

складної рухової реакції. Вибрані показники ми розглядаємо як провідні психологічні фактори, що забезпечують змагальний процес шахіста.

Висновки. Ефективні прояви вибраних психологічних показників можуть дозволити шахістові стабільніше та результативніше виступати у вирішальних змаганнях. Вибрані показники також можуть характеризувати рівень спортивної підготовки шахіста високої кваліфікації та слугувати модельними характеристиками психологічної служби.

Ключові слова: модельні характеристики, психологічні показники, провідні фактори, шахіст, кореляційні зв'язки.

Information about the authors

Geghamyan, Vardan: vardan-gegamyan@mail.ru; https://orcid.org/0000-0001-6516-9120; Department of Sports Pedagogy and Psychology, Armenian State Institute of Physical Culture and Sport, Alek Manukyan St, 11, Yerevan, 0010, Armenia.

Tarjumanyan, Silvi: silvitarjumanyan@yahoo.com; https://orcid.org/0000-0001-6071-9058; Department of psychology, European University of Armenia, Davit Anhaght St, 10, Yerevan, 0037, Armenia.

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ORIGINAL SCIENTIFIC ARTICLE

HIGH-INTENSITY INTERVAL EXERCISE WITH BLOOD FLOW RESTRICTION IMPROVES VASCULAR FUNCTION IN OBESE MALE ADOLESCENTS

Thitiwat Noikhammueang[1ABCD] and Witid Mitranun[1ABCD]

[1]Srinakharinwirot University

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

Corresponding Author: Witid Mitranun, E-mail: mitranunwitid@hotmail.com
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Abstract

Study purpose. Obesity, a chronic metabolic disease is on the rise among children and adolescents and is a leading cause of mortality in adults worldwide. It is imperative to prevent obesity in children to lower the risk of adult obesity and cardiovascular diseases. Considering the effectiveness of exercise program, high-intensity interval exercise with blood flow restriction (HIIE-BFR) may have potential beneficial effects on the vascular functions of obese individuals. This study aimed to compare the acute effects of supramaximal high-intensity interval exercise (HIIE-SUPRA) and HIIE-BFR on the vascular function in obese adolescents.

Materials and methods. The subjects were adolescent males aged 13 to 15. The crossover study was divided into two trials. The first trial was a pilot study involving five obese adolescent males whose heart rates were evaluated under four conditions of exercise: 1) HIIE-SUPRA at 170% (VO_2peak), 2) HIIE-BFR at 85% VO_2peak with 40% arterial occlusion pressure (AOP), 3) 60% AOP, and 4) 80% AOP. The second trial was conducted on ten obese adolescent males who performed HIIE-SUPRA and HIIE-BFR exercises separately, each for at least three days. Data collection was done to analyze the vascular function parameters before and after exercising (immediately, 10 min, 30 min, and 60 min after).

Results. The results of the first trial showed that the mean heart rate of HIIE-BFR at 40% AOP was similar to that of HIIE-SUPRA ($p>0.05$). In the second trial, both types of exercises showed similar outcomes, with increased flow-mediated dilatation (FMD), while brachial-ankle pulse wave velocity (baPWV) decreased after exercise as compared to the baseline values (before exercise) ($p<0.05$). However, HIIE-BFR at 40% AOP demonstrated a lower rate of perceived exertion (RPE) as compared to HIIE-SUPRA ($p<0.05$).

Conclusions. HIIE-BFR at 40% AOP was effective in regulating the RPE and acutely increasing the vascular function after exercise in obese adolescents, similar to HIIE-SUPRA.

Keywords: flow-mediated dilatation, pulse wave velocity, endothelial function, obesity.

Introduction

Obesity is a chronic metabolic disorder that causes endothelial cell dysfunction and is linked to decreased vascular function, i.e., flow-mediated dilatation (FMD) (Tremblay et al., 2019; Zhai et al., 2020; Kwaifa et al., 2020). Recently, a rise in childhood and adolescence obesity has been observed worldwide with a parallel increase in mortality rate linked to high BMI and cardiovascular disease (Collaborators, 2017). Therefore, preventing childhood obesity is critical for lowering the risk of adult obesity and cardiovascular diseases. Obese adolescents have lower physical fitness than normal-weight adolescents (Vandoni et al., 2021), which may be attributed to a negative opinion of exercise, a preference for spending their time alone rather than with others (Salvy et al., 2012), a change in the emotional state, and lesser willingness to participate in long-term workouts (Alberga et al., 2019). ACSM (2020) guidelines advocate moderate-intensity continuous exercise for 150 min per week for obese individuals to improve their cardiac functions and increase energy metabolism (Liguori, 2020; Fragnani et al., 2017). Interval exercise is a time-saving strategy linked to good health (Gibala et al., 2018; MacInnis & Gibala, 2017). An earlier study found that obese male children had higher FMD and lower brachial-ankle pulse wave velocity (baPWV) following immediate supramaximal high-intensity interval training (170% VO_2peak) than that before exercise (Chuensiri et al., 2015). Therefore, supramaximal high-intensity interval exercise (HIIE-

SUPRA) might elicit great health benefits in obese children. However, a high rate of perceived exertion (RPE) may be a cause of concern in these cases.

Blood flow restriction (BFR) exercise is currently gaining popularity as a low-intensity workout that applies external pressure to the arm or leg, decreasing the strain on the joints and muscles. Unlike conventional exercises, it has no harmful effects on the body (Brandner et al., 2018). Previous studies have found that exercise with BFR causes physiological adaptation (increased heart rate), similar to high-intensity exercise in obese adults (Karabulut et al., 2017), athletes (Willis et al., 2016), and hypertensive elderly people (Barili et al., 2018). Regarding vascular function, BFR does not cause damage to the blood vessels during either walking or resistance exercises (Stray-Gundersen et al., 2020; da Cunha et al., 2020). Aerobic exercise with BFR could significantly increase the heart rate when compared to aerobic exercise alone (Barili et al., 2018; Thomas et al., 2018). Hence, HIIE-BFR might have the potential to maximize vascular function while regulating the RPE.

Despite the beneficial effects of HIIE-SUPRA on vascular function, it may be difficult to generalize these findings in adolescents with obesity and low physical fitness. Considering the effectiveness of the exercise program, high-intensity interval exercise (lower workload program when compared to HIIE-SUPRA) with BFR might be a prospective option in adolescents. We hypothesized that HIIE-BFR could yield acute effects on vascular functions comparable to HIIE-SUPRA and might even be more effective in lowering RPE.

Materials and methods

Study Participants

Ten obese male adolescents of Thailand, aged 13-15 years, with a BMI ≥ 1.5 standard deviation above the growth reference data for boys, based on the growth reference criteria of subjects aged 6-19 years, were selected for the study. Participants were excluded from the study if they scored highly on screening tests: Physical Activity Readiness Questionnaires, PAR-Q, or if they had any conditions affecting their musculoskeletal, cardiovascular, respiratory systems, or brain that would impact the results of the study. Written informed consent was obtained from all the participants and their parents prior to the study. The study was approved by the Ethics Committee of Srinakharinwirot University in Thailand (No. SWUEC-G-331/2563E) and conducted in accordance with the Declaration of Helsinki. The protocol was registered on www.thaiclinicaltrials.org (Identifier: TCTR20210716008).

Study Protocol

The study was conducted using a crossover design that included two trials: a pilot study in the first trial, and a comparison of HIIE-SUPRA with HIIE-BFR in the second trial. General physiological traits including body composition, resting heart rate, and blood pressure were assessed. Each person's total arterial occlusion pressure (AOP) for the lower limb (posterior tibialis artery) was measured using a vascular Doppler probe (Duplex Assist Range ACC214, Huntleigh Healthcare, UK). The AOP was marked at the lowest cuff pressure at which there was no pulse and was used as the pressure for the BFR trial. Cycling with and without BFR was performed once during the familiarization period. On the initial visit to the laboratory, baseline FMD and baPWV were measured. These measurements were followed by FMD and baPWV measurements immediately following exercise and three times post-exercise (after 10 min, 30 min, and 60 min). Following completion, cycle ergometer's peak oxygen consumption (VO_2peak) test was conducted to determine the load to be employed during the cycling interval workout. After the completion of the exercise, the exercise pleasure scale (EES) was evaluated (Martinez et al., 2015).

All subjects were instructed to fast for at least 6 hours or eat a light meal for at least 2-3 hours before the vascular function test and take rest for at least 8 hours. The participants were asked not to exercise, consume caffeine, vitamin C, alcohol, medicines, or supplements that might affect vascular function, or smoke, at least 6 hours before the test.

The participants spent 10 minutes for warming up and stretching, followed by 5 minutes of cycling at 50% VO_2peak (50 rpm), 4 minutes of maintaining exercise intensity at 90 rpm, and 5 minutes of cooling down. Eight 20-second bouts of cycling high-intensity interval training were followed by ten seconds of rest per bout (Chuensiri et al., 2015). While exercising, heart rate and RPE were monitored continuously.

1. Pilot Study

Five obese adolescent males took part in the pilot study that involved cycling under four different exercise conditions: 1) HIIE-SUPRA at 170% VO_2peak; 2) HIIE-BFR at 85% VO_2peak with BFR pressure at 40% AOP; 3) 60% AOP and, 4) 80% AOP. Cuff belts (8 cm wide) were wrapped over the proximal regions of both legs during interval exercise with the BFR protocol, and each activity was carried out independently for at least three days. The results of the first trial, which had a mean heart rate similar to that of HIIE-SUPRA, were applied to the second trial.

2. HIIE-SUPRA and HIIE-BFR condition

A crossover design was used in this study (Fig. 1). We compared BFR exercise with a similar mean heart rate to HIIE-SUPRA at 170% VO_2peak in ten obese teenagers who were randomly allocated into two groups: Groups A and B. They are involved cycling interval under two exercise condition: 1) HIIE-SUPRA at 170% VO_2peak; 2) HIIE-BFR at 85% VO_2peak. Each activity was performed separately over a period of at least three days without repeating the protocol sequence within or between the experiments.

Measurement

General physical characteristics

Body composition was measured using an electrical body composition analyzer (Tanita, Japan). Heart rates were assessed using a heart rate monitor (H10, Polar, Finland) at the initial visit, during interval exercise, immediately after the exercise, and three times after the exercise (after 10 min, 30 min, and 60 min).

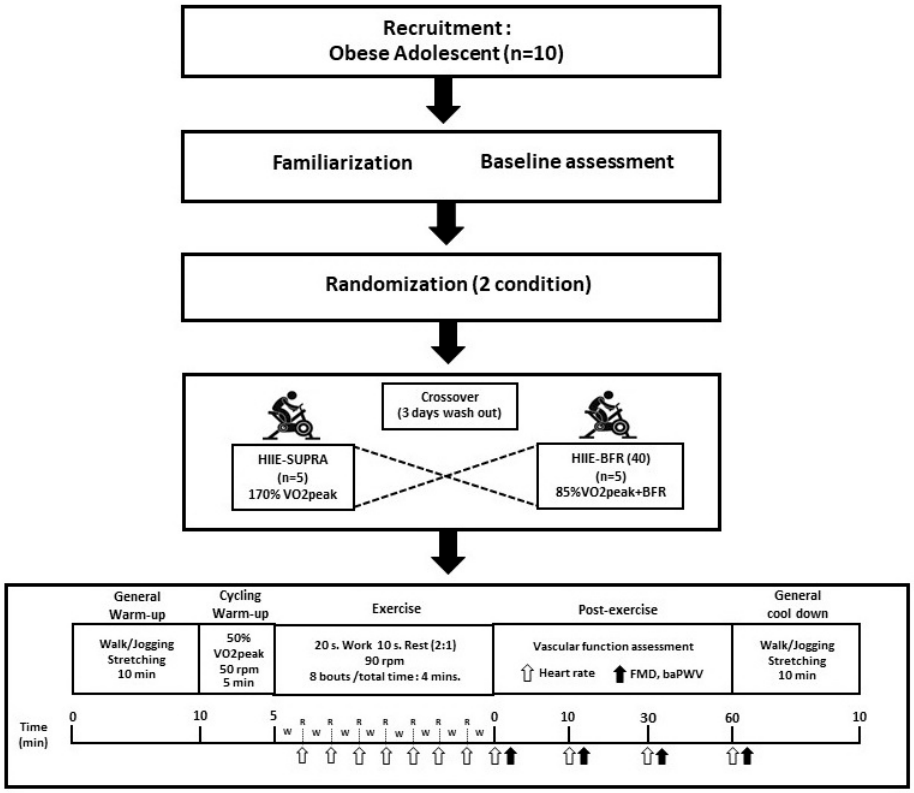

Fig. 1. HIIE-SUPRA and HIIE-BFR exercise protocol. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction

Cardiopulmonary gas exchange analysis equipment was used to calculate the peak oxygen demand (VO_2peak) (Cardio Coach, KORR Medical Technologies, USA). The participants were asked to complete a graded exercise test on a cycling ergometer (Monark Ergomedic 894E Peak Bike) applied by Chuensiri (2015), with the grade and intensity increasing by 20 watts every 3 min until exhaustion or other symptoms indicating maximum potential, such as shortness of breath, dizziness, or participants asking to stop the test. During the cycling interval exercise, the peak workload was used to determine the load.

Vascular function

FMD of the brachial artery was measured using an ultrasound machine (Vivid i-GE Healthcare Cardiovascular Ultrasound System, Tirat Carmel, Israel). The brachial artery was visualized in the longitudinal plane, above the antecubital fossa. After 15 min of supine rest, the subjects had a blood pressure cuff wrapped over their right forearms. Baseline data were monitored for 1 min before being quickly inflated to 50 mmHg above the systolic blood pressure for 5 min and then deflated for 5 min (Mitranun et al., 2014). Ultrasound images were uploaded to a digital software (Brachial Analyzer, Medical imaging application, USA) for offline analysis of vascular data.

The FMD was computed as: (maximum diameter - baseline diameter) × 100 / baseline diameter.

baPWV is a non-invasive vascular screening device (OMRON; Colin VP-1000 plus, Kyoto, Japan) that uses four cuffs placed on both arms and ankles to evaluate arterial stiffness. The individuals were assessed in a supine position, and baPWV was used to compute the time intervals of the brachial waveform and the matching maximum of the ankle waveform. The pressure waveform between the left and right brachial arteries and the posterior tibial artery were examined. The distances between baPWV measurement locations were automatically computed based on the individual's heights.

Statistical Analyses

The data is presented as mean and standard deviation. The Shapiro-Wilk test was used to verify data normality. The difference between the mean heart rates of the pilot study was determined using a one-way repeated-measures analysis of variance (ANOVA) followed by Bonferroni's multiple comparison test. In the second trial, vascular function parameters were compared using a 2 × 5 (group × time) two-way repeated-measures ANOVA. A post-hoc Bonferroni test was used for multiple comparisons. A paired sample t-test was used to assess differences in RPE and exercise enjoyment scales. The significance threshold was set at $p<0.05$.

Results

The mean heart rate was found to be similar under all exercise conditions ($p>0.05$). HIIE-BFR at 40% AOP showed a mean heart rate equivalent to that of HIIE-SUPRA ($p>0.05$) (Fig. 2). The anthropometric data (height, weight, and VO_2max) of the participants are presented in Table 1.

We observed that FMD increased under both workout conditions. The primary outcome of the study was that no significant difference was found between the two exercise conditions in terms of FMD, as shown in Fig. 3.

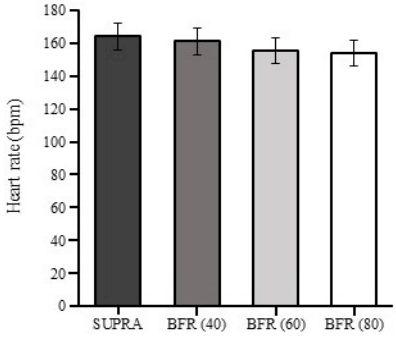

Fig. 2. Comparison of heart rate average during exercise for all pilot study conditions. Abbreviations: SUPRA, supramaximal; BFR, blood flow restriction

Table 1. Participant characteristics.

Variable	Mean	Standard deviation
Age (years)	13.40	0.52
Weight (kg)	82.55	17.60
Height (cm)	165.20	10.18
Body mass index (BMI, kg/m^2)	29.93	3.48
Fat percentage (%)	46.17	8.90
Maximum heart rate (bpm)	198.60	0.52
Resting heart rate (bpm)	90.00	9.73
Systolic blood pressure (SYS, mmHg)	129.00	11.32
Diastolic blood pressure (DIA, mmHg)	76.50	6.41
Peak oxygen consumption (VO_2peak, ml/kg/min)	22.01	8.41
Flow-mediated dilatation (FMD, %)	7.68	3.21
Brachial-ankle pulse wave velocity (baPWV, cm/s)	943.05	112.84

Sample size; 10 subjects

However, when comparing the baseline values with that at 60 min after exercise, it was found that FMD measurements immediately (0 min) and 10 min after HIIE-SUPRA were significantly ($p<0.05$) greater than those at the three time-points (baseline, 30 min, and 60 min). When HIIE-BFR at 40% AOP was observed at the second time point (10 min) after exercise, there was a significant difference ($p<0.05$) greater than baseline and 60 min after activity. Furthermore, the FMD at 30 min after exercise was significantly ($p<0.05$) higher than that at 60 min.

Both protocols showed a decrease in baPWV following exercise, with no significant differences between the two conditions (Fig. 4).

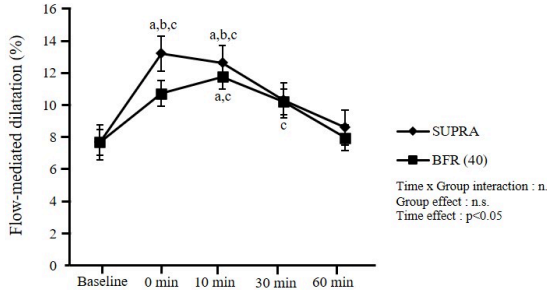

Fig. 3. Flow-mediated dilation change over time during HIIE-SUPRA and HIIE-BFR exercise protocol. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction. Different letters indicate significant differences over time for each condition. a: $p<0.05$, vs. baseline, b: $p<0.05$ vs. 30 min and c: $p<0.05$ vs. 60 min

As shown in Fig.5, after immediate exercise, systolic blood pressure was significantly higher ($p<0.05$) than that at 10 min, 30 min, and 60 min after performing both workouts.

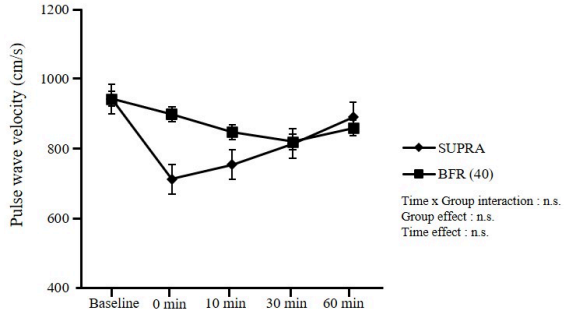

Fig. 4. Brachial Pulse wave velocity change over time during HIIE-SUPRA and HIIE-BFR exercise protocol. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction

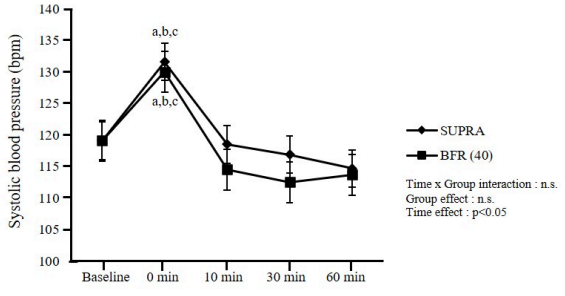

Fig. 5. Systolic blood pressure change over time during HIIE-SUPRA and HIIE-BFR exercise protocol. Different letters indicate significant differences over time for each condition. a: $p<0.05$ vs 10 min, b: $p<0.05$ vs. 30 min and c: $p<0.05$ vs. 60 min. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction

There was no significant difference in diastolic blood pressure or mean arterial pressure between the conditions and time of total exercise (Fig. 6 and Fig. 7).

Finally, we discovered that HIIE-BFR (40) had a significantly lower ($p<0.05$) rating of perceived exertion than HIIE-SUPRA (Fig. 8).

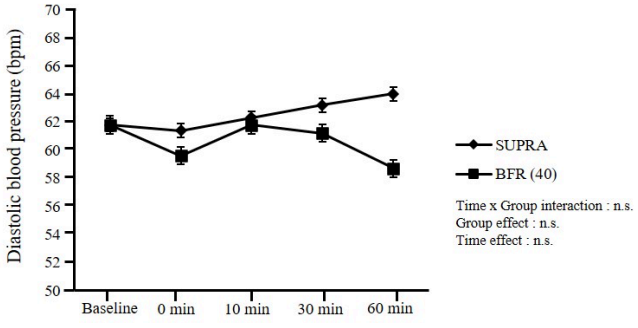

Fig. 6 Diastolic blood pressure change over time during HIIE-SUPRA and HIIE-BFR exercise protocol. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction.

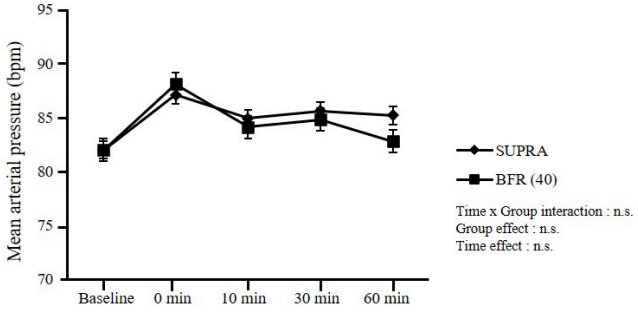

Fig. 7 Mean arterial pressure change over time during HIIE-SUPRA and HIIE-BFR exercise protocol. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction

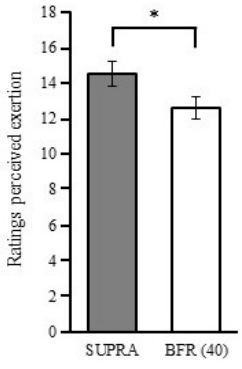

Fig. 8 Comparison rating perceived exertion during HIIE-SUPRA and HIIE-BFR exercise protocol. Abbreviations: HIIE-SUPRA, supramaximal high-intensity interval exercise; HIIE-BFR, high-intensity interval exercise with blood flow restriction

Discussion

HIIE-BFR is expected to maximize vascular function while regulating the RPE in obese individuals. In the current study, we compared the acute effects of HIIE-SUPRA and HIIE-BFR on vascular function in obese adolescents. The major findings of this investigation were as follows: (1) HIIE-BFR at 40% AOP achieved mean heart rate similar to that with HIIE-SUPRA; (2) both types of exercise showed similar outcomes: FMD increased and baPWV decreased; however, not significantly for the vascular function at 40% AOP compared to HIIE-SUPRA condition. These results suggest that HIIE-BFR at 40% AOP has a similar effect on vascular function as compared to that of HIIE-SUPRA in obese male adolescents. Moreover, the HIIE-BFR at 40% AOP showed an improvement in RPE. To our knowledge, this is the first study to investigate the acute effects of heart rate on HIIT-BFR workouts at different pressures, as well as the vascular function between HIIE-SUPRA and HIIE-BFR in obese male adolescents in Thailand.

Some of the reasons for obese adolescents are low physical fitness due to their preference to spend time alone rather than with others, negative attitudes toward exercise (Salvy et al., 2012), changes in emotional state, and hesitancy to exercise for long duration (Alberga et al., 2019). Therefore, short-duration exercises are challenging for obese people. A previous study revealed that a single session of high-intensity intermittent exercise (VO_2peak: 170%) increased the heart rate to approximately 93% of maximum heart rate in obese boys (Chuensiri et al., 2015). In this study, the HIIE-SUPRA condition increased the heart rate of obese adolescents to approximately 82% of HRmax. Furthermore, we observed that HIIE-BFR at 40% AOP in a single session boosted HR during exercise to approximately 81% of HRmax.

BFR exercise is an alternative to conventional exercise regimes and is commonly performed at a low load intensity (Freitas et al., 2021; Lorenz et al., 2021). It is a training approach that restricts arterial blood flow to the muscles while blocking venous blood return during exercise, by wrapping a tourniquet around the muscle and increasing the external pressure (Scott et al., 2015; Patterson et al., 2019). As a result, BFR training may decrease both oxygen delivery and metabolite clearance, creating a more stressful environment and stimulating physiological adaptations, such as increased heart rate and blood pressure (Pope et al., 2013; Bennett et al., 2019). Many studies have shown that exercise with BFR causes an increase in HR in athletes (Willis et al., 2016), inactive adult obesity (Karabulut et al., 2017), hypertensive elderly women (Barili et al., 2018), and healthy males (Silva et al., 2021). Thus, low-intensity exercise combined with BFR appears to have the same effect on the cardiovascular system as high-intensity exercise. In addition, other studies found that continued low-intensity aerobic exercise with BFR did not cause changes in vascular function after 8 weeks (Beak et al., 2022), while low-intensity resistance exercise with BFR promotes vascular function similar to traditional high-intensity resistance exercise (Santos et al., 2015). High-intensity aerobic exercise in combination with BFR is worth researching.

In the vascular function effect, both the HIIE-SUPRA and HIIE-BFR at 40% AOP exercise conditions improved vascular function as measured by FMD, a non-invasive technique for assessing vascular endothelial function and

evaluating changes in brachial artery diameter following an increase in shear stress caused by reactive hyperemia (Mitranun et al., 2014; Ghiadoni et al., 2015; Thijssen et al., 2019). We discovered a 5.54% change in the HIIE-SUPRA condition and a 3.05% change in the HIIE-BFR at 40% AOP condition immediately after the exercise compared to the baseline, then increased for up to 60 min, returning to near baseline. The findings of our study were unexpected because they showed that external compression and low-intensity exercise had the same beneficial effects on blood vessels as high-intensity training. Although there are few studies that assess vascular function in BFR exercise, our results are consistent with a previous study that revealed a 7.49% change of FMD in obese boys immediately after high-intensity intermittent exercise at 170% VO_2max (Chuensiri et al., 2015). A recent study in adults found that interval exercise with a cross-trainer combined with BFR training substantially improved acute response FMD as compared to that with routine training (Wlodarczyk et al., 2022). Additionally, in the present study, the baPWV decreased under both conditions. This is one of the key indicators of arterial stiffness assessment and is the most commonly used technique (Lee et al., 2019). In a previous study, baPWV decreased after acute aerobic exercise in the non-hypertensive and hypertensive groups (Zang et al., 2022). Furthermore, meta-analysis studies have shown that 30 min after aerobic and interval exercises, there is a significant reduction in acute baPWV (Saz-Lara et al., 2021). Thus, the HIIE-BFR exercise trial was effective in improving vascular function in obese male adolescents.

The mechanism of increased vascular function with BFR exercise may be related to the generation of vasodilators. When the tourniquet is relaxed, the blood flow increases dramatically, resulting in increased blood shear stress and blood vessel expansion (Pignanelli et al., 2021). Previous studies in young inactive and exercise trained groups discovered an increase in FMD 30 min after leg press workouts with a cuff wrap placed on the arm (Buchanan et al., 2021). Furthermore, walking interval exercises with BFR did not impair vascular function efficiency (Stray-Gundersen et al., 2020). It could be inferred that when blood flow is restricted during exercise, the blood is retained, which raises blood circulation within the arteries when the pressure from the tourniquet is released. This might elevate shear stress and increase the secretion of a vasodilator (nitric oxide), which enhances vascular function (Pignanelli et al., 2021). This outcome was comparable to that of supramaximal workouts. This could be related to systemic hemodynamics, which causes blood vessels to dilate even in non-constricted locations. Although the vascular response mechanisms of BFR exercise may be difficult to understand and not technically measured, this study clearly showed that HIIE in combination with BFR had a similar effect on vascular function as HIIE-SUPRA.

Our study had some advantages, such as the ability to assess multiple time points of FMD and baPWV. In addition, there have been no reports of injuries after exercise. However, this study has several limitations. First, this study included only adolescent males and had a small sample size. Second, pressure control during exercise might be difficult under non-automatic BFR exercise equipment. Third, we investigated only the acute phase of vascular function following exercise. Further studies are needed to design an exercise program for either short-term or long-term training, as well as to monitor changes in vascular function in obese adolescents.

Conclusions

HIIE-BFR at 40% AOP improved vascular function in obese adolescent equivalent to that of HIIE-SUPRA following a single exercise session. HIIE-BFR at 40% AOP was effective in regulating RPE and acutely increasing vascular function after exercise, similar to that observed with HIIE-SUPRA in obese adolescents. As a result, we believe that HIIE-BFR at 40% AOP can improve vascular function and may be a suitable exercise for obese adolescents.

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Conflict of interest

We declare that there are no conflicts of interest regarding this research.

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ВИСОКОІНТЕНСИВНІ ІНТЕРВАЛЬНІ ВПРАВИ З ОБМЕЖЕННЯМ КРОВОТОКУ ПОКРАЩУЮТЬ РОБОТУ СУДИН У ПІДЛІТКІВ ЧОЛОВІЧОЇ СТАТІ З ОЖИРІННЯМ

Тітіват Нойхаммуеан[1ABCD], Вітід Мітранун[1ABCD]

[1]Університет Срінахарінвірот

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

Реферат. Стаття: 6 с., 1 табл., 8 рис., 38 джерел.

Мета дослідження. Ожиріння, хронічне метаболічне захворювання, стрімко поширюється серед дітей і підлітків і є основною причиною смертності дорослих в усьому світі. Вкрай необхідно попередити ожиріння в дітей, щоб знизити ризик розвитку ожиріння та серцево-судинних захворювань у дорослому віці. Беручи до уваги ефективність програми вправ, високоінтенсивні інтервальні вправи з обмеженням кровотоку (HIIE-BFR) можуть мати потенційний сприятливий вплив на функції судин у людей з ожирінням. Метою цього дослідження було порівняння негайного впливу супрамаксимальних високоінтенсивних інтервальних вправ (HIIE-SUPRA) і HIIE-BFR на роботу судин у підлітків з ожирінням.

Матеріали та методи. Учасниками дослідження були підлітки чоловічої статі віком від 13 до 15 років. Перехресне дослідження було розділене на два випробування. Перше випробування було пілотним дослідженням за участю п'яти підлітків чоловічої статі з ожирінням, частоту серцевих скорочень яких оцінювали за чотирьох режимів виконання вправ: 1) HIIE-SUPRA за рівня 170% пікового споживання кисню (VO_2peak), 2) HIIE-BFR за рівня 85% VO_2peak та за рівня 40% тиску оклюзії артерії (AOP), 3) за рівня 60% AOP та 4) за рівня 80% AOP. Друге випробування було проведене на десяти підлітках чоловічої статі з ожирінням, які виконували вправи HIIE-SUPRA та HIIE-BFR окремо, кожний вид вправ протягом принаймні трьох днів. Збір даних для аналізу параметрів роботи судин проводили до та після тренування (негайно, через 10 хв, 30 хв та 60 хв після).

Результати. Результати першого дослідження показали, що середня частота серцевих скорочень у режимі HIIE-BFR за рівня 40% AOP була аналогічною до частоти серцевих скорочень у режимі HIIE-SUPRA ($p>0,05$). У другому дослідженні обидва типи вправ показали аналогічні результати зі збільшенням потік-опосередкованого розширення (FMD), при цьому швидкість пульсової хвилі в плечощиколотковому відділі (baPWV) зменшилася після виконання вправ порівняно з базовими значеннями (до виконання вправ) ($p<0,05$). Проте режим HIIE-BFR за рівня 40% AOP продемонстрував нижчий рівень індивідуального сприйняття навантаження (RPE) порівняно з режимом HIIE-SUPRA ($p<0,05$).

Висновки. Режим HIIE-BFR за рівня 40% AOP був ефективним у регулюванні RPE та негайному посиленні роботи судин після виконання вправ у підлітків із ожирінням, аналогічно до режиму HIIE-SUPRA.

Ключові слова: потік-опосередковане розширення, швидкість пульсової хвилі, ендотеліальна функція, ожиріння.

Information about the authors:

Noikhammueang, Thitiwat: nuengdinho19@gmail.com; https://orcid.org/0000-0002-3839-504X; Department of Sports Science, Srinakharinwirot University, 114 Soi Sukhumvit 23, Khlong Toei Nuea, Watthana, Bangkok 10110, Thailand.

Mitranun, Witid: mitranunwitid@hotmail.com; https://orcid.org/0000-0002-9334-2696; Department of Sports Science, Srinakharinwirot University, 114 Soi Sukhumvit 23, Khlong Toei Nuea, Watthana, Bangkok 10110, Thailand.

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ORIGINAL SCIENTIFIC ARTICLE

LARGE SIDED GAMES AND SPORT-SPECIFIC TRAINING: PARAMETERS OF HIGH INTENSITY IN PROFESSIONAL SOCCER PLAYERS

Italo Sannicandro[1ABD] and Giacomo Cofano[1ABC]

[1]University of Foggia

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

Corresponding Author: Italo Sannicandro, E-mail: italo.sannicadro@unifg.it
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Abstract

Study purpose. This study aimed to describe, analyze and compare the high intensity in internal and external load deriving from Large-Sided Games (LSG) exercises during the 4vs4 and 5vs5 formats, with goalkeepers.

Materials and methods. The study participants were 22 professional soccer players (average age: 23.59±4.87 years, weight: 77.8±7.6 kg; height: 183.5±7.5 cm). The 4vs4 + 2 goalkeepers format was performed on a 60×54 m field (324 m^2 per player), while the 5vs5 + 2 goalkeepers format was performed on a 65×60 m field (325 m^2 per player). During the two LSG exercises, the internal load and the external load were analyzed. The LSG exercises were performed in 4 sets of 5 minutes each, with 2 minutes of passive recovery between each set.

Results. The data obtained show that the 4vs4 is the LSG exercise that succeeds in ensuring high exercise intensity: the time spent between 90-100% of the Heart Rate (HR) is significantly higher than in the 5vs5 ($p < 0.005$). The average HR values (percentage and absolute) were also higher and significant ($p < 0.05$) in the 4vs4 LSG.

The peak speed ($p < 0.05$), average metabolic power during exercise phases ($p < 0.05$) and sprint distance ($p < 0.005$) are higher in the 5vs5 LSG.

Conclusions. By modulating the practice time, both formats can be used on the day after the match for those who did not play or on the match-day +3 for the whole team.

Keywords: large-sided games, high intensity, soccer, external load, internal load, professional soccer players.

Introduction

The concept of high intensity activities (HIA) in soccer is still an argued issue. If over the years the concept has been frequently approached to the domain of speed (Di Salvo et al., 2007; Di Salvo et al., 2009; Andrzejewski et al., 2014), quite recently the concept has been increasingly linked to the acceleration domain. In this context, some Authors proposed a different definition of high intensity, closer to the acceleration concept: "any movement that reaches or exceeds the sprint threshold velocity for at least 1 second and any movement with an acceleration that occurs within the highest 5% of accelerations found in the corresponding velocity range" (Dwyer & Gabbett, 2012). Currently the HIA have been seen more and more as a product of the speed by the acceleration, leading to the new concept of Metabolic Power (di Prampero et al., 2005; Osgnach et al., 2010). They suggested a synthesis of all these parameters and proposed an estimate of the internal load. It is known from the literature that the energy cost of running at acceleration is similar to running at constant speed on a slope (Osgnach et al., 2010): in fact, knowing the energy cost of running on a slope at constant speed, it was possible to assume this new parameter [Metabolic Power: MP = Csr (energy cost) × v (speed)]. Applying the concept of Metabolic Power to soccer, 43.1 percent of the actions are in a high-intensity zone, instead of only 6.3 percent as previously reported speed approach (di Prampero et al., 2005; Osgnach et al., 2010).

In a high-intensity intermittent sport such as soccer, the physical demands are complex, encompassing both high endurance capacity and fatigue resistance during high intensity exercise (Fransson et al., 2017; Mohr et al., 2005).

Infact, soccer is a high intensity intermittent exercise that requires a high level of physical fitness for players to successfully perform in the game, and it is characterized

by combining high-intensity activities, such as sprinting, running, accelerating, jumping, and changing direction, with low-intensity phases such as stopping, jogging or walking (Haycraft et al., 2017). The average distance covered by players during a soccer match is between 8 and 12 km (Di Salvo et al., 2010), where they perform between 50 and 250 high-intensity actions (Mohr et al., 2003) that represent about 1-12% of the total distance covered (Krustrup et al., 2005) and perform a run at high intensities (>19.8 km•h^{-1}) every 72s (Bradley et al., 2009). In this sense, during the high- and maximum-intensity phases, the energy that a player gets is obtained through anaerobic processes (both phosphagen and anaerobic metabolism), whereas during the general effort of a soccer match (90 or 120 min), it is obtained aerobically (Krustrup et al., 2006). Therefore, having substrates that provide the necessary energy in each phase seems to be an objective to obtain maximal performance (Thomas et al., 2016).

Elite soccer players perform 587±133 m of high speed running (19.8-25.2 km•h^{-1}) and 184 ± 87 m of sprinting (>25.2 km•h^{-1}) during a typical game (Carling et al., 2016). The total distance of high intensity running depends on the position of the player and team success in a league (Di Salvo et al., 2009). The amount of high-intensity running performed during a game also depends on the competitive standards between leagues: top-class professional soccer player performs more high-intensity running compared with moderate professional soccer players (Mohr et al., 2003). Thus, high level of physical performance is an important factor in determining team success in soccer. Due to the high intensity performance required in soccer, players should perform systematic and scientific physical fitness training. Several studies have shown that high-intensity training improves soccer players' fitness levels and skills, such as sprint, strength, and speed endurance (Kotzamanidis et al., 2005; Thomassen et al., 2010; D'elia et al., 2021; Izzo et al., 2020).

In addition, elevation of high intensity running (24–36%) and sprint distance (50%) over 7 seasons (2006–2013) in English Premier League highlights these factors as important qualities for soccer players (Bush et al., 2015).

Some researchers have suggested that distances covered during high intensity running in matches are valid measures of physical performance in because of their strong relationship with training status (Krustrup et al., 2003; Krustrup, et al., 2005) and are a distinguishing characteristic between different standards of player (Mohr et al., 2003; Bradley et al., 2010; Modric et al., 2022). Recent findings using computerised time–motion analysis of elite-standard Italian League soccer players demonstrated that high-intensity running was reduced towards the end of the game and temporarily after intense periods of the game (Mohr et al., 2003, 2005).

The use of Global Positioning Software (GPS) technology to measure players' training loads has become prevalent in professional soccer. The major focus of GPS use has been to identify the activity profiles of players in training or trial matches (Wehbe et al., 2014). Most studies using GPS in soccer have focussed on movement patterns during match and training activities. However, the relationship between GPS variables and other training load measurements has been explored. Total distance, distances measured at various intensities, and Body Load have been shown to correlate significantly with subjective session-RPE–based training loads (Casamichana et al., 2013; Gomez – Piriz et al., 2011; Scott et al., 2013).

During the weekly microcycles, the technical staff use GPS to quantify specific sport exercises to understand if the physical objectives have been achieved especially in terms of high intensity training.

These specific exercises can simultaneously train both the technical-tactical and the physical aspects. They are better known as Small Sided Games (SSG): in the literature, these exercises have been extensively analysed in order to understand how different formats can influence the internal load (Halouani et al., 2017; Martone et al., 2017; Sanchez-Sanchez et al., 2017; Sannicandro & Cofano, 2017), the external load (Sannicandro et al., 2020; Nevado-Garrosa & Suarez-Arrones, 2015; Gaudino et al., 2014) or both (Arslan et al., 2017; Campos Vazquez et al., 2017; Castellano et al., 2015).

The formats used most often by the technical staff are 4vs4 and 5vs5 because they allow players to train with high intensity; these formats are placed above all in the first post-match training sessions for those players who have been used little during the competition (Goto & King, 2019; Clemente et al., 2019; Póvoas et al., 2018; Gonçalves et al., 2017).

One of the goals of the coaching staff is to monitor and increase the intensity of training. For this reason, ball drills on small spaces (SSG) are replaced by ball drills on large spaces called "Large Sided Games" (LSG).

LSG are these sport-specific exercises carried out with a ball, on fields where each player exploits from 270 to 325 square meters (Sannicandro et al., 2021).

Recently, several studies have emerged that have begun to analyze and understand what happens during these exercises performed on large dimensions (Casamichana et al., 2018; Castagna et al., 2019; Riboli et al., 2020; Cofano et al., 2021).

This study aims to describe, analyse and compare the high intensity in internal and external load deriving from LSG exercises during the 4vs4 and 5vs5 formats, with goalkeepers

Materials and methods

Study participants

22 professional soccer players participated (average age: 23.59±4.87 years, weight: 77.8±7.6 kg; height: 183.5±7.5 cm) including 20 forward players and 2 goalkeepers. The goalkeepers were not considered in the data collection of the external and internal load. The study included the players who had not reported injuries in the previous 60 days and who had played at least two matches in the 4 weeks prior to these LSGs. All footballers knew how to work with GPS monitoring systems and heart rate monitors. The study was carried out respecting the principles contained in the Declaration of Helsinki.

Study organization

For the analysis of the internal load, heart rate (HR) and ratings of perceived exertion (RPE) parameters were

measured. The HR measurement was conducted with a telemetry system and heart rate monitors (Polar Electro Oy, Kempele, Finland) and the analysed values are the average HR and the peak HR in beats per minute (bpm) and as a percentage referred to the maximum HR (% HRmax); in addition to the parameters mentioned above, the time spent (sec) at a HR between 80-90% and between 90-100% was also calculated. For the RPE the CR10 Borg scale was used (Borg, 1982). During the two LSG exercises, the players were monitored using global positioning system (GPS) instrumentation at 18.18 Hz (GPEXE® SYSTEM, EXELIO srl, Udine, Italy) recently validated (Hoppe et al., 2018). The parameters detected and examined are: the distance covered per minute (m), maximum speed (peak in km•h^{-1}), the average metabolic power (W• Kg^{-1}), the average metabolic power (W• Kg^{-1}) during the active phases (MPE avg power), maximum metabolic power (W• Kg^{-1}), the number of accelerations (> 2 m•s^{-2}) and decelerations (<-2 m•s^{-2}) and the maximum acceleration and deceleration (m•s^{-2}). Furthermore the distance covered in different speed has been analyzed: high intensity running (19.90-25.20 km•h^{-1}) and very high speed running > 25.2 km•h^{-1} best know as "sprint" (Di Salvo et al., 2013; Rampinini et al., 2007). Also the distance covered at different intensity pf power has been analysed: high intensity power (20.00 - 35.00 W• Kg^{-1}), very high intensity power (35.00 - 50.00 W• Kg^{-1}) and maximal intensity power that is > 50 W• Kg^{-1} (Osgnach et al., 2010).

The LSG exercises were carried out on a natural grass playing field. The 4vs4 + 2 goalkeepers format were performed on a field 60×54 m (324 m^2 per player) while the 5vs5 + 2 goalkeepers format were performed on a field 65×60 meters (325 m^2 per player).

No. 5 soccer balls were used, positioned both inside the goal and outside the perimeter of the field to speed up the match when the ball ended out. Regular goals (7.32×2.44 m) were used. LSG's exercises were carried out with the encouragement from the technical staff and with the limitation of consecutive touches (3) of the ball. The characteristics of the LSGs are summarized in table 1.

Table 1. The SSG formats used in the study

Variable	4vs4	5vs5
Number of Bouts	4	4
Bout Duration (min)	5	5
Resting Duration (min)	2	2
Pitch Dimension (m × m)	60 × 54	65 × 60
Relative Pitch Size (m^2)	1:324	1:325
Goalkeeper	yes	yes
Specific Rules	Max 3 touches	Max 3 touches
Coach Encouragement	yes	yes

Before starting, players have warmed up for about 15 minutes. The warm-up included an aerobic activation phase, dynamic stretching, conditioning exercises for acceleration and exercises with a ball. After the warm-up, players began with LSG exercises: 4 sets of 5 minutes each, with 2 minutes of passive recovery between each set. During the whole exercise, players were monitored through the use of a heart rate monitor in telemetry and GPS instruments. At the end of each exercise, the RPE value was analysed individually. The two formats were carried out in different days, with a recovery pause of at least 48 hours.

Statistical Analysis

Descriptive statistics (M ± SD) was applied to all observed variables; Student's t-test for paired data was used to verify the existence of statistically significant differences between the average values obtained using the Statistical Package for Social Sciences (SPSS 15.0 for Windows) software. Significance was set at $p<0.05$. Cohen's d was used to verify the effect size index. As for the effect size index (Effect Size), after calculating the δ index it is possible to convert it into Effect Size: ≤ 0.20 small; 0.50 average; ≥ 0.80 large (Cohen, 1992).

Results

A paired t test showed that the different between conditions was significant in the following conditions:

- max speed (km•h^{-1}) 4VS4/ max speed (km•h^{-1}) 5VS5(t=-2,776, df=19, p <.05). The effect size is large (d=-1.27);
- MPE avg power (W• Kg^{-1}) 4VS4/ MPE avg power (W• Kg^{-1}) 5VS5(t=-2,288, df=19, p <.05). The effect size is large (d= -1.04);
- distance (> 25.2 km•h^{-1}) 4VS4/ distance (> 25.2 km•h^{-1}) 5VS5(t=-3,235, df=19, p <.005). The effect size is large (d= -1.48);
- max HR bpm 4VS4/ max HR bpm 5VS5(t=-4,569, df=19, p <.005). The effect size is large (d=2.09);
- max HR % 4VS4/ max HR % 5VS5(t=4,236, df=19, p <.005). The effect size is large (d=1.94);
- avg HR bpm 4VS4/ avg HR % 5VS5(t=2,261, df=19, p <.05). The effect size is large (d=1.03);
- avg HR % 4VS4/ avg HR % 5VS5(t=2,435, df=19, p <.05). The effect size is large (d=1.11);
- time 90-100 4VS4/ time 90-100 5VS5(t=3,698, df=19, p <.005). The effect size is large (d=1.69).

The table 2 shows the results of external load recorded in the 4vs4 and in 5vs5 large sided games.

The table 3 shows the results of internal load recorded in the 4vs4 and in 5vs5 large sided games.

Discussion

The aim of the study is to investigate, analyse and compare high intensity during LSG exercises by monitoring internal and external load parameters during SSG, 4vs4 and 5vs5 exercises.

This study extends the analysis conducted in the literature on LSGs: in fact, this type of exercise manages to come very close to the match demands (Riboli et al., 2021; Cofano et al., 2021; Sannicandro et al., 2021).

The 4vs4 and 5vs5 formats were taken into account as they represent the drills that are most used by the technical staff during the weekly micro-cycle.

The analysis of the internal load data shows that the 4vs4 LSG succeeds in producing both higher and significantly higher peak HR values in percentage and absolute terms per minute than the 5vs5 LSG ($p < .005$).

Table 2. Results of external load recorded in the 4vs4 and in 5vs5 large sided games.

Variable	Mean	Std. Dev	SE. Mean	Paired t test		
				t value	df	Sig.(2-tailed)
Max speed (km•h^{-1}) 4VS4	26.57	.87	.19	-2.77	21	.012*
max speed (km•h^{-1}) 5VS5	27.58	.90	.20			
max acc (m•s^{-2}) 4VS4	4.15	.55	.12	.86	21	.398
max acc (m•s^{-2}) 5VS5	4.03	.24	.05			
max dec (m•s^{-2}) 4VS4	-4.88	.32	.07	1.72	21	.101
max dec (m•s^{-2}) 5VS5	-5.05	.41	.09			
avg met power (W• Kg^{-1}) 4VS4	12.03	.70	.15	-.21	21	.834
avg met power (W• Kg^{-1}) 5VS5	12.11	1.30	.29			
max met power (W• Kg^{-1}) 4VS4	87.98	7.85	1.75	.86	21	.401
max met power (W• Kg^{-1}) 5VS5	84.84	9.38	2.09			
MPE avg power (W• Kg^{-1}) 4VS4	22.30	.49	.11	-2.28	21	.034*
MPE avg power (W• Kg^{-1}) 5VS5	22.63	.87	.19			
distance (19.8-25.2 km•h^{-1}) 4VS4	215.68	49.69	11.11	-1.30	21	.208
distance (19.8-25.2 km•h^{-1}) 5VS5	241.54	73.92	16.52			
distance (> 25.2 km•h^{-1}) 4VS4	15.27	7.99	1.78	-3.23	21	.004***
distance (> 25.2 km•h^{-1}) 5VS5	33.84	20.72	4.63			
distance (20-35 W• Kg^{-1}) 4VS4	629.85	64.31	14.38	.24	21	.812
distance (20-35 W• Kg^{-1}) 5VS5	619.96	144.26	32.25			
distance (35-50 W• Kg^{-1}) 4VS4	223.81	51.91	11.60	-1.61	21	.122
distance (35-50 W• Kg^{-1}) 5VS5	248.96	27.58	6.16			
distance (> 50 W• Kg^{-1}) 4VS4	94.26	24.41	5.45	-1.31	21	.205
distance (> 50 W• Kg^{-1}) 5VS5	108.44	30.98	6.92			
acc events 4VS4	27.75	4.33	.97	.07	21	.940
acc events 5VS5	27.60	5.75	1.28			
dec events 4VS4	33.15	8.45	1.89	.38	21	.704
dec events 5VS5	32.20	4.37	.97			
distance/min 4VS4	146.05	6.71	1.5	-.850	21	.406
distance/min 5VS5	149.34	12.21	2.73			

* p < .05, ** p < .01, *** p < .005

Table 3. Results of internal load recorded in the 4vs4 and in 5vs5 large sided games.

Variable	Mean	Std. Dev	SE. Mean	Paired t test		
				t value	df	Sig.(2-tailed)
RPE 4VS4	7.70	.73	.16	-.34	19	.733
RPE 5VS5	7.80	1.19	.26			
max HR bpm 4VS4	189.65	3.29	.73	4.56	19	.000***
max HR bpm 5VS5	182.50	6.09	1.36			
max HR % 4VS4	95.15	1.69	.37	4.23	19	.000***
max HR % 5VS5	91.75	2.65	.59			
avg HR bpm 4VS4	170.90	7.18	1.60	2.26	19	.036*
avg HR bpm 5VS5	165.00	8.17	1.82			
avg HR % 4VS4	85.85	3.73	.83	2.43	19	.025*
avg HR % 5VS5	82.75	3.65	.81			
time 80-90 4VS4	532.95	273.09	61.06	.36	19	.719
time 80-90 5VS5	498.00	296.82	66.37			
time 90-100 4VS4	257.45	296.66	66.33	3.69	19	.002***
time 90-100 5VS5	9.50	14.60	3.26			

* p < .05, ** p < .01, *** p < .005

These data attest to the fact that 4vs4 is the LSG exercise that succeeds in ensuring high exercise intensity, as football training requires.

Confirming this trend, the analysis shows that the time spent between 90-100% of the FC is significantly higher than in the other format ($p < .005$).

The average HR values in both percentage and absolute terms (beats per minute) were also higher and significant ($p < .05$) when comparing 4vs4 and 5vs5.

The value for the time elapsed between 80-90% of FCmax was greater in 4vs4 although not significant; the RPE values were very similar and therefore not statistically significant, standing at 7.70 ± 0.73 for 4vs4 and 7.80 ± 1.19 for 5vs5.

The analysis of the time spent at HR > 80 %, in both formats, was analysed to understand the effects of the use of LSGs on the parameters of high intensity from a cardiovascular point of view: the 4vs4 format allows high intensity HR to be exerted for 62.89 ± 26.47 % of the total exercise time compared to 42.29 ± 29.17 % for 5vs5.

The external load analysis, on the other hand, does not reveal as much significance as did the internal load analysis.

The parameters found to be statistically different and significant were: peak speed ($p < .05$), average metabolic power during exercise phases ($p < .05$) and sprint distance ($p < .005$), which were greater in the 5vs5 exercise.

On the other hand, observation of the peak values and the number of accelerations and decelerations shows that the two formats impose the same neuromuscular load.

Looking at what has been found with the two formats, the reasons why research interest has shifted in recent years to understanding what occurs with LSGs (Asian-Clemente et al., 2021; Dello Iacono et al., 2022) emerges with greater relevance: in this study, it emerges how the density of 324 m^2/player allows for the structuring of drills that can ensure high-intensity exercise for the footballer.

Comparison with other studies in the literature that have monitored internal load parameters reveals data that are not always in agreement: the %HRmax is higher in the formats observed (in 4vs4: 95.15±1.69% and in 5vs5: 91.75±2.65%) than in the Game profile-training circuit (89.4 ± 2, Dello Iacono et al., 2021) and in another LSG exercise in the literature (86.5 ± 4.5%, Casamichana et al., 2018).

RPE values, on the other hand, are broadly similar compared to the two studies mentioned above.

The participation levels, the aerobic fitness levels of each footballer and the different duration of the exercises may have substantially influenced the internal load data, thus explaining the differences between the studies conducted (Aliberti et al., 2021; Dello Iacono et al., 2021; Zurutuza et al., 2021).

Observation of some high-intensity indicators referring to the external load shows that the distance/minute in both 4vs4 and 5vs5 is slightly lower (4vs4: 146.05±6.71 m/minute, 5vs5: 149.34±12.21 m/minute), than during a sport–specific training circuit (153.1±3.9 m/minute) based on the football performance model (Dello Iacono et al., 2021).

On the contrary, the LSG formats analysed of 4vs4 and 5vs5 manage to ensure a higher distance/minute than exercises carried out in the form of matches in which the values stop at 107.6±14.4 m/minute (Zurutuza et al., 2020), 121.9±2.9 m/minute (Owen et al., 2014) and finally 105.4 ± 10.7 m/minute (Martin-Garcia et al., 2019).

Even when comparing with other studies that have monitored LSGs with the 5vs5 format (Casamichana et al., 2018), the values found in this study are higher for both formats observed.

Analysing the two speed thresholds (19.8-25.2/ > 25.2 $km \bullet h^{-1}$) that attest the distance travelled at high intensity shows that in LSG drills, the values of total metres travelled within the two thresholds are higher than during 10vs10 + GK (Owen et al., 2014) or during official matches (Martin-Garcia et al., 2019); on the other hand, comparisons with other types of sport-specific drills are very difficult, where there has been an attempt to structure a Game profile-training circuit capable of reproducing the same match intensities (Dello Iacono et al., 2021).

The data observed in this study confirm that LSGs are an exercise that effectively stresses the player to meet the demands of match performance (Andrzejewski et al., 2013; Haycraft et al., 2017; Izzo et al., 2020).

In the analysis of the distance travelled at high power (> 20 $W \bullet Kg^{-1}$), it is observed that these values are lower than during the 5vs5 + GK already used in the literature (Goto & King, 2019): however, the different training volume adopted (35 min vs. 20 min) may be the parameter that explains these differences.

The peak velocity (in 4vs4: 26.57±0.87 $km \bullet h^{-1}$, in 5vs5: 27.58±0.90 $km \bullet h^{-1}$) appears to be higher than both other LSG formats that obtained a value of 22.31±2.15 $km \bullet h^{-1}$ (Casamichana et al., 2018) and during a drill that mimics the match where a value of 24.7±0.7 $km \bullet h^{-1}$ is found (Owen et al., 2014).

The peak velocity observed in the two LSGs is very similar to that recorded during official matches (Abbott et al., 2018; Redkva et al., 2018).

A final consideration to be made concerns the comparison of the values obtained in the LSG formats observed in this study with what emerges in the most intense 3,4,5 and 10 minutes recorded during an official competition (Riboli et al., 2021): the values of 4vs4 and 5vs5 are always higher than these indicators observed in competition.

Conclusions

In conclusion, the data from this study can be transferred to field practice.

In organising training, the data from this study can support the choices of the staff. Indeed, LSGs, both in the 4vs4 and 5vs5 formats, seem to reproduce more reliably what emerges in the performance profile of the competition (Riboli et al., 2021).

By modulating the exercise times (even with volumes of more than 20 minutes), both formats can be used to train players who have partially taken part in the match on the day after the match; they can also be particularly useful in the match-day +3 in which the entire team is involved at the same time with sport-specific and general exercises that aim to reproduce match intensities.

Conflict of interest

The authors declare no conflict of interest

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ІГРИ ВЕЛИКИМИ НЕПОВНИМИ СКЛАДАМИ ТА СПЕЦІАЛЬНІ СПОРТИВНІ ТРЕНУВАННЯ: ПАРАМЕТРИ ВИСОКОЇ ІНТЕНСИВНОСТІ В ПРОФЕСІЙНИХ ФУТБОЛІСТІВ

Італо Саннікандро[1ABD], Кофано Джакомо[1ABC]

[1]Університет Фоджа

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

Реферат. Стаття: 6 с., 1 табл., 8 рис., 38 джерел.

Мета дослідження. Метою цього дослідження було описати, проаналізувати та порівняти високу інтенсивність внутрішнього та зовнішнього навантаження, що випливає з виконання вправ з ігор великими неповними складами (LSG) під час виконання вправ у форматах 4 на 4 та 5 на 5 з воротарями.

Матеріали та методи. Учасниками дослідження стали 22 професійних футболісти (середній вік: 23,59±4,87 року, вага: 77,8±7,6 кг; зріст: 183,5±7,5 см). Вправу у форматі 4 на 4 + 2 воротарі виконували на полі розміром 60×54 м (324 м^2 на гравця), а вправу у форматі 5 на 5 + 2 воротарі – на полі розміром 65×60 м (325 м^2 на гравця). Під час виконання цих

двох вправ LSG проводили аналіз внутрішнього та зовнішнього навантаження. Вправи LSG виконували в 4 підходи по 5 хвилин кожен, з 2 хвилинами пасивного відпочинку між кожним підходом.

Результати. Одержані дані свідчать про те, що формат 4 на 4 – це вправа LSG, яка успішно забезпечує високу інтенсивність вправи: час, витрачений на 90-100% частоти серцевих скорочень (ЧСС), статистично значуще вищий, ніж у форматі 5 на 5 ($p < 0,005$). Середні значення ЧСС (у відсотках та абсолютні) також були вищими та статистично значущими ($p < 0,05$) у форматі виконання вправи LSG 4 на 4.

Пікова швидкість ($p < 0,05$), середня метаболічна потужність під час виконання фаз вправ ($p < 0,05$) і дистанція спринту ($p < 0,005$) є вищими у форматі виконання вправи LSG 5 на 5.

Висновки. Модулюючи час виконання вправ, обидва формати можна використовувати на наступний день після матчу для тих, хто не грав, або через три дні після матчу для всієї команди.

Ключові слова: ігри великими неповними складами, висока інтенсивність, футбол, зовнішнє навантаження, внутрішнє навантаження, професійні футболісти.

Information about the authors:

Sannicandro, Italo: italo.sannicandro@unifg.it; https://orcid.org/0000-0003-1284-2136; Department of Humanities, Literature, Cultural Heritage, Education Sciences, University of Foggia, Via A. Gramsci 89/91, 71122 Foggia, Italy.

Cofano, Giacomo: giacomo.cofano@unifg.it; https://orcid.org/0000-0001-9973-1740; Sciences and techniques of preventive and adapted motor activities, Professional soccer strength and conditioning coach, University of Foggia, Via A. Gramsci 89/91, 71122 Foggia, Italy.

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ORIGINAL SCIENTIFIC ARTICLE

RELATIONSHIP BETWEEN TALENT IDENTIFICATION AND CHANGE OF DIRECTION IN YOUNG BASKETBALL PLAYERS

Arturo Quílez-Maimón[1ABCD], Jesús Siquier-Coll[1ABCD], Carlos Arrondo Nadal[1ABCD], Filipe Manuel Clemente[2ABCD] and Francisco Tomás González-Fernández[3ABCD]

[1]Comillas Pontifical University
[2]Polytechnic Institute of Viana do Castelo
[3]University of Granada

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

Corresponding Author: Arturo Quílez-Maimón, E-mail: arturoquilez@gmail.com
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Abstract

Study purpose. Regarding Talent identification (TID) programs, which are an integral part of the selection process for elite-level athletes, the authors detected a lack of evidence, as surprisingly little research has been conducted to elucidate the effects of Change of Direction (COD) test performance on TID in basketball. This study aimed to: i) analyze the anthropometrical measures, performance variables of COD and talents values of each basketball player, ii) conduct through a COD test, a talent identification procedure in basketball, and iii) run a correlation analysis to try to explain the relationship between COD test and basketball talent through either offensive and defensive skills.

Materials and methods. A cross-sectional study was conducted on nineteen youth basketball players (age = 15.68 ± 1.20 years; height = 188.84 ± 5.81 cm, and weight= of 75.74 ± 8.37 kg) with at least 3 years of experience. To assess the overall performance of the selected players, a questionnaire regarding either offense or defense variable was used. In addition, players were required to perform V-Cut, 5-0-5 and Illinois Dribbling tests. Single beam photocells (Chronojump Boscosystem) were used and 3D motion capture system with a video camera set at 210 Hz (CASIO EX-ZR800) recorded the entire action.

Results. Findings point out that the players' COD test result correlates positively [505 test (Contact time, r = 0.62, p = 0.004 and COD deficit, r = 0.55, p = 0.01) and Illinois Dribbling test [velocity (r = 0.45, p = 0.04)] with offensive skills whilst it correlates negatively [Illinois Dribbling test (r = -0.46, p = 0.04)] with defensive skills.

Conclusions. This study highlights the importance to perform a multidisciplinary approach considering either the coaches' assessment and players' COD performance to provide relevant information for TID.

Keywords: COD, basketball, talent identification, multidisciplinary approach.

Introduction

Basketball is one of the most popular team sports, being played world-wide. Several varieties of athletic skills can be valuable indicators of a talented player (Anshel & Lidor, 2012). In this sense, it must be mentioned that testing these skills might be useful as a Talent Identification (TID) screening process which might help trainers and scouts to make the best decisions during player selection of different competitive levels and field positions (Till et al., 2013). The talent detection process must have the ability to recognize athletes at younger ages, thus being able to generate more opportunities for success for people with more potential (Johnston et al., 2018). Many investigators have taken this matter into consideration, resulting in a rapid growth of the interest on the link about talents and sports in the last decade (Lidor et al., 2009). However, to the best of our knowledge, there are no previous studies available on talent in basketball. In fact, the detection of talent in basketball has been changing over time, several studies put the effort on relevant anthropometric aspects (Erčulj et al., 2009). Likewise, coordination and precision measures were found to successfully discriminate between skills levels, as well as physiological data, age, playing position and fitness (Gonaus & Müller, 2012; Till et al., 2016) however, these values must

be complemented by performing sprints and agility tests, such as Change of Direction (COD) tests (Pino-Ortega et al., 2021).

The ability to accelerate, stop quickly, turn or change of direction (COD), and accelerate again is an essential part of the motor skills of a basketball player (Paul et al., 2016). COD speed predominately characterizes the ability of the athletes during running to decelerate in the shortest possible time and to re-accelerate quickly in a new direction (Chaabene et al., 2018). On one hand, biomechanical aspects as the acceleration phase, the deceleration, the contact of the foot in the change and finally the acceleration towards the new destination are to be considered crucial phases to obtain the best performance (McBurnie, 2021). On the other hand, physiological aspects are crucial too; during COD tasks, two distinct forms of muscle actions are required to quickly decelerate (eccentric action) and accelerate (concentric action) the body during movement. More specifically, eccentric muscle strength may influence CoD speed performance to a high degree because it allows athletes to quickly decelerate the body during high movement velocities which is an important prerequisite for the subsequent acceleration phase of the body and the overall performance of COD tasks (Nimphius et al., 2016).

In this context, COD speed represents the physical quality of agility while perceptual and decision-making factors constitute the under-lying cognitive components of agility (Sheppard & Young, 2006). The muscle that helps improve COD is the hamstring at the time of deceleration. Authors as Gonzalo-Skok et al., (2015) explain that eccentric braking force is necessary to decrease braking time and improve COD. Besides, previous studies have examined whether COD speed is related to other physical fitness components such as speed, muscle strength, and muscle power (Brughelli et al., 2008; Sheppard & Young, 2006).

Unfortunately, there is a lack of practical, ecologic tools to assess TID in basketball (Johnston et al., 2018). Hence, new methods designed to identify young athletes with the potential for success in both U18 and U21 elite sport are needed such as test that give valid, sensible and reliable information. Following Quílez-Maimón et al. (2021), tests can be classified into field or laboratory tests; field test contribute to add an ecological approachment which is more likely to be transferred to real game situations. Consequently, field tests must be sensitive enough to detect very small changes (Pardos-Mainer et al., 2019). Accordingly, Pino-Ortega et al. (2021), mention that agility tests are necessary to identify young talents, as well as Suarez-Arrones et al. (2020) explain, COD is the result of agility and, therefore, performing COD tests will allow the evaluation of the concept of agility, which is a key point in talent identification in basketball.

However, very few studies have tested the relationships between basketball TID and performance among young basketball players. Nevertheless, it is pertinent to consider, following Dežman et al. (2001), either offensive and defensive variables to assess talent factors and correlate results with COD test. Following the above literature mentioned, the present study aims to: i) analyze the anthropometrical measures, performance variables of COD (505 test, VCut test and Illinois Dribling test) and talents values of each basketball players, ii) to conduct through a COD test, a talent identification procedure in basketball and iii) run a correlation analysis to try to explain the relationship between COD Test and basketball talent of attack and defense. The hypothesis of the study is that COD test are directly correlated to talent identification screening process. Authors expect that the results obtained in this study will set the definition of talent identification methods for trainers and scouts in the future.

Materials and methods

Study design

This study followed a cross-sectional design. A convenience sampling was performed. The study was approved by scientific council of Pontifical University of Comillas (code: 2021/64), and the Research Ethics Committee of the Pontifical University of Comillas (2021/90) and followed the Declaration of Helsinki ethical standards for the study in humans. The team staff was informed about the objectives of the study, and the research team ensured that parents or guardians signed their informed consents after having received details of the possible benefits and risks of the study.

Setting and context

The study occurred on 3 May 2022, corresponding to end season. The data collection was preceded by 48 hours of rest. In the day of data collection, the players' coaches answered to a questionnaire centered in the offensive and defensive behaviors of each player aiming to classify players in terms of offensive and defensive talent. After that, the COD assessments were executed on the players itself, and with the following sequences: (i) V Cut test; (ii) 5-0-5 test; and (iii) Illinois test. Players performed 2 trials for each test and rested 3 minutes between tests. The tests were preceded by a standardized warm-up protocol of 12 minutes consisting in standardized range-of-motion warm-up plus ballistic stretching. The data collection was performed in an indoor court, between 10:30h and 12 hours of the day with an average temperature of 21ºC and relative humidity of 60%.

Participants

Concerning the sample size, the next equation was used: Sample Size = $Z2 \times (p) \times (1 - p)/C2$, where Z = confidence level (95%); p = 0.05 and C = margin of error 0.05. Nineteen U21 basketball players voluntarily participated in this study (age= 15.68 ± 1.20 years; stature = 188.84 ± 5.81 cm, and body mass= of 75.74 ± 8.37 kg; 7.64 ± 2.02 years of experience) from the region of Baleares, Spain, were recruited from the Centre for Sport Technification of the Balearic Islands (CTEIB).

The eligibility criteria were: i) to be a member of CTEIB program during the whole academic year, ii) to be a member of male basketball U21 team, and iii) not have suffered any serious injury within the last 3 months previous to the data collection. These players had at least 3 years' experience in basketball practice and took part in high level competitions. In addition, these players trained three days a week (90 min per session) and played one match a week. The training sessions were based on technical and tactical content development (70% of training time), technical

skill improvements (10% of training time), and general improvements in physical condition (20% of training time). Generally, training sessions comprised a warm-up, main part, and cooldown.

Talent identification process

To assess the actual quality or overall performance of basketball players the variables – criteria established by Dèzman were used. Table 1 shows the variables (criteria) to evaluate actual quality of basketball players either on defense and offense:

Table 1. Items of the young talent questionnaire. The defensive and offensive items of the assessment questionnaires are presented. Adapted from Dèzman et al. (2001).

Offensive variables (criteria)	Defensive variables (criteria)
Ball control (BC)	Level of defensive pressure (LDP)
Passing skills (PS)	Defensive help (DH)
Dribble Penetration (DP)	Blocking shots (BS)
Three-point shots (TS)	Ball possession gained (BPG)
Two-point shots (TPS)	Defensive rebounding efficiency (DRE)
Free throws (FT)	Transition defense efficiency (TDE)
Two-and-one plays (TOP)	Playing multiple positions on defense (PMPD)
Efficiency of screening (ES)	-
Offense without the ball (OWB)	-
Offensive rebounding efficiency (ORE)	-
Transition offense efficiency (TOE)	-
Playing multiple positions on offense (PMPO)	-

Secondly, the questionnaire proposed by Dèzman et al. (2001), with the game items about the basketball player's game has been completed by the CTEIB sports responsible, who had specific knowledge for every player and marked out of 5 points either offensive and defensive criteria (see Table 1) for every player. On the other hand, an experimental part has been carried out, composed by three change-of-direction tests, the V-Cut test, the 505 test and the Illinois dribbling test.

Change-of-direction assessment

Players were required to perform three tests, described below, in the day of data collection. Data collect was carried out by the authors. Single beam photocells (Chronojump Boscosystem) were positioned at 80 cm from the floor in the start and end line. The players started with the same preferred foot at 5 cm from the starting point, while using split position. 3D motion capture system with a video camera set at 210 Hz (CASIO EX-ZR800) recorded the entire action.

V Cut Test

V-Cut test is a validated CoD test for basketball players by Gonzalo-Skok et al., (2015), it has a distance of 25 meters, with 4 changes of direction of 45 degrees every 5 meters of distance. Participants must go from the start point to the end point passing through each turn, where there will be a line separated by two cones and the distance between them is 0.7m. For each cone pass to be valid, they must step with at least one foot beyond the line. Two attempts were each player within a 2-minute rest. The best score obtained in the test was used for further data treatment. The coefficient of variation within-subject was 0.43%.

505 Test

The methodology for the 505-COD involved a 10-m linear sprint from a static start, a 180º turn on a predetermined turn leg (right/left) ensuring contact with a designated line, and a 5-m return sprint through an identified finish line. The time taken to complete the final 5 m of the 10-m linear sprint, turn, and 5 m return sprint was recorded (Nimphius et al., 2016). The COD (turn at 180ºC) was performed with preferred leg. For time evaluation, 2 attempts were performed with a recovery time of 2 min between repetitions and the best score of the two repetitions was used for subsequent analysis. Times were measured in sec. The coefficient of variation within-subject was 2.01%.

Illinois dribbling test

It is a test that has a distance of 20 meters at maximum speed, changes of direction and is carried out by driving the ball by hand and bouncing (Matulaitis et al., 2019). As explained by Nimphius et al., (2016), the test has 11 changes of direction, the duration of the test is between 13-19 seconds and the total travel distance is 60 meters and the types of changes of direction found in the test are 90 and 180 degrees. Each participant had 2 attempts, although if the participant lost control of the ball, it must be repeated until a valid one is achieved, two attempts were performed with a recovery time of 2 min between repetitions and the best score of the two repetitions was used for subsequent analysis. The coefficient of variation within-subject was 2.14%.

Statistical analysis

All analysis were conducted using statistical software Statistica (version 13.1; Statsoft, Inc., Tulsa, OK, USA) and the significance level was set at $p<0.05$. Descriptive statistics were calculated for each variable. Normal distribution and homogeneity tests (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all metrics. Subsequently, Pearson's correlation coefficient r was used to examine the relationship between the COD values (505 test, VCut test and Illinois Dribling test) and the talent values (attack mean, deffense mean and overall values) We adopted the following criteria to interpret the magnitude of these correlations: $r \leq 0.1$, trivial; $0.1 < r \leq 0.3$, small; $0.3 < r \leq 0.5$, moderate;

0.5 < r ≤ 0.7, large; 0.7 < r ≤ 0.9, very large; and r > 0.9, almost perfect.

Results

Descriptive statistics were calculated for each variable (Table 2, 3 and 4).

First, a correlation analysis as performed between anthropometric values [i) weight, ii) height and iii) Body Mass Index] and talent values [i) attack mean, ii) defense mean and iii) overall], not revealed any significant correlation. See table 5 for more information.

Posteriorly, A correlation analysis was realized between 505 values [i) time, ii) velocity, iii) contact time, iv) 10m and v) COD_D] and talent values [i) attack mean, ii) defense mean and iii) overall]. A large positive correlation was found between defense skills and Contact time and COD Deficit (r =.62, p= .004 and r =.55, p= .01). (See table 6 and figure 1 for more information.

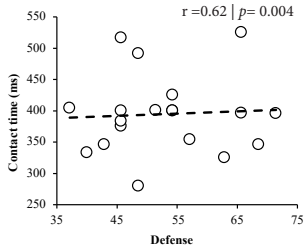

Fig. 1.1

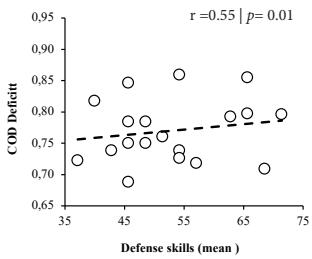

Fig. 1.2

Fig. 1. Representation of significative correlations 505 values (COD deficit) and talent values (Defense mean). Figure 1.1. Correlations analysis between Contact time and defense skills and Figure 1.2. Correlations analysis COD deficit and defense skills

Another correlation analysis was performed between V cut values [i)time, ii) velocity] and talent values [i) attack mean, ii) defense mean and iii) overall]. Crucially, any

Table 2. Antropometrical measures and ofensive and defensive performance variables related to talent questionnary of each basketball players (mean ± SD)

BP (n = 19)																						
	Antropometric measures					Variables on defense							Variables on offense									
	A	H	BM	BMI	LDP	DH	BS	BPG	DRE	TDE	PMPD	BC	PS	DP	TS	TPS	FT	TOP	ES	OWB	ORE	TOE
BP1	15	194.00	80.00	21.30	1.00	2.00	3.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	2.00	2.00	2.00
BP2	15	189.00	73.00	20.40	2.00	2.00	3.00	3.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00	1.00	4.00	4.00	2.00
BP3	14	184.00	70.00	20.70	3.00	2.00	2.00	3.00	3.00	3.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00	1.00	2.00	2.00	2.00
BP4	14	183.00	80.00	23.90	3.00	2.00	4.00	3.00	4.00	4.00	3.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00	2.00	3.00	3.00	2.00
BP5	14	184.00	72.00	21.30	4.00	2.00	4.00	2.00	4.00	3.00	4.00	4.00	4.00	4.00	3.00	2.00	4.00	3.00	2.00	3.00	2.00	4.00
BP6	15	177.00	62.00	19.80	4.00	1.00	2.00	3.00	2.00	2.00	3.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	2.00	2.00	3.00
BP7	15	188.00	68.00	19.20	2.00	2.00	2.00	2.00	3.00	2.00	3.00	3.00	2.00	4.00	3.00	2.00	3.00	3.00	1.00	2.00	2.00	4.00
BP8	15	193.00	71.00	19.10	2.00	2.00	3.00	2.00	3.00	2.00	2.00	3.00	3.00	3.00	4.00	3.00	4.00	3.00	1.00	4.00	2.00	3.00
BP9	15	188.00	75.00	21.20	2.00	2.00	3.00	2.00	3.00	2.00	2.00	3.00	3.00	2.00	3.00	3.00	3.00	2.00	1.00	2.00	2.00	2.00
BP10	15	198.00	100.00	25.50	3.00	4.00	4.00	4.00	2.00	2.00	3.00	2.00	1.00	3.00	1.00	3.00	1.00	3.00	2.00	3.00	4.00	3.00
BP11	18	194.00	85.00	22.60	3.00	3.00	4.00	2.00	1.00	2.00	3.00	2.00	3.00	3.00	2.00	4.00	3.00	3.00	2.00	3.00	4.00	3.00
BP12	17	198.00	76.00	19.40	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	2.00	2.00	2.00	2.00	3.00
BP13	17	198.00	81.00	20.70	1.00	1.00	2.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	4.00	3.00	2.00	2.00	2.00	3.00	3.00
BP14	16	190.00	70.00	19.40	4.00	2.00	3.00	4.00	3.00	4.00	4.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00	3.00	3.00	4.00	3.00
BP15	16	189.00	81.00	25.50	4.00	2.00	4.00	4.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	4.00	4.00
BP16	17	185.00	80.00	23.40	2.00	3.00	3.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00
BP17	17	188.00	75.00	21.20	2.00	1.00	2.00	2.00	3.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00	3.00	2.00	3.00	2.00	3.00	2.00
BP18	16	184.00	75.00	22.20	3.00	2.00	4.00	3.00	3.00	3.00	3.00	2.00	2.00	3.00	3.00	3.00	3.00	3.00	4.00	2.00	4.00	3.00
BP19	17	184.00	65.00	19.20	3.00	1.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00
Mean	15.68	188.84	75.74	21.37	2.63	2.00	3.00	2.58	2.58	2.58	2.74	2.58	2.53	2.79	2.63	2.84	2.95	2.53	2.00	2.74	2.95	2.84
SD	1.20	5.81	8.37	2.02	0.96	0.75	0.82	0.84	0.96	0.90	0.73	0.77	0.84	0.79	0.76	0.69	0.71	0.51	0.94	0.81	0.91	0.69
UCI	17.41	186.23	71.98	20.46	2.20	1.66	2.63	2.20	2.15	2.17	2.41	2.23	2.15	2.44	2.29	2.53	2.63	2.30	1.58	2.37	2.54	2.53
LCI	14.58	191.46	79.50	22.48	3.06	2.34	3.37	2.96	3.01	2.98	3.07	2.92	2.90	3.14	2.97	3.15	3.26	2.76	2.42	3.10	3.36	3.15

Note: BP: Basketball Players; A: Age; H: height; BM: body mass; BMI: Body Mass Index; LDP: Level of defensive pressure; DH: Defensive help; BS: Blocking shots; BPG: Ball possesion gained; DRE: Defensive rebounding eficiency; TDE: Transition defense efficiency; PMPD: Playing multiple positions on defense; BC: Ball control; PS: Passing skills; DP: Dribble Penetration; TS: Three-point shots; TPS: Two-point shots; FT: Free throw; TOP: Two-and-one plays; ES: Efficiency of screening; OWB: Offense without the ball; ORE: Offensive rebounding efficiency; TOE: Transititon offense efficiency; SD: Standard Deivation; UCI: Upper confident interval and LCI: Lower confident interval

Table 3. Anthropometrical measures and mean performance variables of talent questionnaire (attack, deffense and overall) of each basketball players (mean ± SD).

BP (n = 19)							
	Antropometric Measures				Mean Performance Variables		
	A	H	BM	BMI	Attack Mean	Defense Mean	Overall
BP1	15	194.00	80.00	21.30	37.14	40.00	38.57
BP2	15	189.00	73.00	20.40	42.86	50.00	46.43
BP3	14	184.00	70.00	20.70	51.43	41.67	46.55
BP4	14	183.00	80.00	23.90	65.71	46.67	56.19
BP5	14	184.00	72.00	21.30	65.71	63.33	64.52
BP6	15	177.00	62.00	19.80	48.57	40.00	44.29
BP7	15	188.00	68.00	19.20	45.71	53.33	49.52
BP8	15	193.00	71.00	19.10	45.71	61.67	53.69
BP9	15	188.00	75.00	21.20	45.71	46.67	46.19
BP10	15	198.00	100.00	25.50	62.86	48.33	55.60
BP11	18	194.00	85.00	22.60	51.43	58.33	54.88
BP12	17	198.00	76.00	19.40	40.00	46.67	43.33
BP13	17	198.00	81.00	20.70	28.57	48.33	38.45
BP14	16	190.00	70.00	19.40	68.57	60.00	64.29
BP15	16	189.00	81.00	25.50	68.57	66.67	67.62
BP16	17	185.00	80.00	23.40	51.43	70.00	60.71
BP17	17	188.00	75.00	21.20	40.00	48.33	44.17
BP18	16	184.00	75.00	22.20	60.00	58.33	59.17
BP19	17	184.00	65.00	19.20	62.86	66.67	64.76
Mean	15.68	188.84	75.74	21.37	51.73	53.42	52..58
SD	1.20	5.81	8.37	2.02	11.78	9.45	9.24
UCI	17.41	186.23	71.98	20.46	46.43	49.17	48.42
LCI	14.58	191.46	79.50	22.48	57.02	57.67	56.73

Note: BP: Basketball Players; A: Age; H: height (cm); BM: body mass (kg); BMI: Body Mass Index; SD: Standard Deivation; UCI: Upper confident interval and LCI: Lower confident interval

Table 4. COD values (505 test, VCut test and Illinois Dribling test) of each basketball players (mean ± SD)

BP (n = 19)											
	505					V-CUT				IDT	
	T(s)	V (km/h)	CT (ms)	10m (s)	COD	T(s)	V (km/h)	CT (ms)	10m (s)	T(s)	V (km/h)
BP1	2.50	8.40	404.58	1.78	0.72	6.60	13.62	421.25	1.714	15.55	3.63
BP2	2.41	9.05	525.41	1.56	0.85	6.50	13.82	404.583	1.78	15.95	3.76
BP3	2.35	9.16	516.66	1.57	0.78	6.57	13.68	525.417	1.56	17.09	3.51
BP4	2.39	8.86	354.16	1.67	0.71	6.07	14.81	516.667	1.572	16.62	3.60
BP5	2.27	9.43	346.25	1.53	0.73	6.24	14.42	-	-	17.02	3.52
BP6	2.25	9.54	425.41	1.51	0.73	6.27	14.34	346.25	1.539	15.52	3.86
BP7	2.60	8.28	400.00	1.74	0.85	6.87	13.09	395.833	1.597	16.80	3.57
BP8	2.39	9.02	395.83	1.59	0.79	6.57	13.68	425.417	1.518	16.28	3.68
BP9	2.38	9.05	491.66	1.59	0.78	6.34	14.19	400	1.743	15.81	3.79
BP10	2.48	8.74	375.41	1.63	0.84	6.44	13.97	491.667	1.597	17.53	3.42
BP11	2.51	8.53	333.33	1.70	0.81	6.80	13.22	375.417	1.635	16.91	3.54
BP12	2.41	8.94	396.25	1.61	0.79	6.50	13.82	333.333	1.701	16.33	3.67
BP13	2.47	8.66	325.41	1.68	0.79	6.64	13.55	396.25	1.614	16.94	3.54
BP14	2.23	9.18	279.58	1.68	0.55	6.64	13.55	325.417	1.68	16.28	3.68
BP15	2.50	8.44	400.00	1.75	0.75	6.64	13.55	279.583	1.685	17.21	3.48
BP16	2.34	9.16	400.41	1.58	0.76	6.30	14.26	400	1.755	16.44	3.65
BP17	2.23	9.59	400.00	1.51	0.72	5.77	15.58	400.417	1.584	15.88	3.77
BP18	2.38	9.16	346.25	1.61	0.70	6.44	13.97	-	-	15.96	3.75
BP19	2.45	8.54	383.75	1.76	0.68	6.64	13.55	346.25	1.61	17.14	3.49
Mean	2.40	8.94	394.76	1.64	0.76	6.47	13.93	357.04	1.47	3.53	16.54
SD	0.10	0.39	62.88	0.08	0.07	0.26	0.58	140.38	0.52	1.03	0.56
UCI	2.35	8.76	366.48	1.60	0.73	6.35	13.67	293.92	1.23	3.07	16.29
LCI	2.44	9.11	423.03	1.68	0.79	6.59	14.20	420.16	1.70	4.00	16.79

Note: BP: Basketball Players; T: Time (s); V: Velocity; CT= Contact Time; COD_D: Change of Direction deficit; IDT: Illinois Dribling Test.

Table 5. Correlation between anthropometric values [i) weight, ii) height and iii) Body Mass Index] and and talent values (attack mean, defense mean and overall)

	BP (n=19)		
	Height (cm)	Weight (kg)	BMI (%)
AM	r=-.18	r=-.20	r=-.23
	p=.46	p=.39	p=.33
DM	r=-.11	r=.07	r=-.01
	p=.63	p=.76	p=.96
O	r=-.12	r=-.31	r=-.28
	p=.60	p=.18	p=.24

Note: AM: Attack Mean; DM: Defense Mean; O: Overall. * Denotes significance at p<0.05, and ** denotes significance at p<0.01.

Table 6. Correlation between 505 values (time, velocity, contact time, 10m and COD_D) and talent values (attack mean, defense mean and overall)

	BP (n=19)				
	T(s)	V (km/h)	CT (ms)	10m (s)	COD_D
AM	r=-.16	r=.25	r=.05	r=-.35	r=.19
	p=.51	p=.29	p=.81	p=.13	p=.43
DM	r=.07	r=.13	r=.62	r=-.37	r=.55
	p=.76	p=.57	p=.004**	p=.11	p=.01*
O	r=-.071	r=.24	r=.36	r=-.44	r=.41
	p=.77	p=.31	p=.12	p=.06	p=.07

Note: AM: Attack Mean; DM: Defense Mean; O: Overall; T: Time (s); V: Velocity; CT = Contact Time; COD_D: Change of Direction deficit. * Denotes significance at p<0.05, and ** denotes significance at p<0.01.

Table 7. Correlation between V Cut values (time, velocity, contact time, 10m and COD_D) and talent values (attack mean, deffense mean and overall)

	BP (n=19)				
	T(s)	V (km/h)	CT (ms)	10m (s)	COD_D
AM	r=01	r=.10	r=-.08	r=-.11	r=.08
	p=.62	p=.66	p=.72	p=.64	p=.72
DM	r=.01	r=.00	r=.01	r=-.13	r=.13
	p=.97	p=.10	p=.99	p=.59	p=.58
O	r=-.07	r=.07	r=-.05	r=-.14	r=.12
	p=.76	p=.76	p=.81	p=.55	p=.59

Note: AM: Attack Mean; DM: Deffense Mean; O:Overall; T: Time (s); V: Velocity; CT= Contact Time; COD_D: Change of Direction deficit. * Denotes significance at p<0.05, and ** denotes significance at p<0.01.

correlation was found between variables. See table 7 for more information.

Last, a new correlation analysis was performed between Illinois Dribbling test values [i)time, ii) velocity, iii) contact time, iv) 10m and v) COD_D] and talent values [i) attack mean, ii) defense mean and iii) overall]. A negative correlation was found between AM and Time (r =-.46, p= .04) and another positive moderate correlation was found between AM and velocity (r =.45, p= .04). See table 8 and figure 2 for more information.

At this point a correlation analysis was performed between significative values of each test performed, in this case 505 in defense (contact time and COD_D) and Illinois dribbling test in attack (Time and Velocity) and anthropometrical measures (weight, BMI and height). In this respect, dataset revealed a moderate positive correlation between weight and Time (r =.47, p= .04) and other moderate negative correlation between weight and V (r =-.46, p= .04). See table 9 and figure 3 for more information.

Table 8. Correlation between Illinois Dribling test values (time and velocity) and talent values (attack mean, deffense mean and overall)

	Male (n=19)	
	T(s)	V (km/h)
AM	r=-.46	r=.45
	p=.04*	p=.04*
DM	r=-.18	r=.18
	p=.46	p=.43
O	r=-.41	r=.41
	p=.08	p=.07

Note: AM: Attack Mean; DM: Deffense Mean; O:Overall; T: Time (s); V: Velocity * Denotes significance at p<0.05, and ** denotes significance at p<0.01.

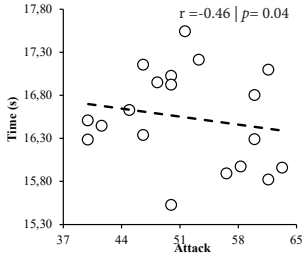

Fig. 2.1

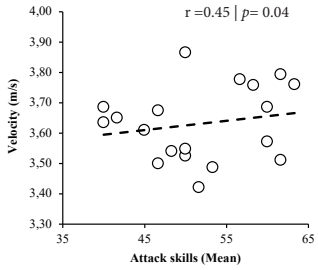

Fig. 2.2

Fig. 2. Representation of significative correlations between Illinois test values (Time and velocity) and talent values (Attack skills mean). Figure 2.1. Correlation analysis between Time and Attack skills and Figure 2.2. Correlation analysis between velocity and attack skills.

Table 9. Correlation between significative values of each test performed, in this case 505 in defense (contact time and COD_D) and Illinois dribbling test in attack (Time and Velocity) and talent values (attack mean, deffense mean and overall)

	Male (*n*=19)			
	Defense		Attack	
	CT (ms)	COD_D	T(s)	V (km/h)
Weight (cm)	r=-.22	r=.32	r=.47	-.46
	p=.36	p=.17	p=.04*	p=.04*
BMI (%)	r=-.41	r=.13	r=.40	r=-.39
	p=.08	p=.58	p=.08	p=.09
Height (cm)	r=-.18	r=.32	r=32	r=-.33
	p=.46	p=.16	p=.17	p=.16

Note: AM: Attack Mean; DM: Deffense Mean; O:Overall; CT = Contact Time; COD_D: Change of Direction deficit; T: Time (s); V: Velocity * Denotes significance at p<0.05, and ** denotes significance at p<0.01.

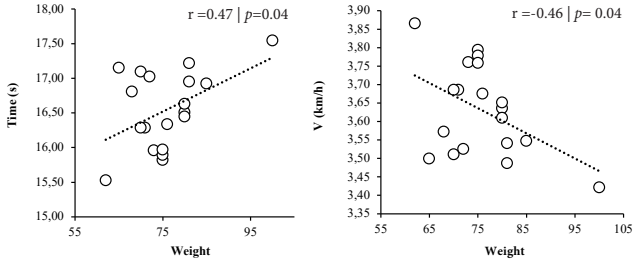

Fig. 3.1 Fig. 3.2

Fig. 3. Representation of significative correlations between significative values (CT and COD of 505 test and Time and velocity of Illinois Dribling test and anthropometrical measures reflected on weight. Figure 3.1. Correlation analysis between Time and weight and Figure 3.2. Correlation analysis between velocity and weight

Discussion

The aim of this study was to identify the possible relationship between the COD and a qualitative test for talent identification in basketball. Physicality-wise, a recent review reported that TID tests in basketball are related to 10-30 m sprinting and agility such as the COD. Thus, accelerations and decelerations become a success factor in basketball performance since they are implicit in the game because they are limited spaces (Pino-Ortega et al., 2021). Therefore, this study focused on the performance of COD tests for TID (505, V-CUT and Illinois). In this sense, COD is considered to be one of the important physical factors for talent identification as mentioned above. Recently, the importance of measuring COD deficit has also been highlighted. Measuring dribble times and dribble deficit during evaluations can allow basketball professionals to accurately determine the effects of training approaches on physical and technical attributes separately. This fact is relevant since the properties of short-duration acceleration and velocity properties are essential for the overall speed of the dribbling motion (Ramirez-Campillo et al., 2021). Thus, the dribbling deficit provides a more isolated measure of dribbling speed than tests using total performance times (Scanlan et al., 2018)

However, it has been mentioned how important it is to involve the coach in TID too. In this regard, (Junior, Vianna, Lauria, Coelho, & Werneck, 2019) reported that coach evaluation is essential and should be part of the TID process. Coaches' performance during years of training can influence TID due to the time spent and the environment involving the player (Roberts et al., 2021). Therefore, a qualitative assessment by the coach has been carried out on the one hand through. This basketball-specific test provides orientation to the player's position and role in the game. Thus, several studies have recently been reported highlighting that a multidimensional approach based on the different physical performance indicators together with the coaches' opinion is necessary for TID (Barraclough et al., 2022; Joseph et al., 2021; Ribeiro Junior et al., 2021). (Gál-Pottyondy et al., 2021) highlight that the relationship of qualitative tools with physical performance factors such as COD is not clear. In this line, this study aims to elucidate their possible relationship.

Considering the above, the results show a strong positive correlation between the defensive skills established by the coaches, the contact time and the COD deficit in the 505 test (see table 3). Thus, players with predominantly defensive skills tend to obtain worse COD skills. However, those players in whom coaches selected with higher attacking average obtained a negative correlation with time and a positive correlation with speed in the Illinos test. Thus, the more exhaustive relationship between position and COD determines a deeper TI (Dežman et al., 2001). This fact leads to an efficiency search due to the model of the club's game. Hence, the correlation between the Dezman questionnaire and the COD obtained could support a further efficient talent identification, providing information towards the player's position (Nasiri et al., 2019) and at the right place on the court according to the game model. In addition, The COD indicates the possible deficits of the players, and, from there, design a plyometric and explosive strength strategy for the improvement of the COD and decrease the incidence of injuries (Stojanovic & Ostojic, 2012). The results of the correlations appear consistent due to the fact that the attacking skills require a greater potential in the COD given the limited spaces per player, being related to a high number of accelerations/decelerations and more displacements of high intensity (Halouani et al., 2014; Hoffmann et al., 2014). In the COD, the stretching-shortening cycle of the muscle is produced. To greater speed in this cycle, the faster the COD will be. Therefore, the performance will be enhanced. It should be noted that this cycle occurs more optimally when there is a higher content of IIx fibers. In addition, the higher content of type IIx fibers will lead to greater performance in specific physical tests of basketball such as short sprints and jumps (Arede et al., 2019). Thus, Cui et al. (2019), reported that leg power is a determining factor for being recruited as a shooting guard, an offensive position where a large number of CODs are produced.

Elsewhere, defensive skills also require COD. However, there are other predominant characteristics. In defense, a greater corpulence is required to reduce the spaces of the attacking player, both for penetration and shooting. This reason could be the reason why defense-related characteristics obtained a positive correlation with a higher contact time and a deficit in COD. Thus, after observing the results, we proceeded to observe the possible correlations between anthropometric characteristics (height, weight and BMI) and the skills evaluated by the coaches. (Karalejic, Jakovljevic, & Macura, 2011) reported that the correlation between certain field tests and some anthropometric parameters indicates that some anthropometric measures could have a moderately negative influence on the results of technical skills tests in 14-year-old players. In this sense, traditionally, the tallest and heaviest players have been placed in positions close to the basket while smaller players belonged to positions farther away (Trninić & Dizdar, 2000; Trninić, Dizdar, & Jaklinović-Fressl, 1999), and the anthropometry of the players may influence their position (Bale, 1991; Ostojic et al., 2006; Young & Pryor, 2007). Thus, for players closer to the basket, a greater body mass is necessary to compete for positions under the basket. Conversely, the less corpulent players are in responsible for bringing the ball up quickly. Therefore, speed and agility are performance factors for these players (Drinkwater et al., 2008). However, in this study no correlation was found between anthropometry and either defensive or offensive skills. This fact could be due to the fact that they are players still in the formative stage, being able to be blamed on the individual physical maturity of each of the players

(Gryko et al., 2018). In this sense, these authors mentioned that maturity in some players could be late, and it could be detrimental to specialize players in a position according to their anthropometric characteristics (Gryko et al., 2019).

Conclusions

Finally, this study provides a multidisciplinary approach to TID, evaluating the COD from different specific tests and taking into account the evaluation of coaches. Further studies correlating defensive and offensive skills are needed to be able to compare the results, as well as studies conducting a multidisciplinary approach to TID. Several limitations exist in this manuscript. The limited number of participants found in this study, the absence of anthropometric parameters such as folds and other performance parameters such as vertical jump. The wide variety of studys found but with by diferents i) designs, ii) talent ranges, iii) variables assessed and iv) durations of the studies (more longitudinal studies is necessary) evidenced that more research is needed. Another limitation might be that other approaches such as psychological were not evaluated. Future research should consider all possible variables to be able to perform a multidisciplinary evaluation for TID. Nevertheless, it should be noted that findings are relevant partly due to the sample of semiprofessional basketball players and their concrete difficulty to access.

The COD is postulated as an essential tool for TID. However, it is important to perform a multidisciplinary approach considering the coaches' assessment. Elsewhere, COD correlates positively with offensive skills whilst correlates negatively with defensive skills. This novel multidisciplinary approach provides relevant information for TID.

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Conflict of interest

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ЗВ'ЯЗОК МІЖ ВИЗНАЧЕННЯМ ТАЛАНТУ ТА ЗМІНОЮ НАПРЯМКУ РУХУ В МОЛОДИХ БАСКЕТБОЛІСТІВ

Артуро Кілес-Маймон[1ABCD], Хесус Сік'є-Колл[1ABCD], Карлос Арондо Надаль[1ABCD], Філіпе Мануель Клементе[2ABCD], Франсіско Томас Гонсалес-Фернандес[3ABCD]

[1]Комільяський папський університет
[2]Політехнічний інститут Віана-ду-Каштелу
[3]Гранадський університет

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

Реферат. Стаття: 10 с., 9 табл., 3 рис., 42 джерела.

Мета дослідження. Стосовно програм визначення талантів (TID), які є невід'ємною частиною процесу відбору для спортсменів висококласного рівня, автори виявили брак доказів: на диво мало досліджень було проведено для з'ясування впливу результатів тесту на зміну напрямку руху (COD) на TID у баскетболі. Метою цього дослідження було: i) проаналізувати антропометричні показники, змінні показників виконання тесту COD і значення талантів кожного баскетболіста, ii) провести тест COD, процедуру визначення талантів у баскетболі та iii) провести кореляційний аналіз, щоб спробувати пояснити зв'язок між тестом COD і баскетбольним талантом через навички нападу або захисту.

Матеріали та методи. Дев'ятнадцять юних баскетболістів (вік = 15,68 ± 1,20 року; зріст = 188,84 ± 5,81 см, вага = 75,74 ± 8,37 кг) із принаймні 3 роками досвіду взяли участь у перехресному дослідженні. Щоб оцінити загальну результативність відібраних гравців, використовували опитувальник щодо змінної нападу або захисту. Крім того, гравці повинні були виконати тест V-Cut (біг ламаною лінією зі зміною напрямку руху в її кутах у формі літери V), тест 5-0-5 (тест на спритність, що передбачає спринт зі змінами напрямку руху на 90 градусів та одним розворотом на 180 градусів) та Іллінойський тест на ведення м'яча. Використовували однопроменеві фотоелементи (Chronojump Boscosystem), а система тривимірного захоплення руху з відеокамерою, налаштованою на 210 Гц (CASIO EX-ZR800), записувала всю дію.

Результати. Результати вказують на те, що показник гравців у тесті COD позитивно корелює [тест 5-0-5 (час контакту, r = 0,62, p = 0,004 та значення змінної «COD дефіцит», яку обчислюють шляхом віднімання часу, витраченого на прямолінійний біг, від загального часу виконання тесту COD, тобто чистий час маневрування, r = 0,55, p = 0,01) та Іллінойський тест на ведення м'яча [швидкість (r = 0,45, p = 0,04)] з навичками нападу, тоді як він негативно корелює [Іллінойський тест на ведення м'яча (r = -0,46, p = 0,04)] з навичками захисту.

Висновки. У цьому дослідженні висвітлюється важливість застосування мультидисциплінарного підходу, враховуючи оцінку тренерів і показники гравців у виконанні тесту COD, щоб надати відповідну інформацію для TID.

Ключові слова: тест на зміну напрямку руху (COD), баскетбол, визначення талантів, мультидисциплінарний підхід.

Information about the authors:

Quílez-Maimón, Arturo: arturoquilez@gmail.com; https://orcid.org/0000-0002-0843-1097; SER Research Group, Center of Higher Education Alberta Giménez, Comillas Pontifical University, Calle, Costa de Saragossa, 16, 07013 Palma, Balearic Islands, Spain.

Siquier-Coll, Jesús: jesussiquier@cesag.org; https://orcid.org/0000-0003-3185-3615; SER Research Group, Center of Higher Education Alberta Giménez, Comillas Pontifical University, Calle, Costa de Saragossa, 16, 07013 Palma, Balearic Islands, Spain.

Nadal, Carlos Arrondo: carlosarrondonadal@gmail.com; https://orcid.org/0000-0002-4763-3580; SER Research Group, Center of Higher Education Alberta Giménez, Comillas Pontifical University, Calle, Costa de Saragossa, 16, 07013 Palma, Balearic Islands, Spain.

Clemente, Filipe Manuel: filipe.clemente5@gmail.com; https://orcid.org/0000-0001-9813-2842; School of Sport and Leisure, Polytechnic Institute of Viana do Castelo; Research Center in Sports Performance, Recreation, Innovation and Technology (SPRINT); Instituto de Telecomunicações, Delegação da Covilhã; Rua Escola Industrial e Comercial de Nun'Álvares, 34, 4900-347 Viana do Castelo, Portugal.

González-Fernandez, Francisco Tomás: ftgonzalez@ugr.es; https://orcid.org/0000-0002-1480-7521; Department of Physical Education and Sport, Faculty of Education and Sport Sciences, University of Granada, Ctra. Alfonso XIII, 52005, Melilla, Spain.

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ORIGINAL SCIENTIFIC ARTICLE

CONTENT AND STRUCTURE OF COMPETITIVE ACTIVITIES OF YOUNG BASKETBALL PLAYERS AGED 13-14

Viktor Koryahin[1ABCDE] and Halyna Hrebinka[1ABCDE]

[1]Lviv Polytechnic National University

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

Corresponding Author: Viktor Koryahin, E-mail: koryahinv@meta.ua
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Abstract

The study purpose was to determine the technical-and-tactical indicators of young basketball players aged 13-14 in the process of competitions and to develop recommendations for assessing the competitive activities of young basketball players.

Materials and methods. The study used the method of pedagogical observations during competitions with recording in a specially developed protocol the following indicators of competitive activity of young basketball players: throws to the basket in motion, two- and three-point throws, free throws, quick breakthrough, positional attack, struggle for rebounding the ball, interception of the ball, "goal assists", technical errors, and other losses of the ball.

Results. As shown by the results of studies of such a technical indicator as throwing the ball into the basket in motion, young basketball players aged 13-14 have the highest accuracy in hitting the basket in this technique of the game – 49.1%. Moreover, the hit percentage (51.6) is higher in the first half of the game than in the second half (46.6) with a high significance level of the difference ($p>0.99$). A similar situation is observed when making two- and three-point shots from the distance. Studies of the effectiveness of free throws have shown that, on average, basketball players aged 13-14 make 14.1 free throws, of which 7.1 hit, which is 52.2 %. Studies have shown that the number of quick breakouts averages 8.45 per game (5.18 in the first half and 3.27 in the second half). The number of possessions of the ball in the fight for the rebound on own backboard is 14.9 times, and on the opponent's backboard – 13.36. The average number of "goal assists" per game is 4.36, ball interceptions – 8.18, technical errors – 15, and other ball losses – 9.54.

Conclusions. Studies of technical-and-tactical indicators of young basketball players during competitions have shown that their role is underestimated in the practice of training young basketball players. The training programs for basic training groups (aged 13-14) shall include in full all technical-and-tactical indicators, and especially throws in motion from under the backboard, two- and three-point shots, "goal assists", free throws, ball losses, interceptions, block shots, struggle for rebound, indicators in a quick breakthrough and in a positional attack, the number of points conceded, etc. It should be noted that there is a higher number of technical-and-tactical indicators in the first half of the game, compared to the second half, with a high significance level of the difference between the indicators. This indicates the growing fatigue of young basketball players and the need to find ways to improve the system of training speed endurance and throwing techniques in a state of fatigue.

Keywords: basketball, technical-and-tactical indicators of young basketball players.

Introduction

Problem statement and analysis of recent research and publications.

In modern basketball, high demands are placed on players not only in terms of physical fitness, which is an important factor itself, but also in terms of their technical and tactical training. (Gonzalo-Skok, Sánchez-Sabaté, Izquierdo-Lupón, & Sáez de Villarreal, 2019; Adigüzel & Günau, 2016; Kondrashin & Koryahin,1978).

The technical-and-tactical preparedness of basketball players in modern basketball is of great importance due to the increase in loads during the game (Koryahin, 2022; Ben Abdelkrim, Castagna, El Fazaa, & El Ati, 2010; Sushko & Mustafa, 2015).

In order to effectively improve the technical-and-tactical preparedness of basketball players, it is necessary to

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know the requirements that the game itself imposes on them (Mitova & Ivchenko, 2015; Sushko, 2017; Koryahin, 2018).

Without a sufficient level of technical-and-tactical fitness based on good physical fitness, it is impossible to ensure a high level of performance during the game (Asadi, 2013; Raiola et al., 2016; Ferreira, Volossovitch, & Sampaio, 2014).

Materials and methods

Study participants and study organization

The research was conducted at the Championship of Ukraine. 29 teams participating in the Ukrainian championship aged 13-14 took part in the research.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Lviv Polytechnic National University.

During the competition, the following indicators were recorded into a specially developed protocol: throws to the basket in motion, two- and three-point shots from the distance, free throws, quick breakthrough, positional attack, struggle for rebounding the ball, interception of the ball, "goal assists", technical errors, other losses of the ball.

Statistical analysis

To keep a log, to perform operations on sorting the obtained research results and storing them, MS Excel was used to calculate statistical data. The choice of methods of mathematical statistics was adequate to the goals and objectives of our research and included the use of the following methods: arithmetic mean according to primary data, average value error and reliability of the difference between the data obtained.

Results

The results of studies of technical-and-tactical indicators of young basketball players aged 13-14 are given in tables 1-3.

The results of the technical-and-tactical indicators of young basketball players aged 13-14 are of particular importance, because in programs for sports schools, the main indicators of competitive activity are offered only for older boys. The program for the age of 13-14 years gives regulatory requirements only for physical, technical training and growth indicators. At the same time, it is known that the principle of complexity is the methodological basis for assessing preparedness in sports games. The importance of such an assessment increases when the level of physical and technical preparedness is compared with the indicators of competitive activity of basketball players.

As shown by the results of studies of such a technical indicator as throwing the ball into the basket (Table 1), young basketball players aged 13-14 have the highest accuracy of hitting in throws in motion from under the shield – 49.1%. Moreover, in the first half of the game, the percentage of hits in these throws is higher (51.6) than in the second (46.6) with a high degree of reliability of the difference (p>0.99). A similar situation is observed in two- and three-point shots from the distance. When making two-point shots, the percentage of hits in the first half of the game was 43.4, in the second half – 38.5 (p>0,999). With three-point shots, the hit percentage in the first half of the game is significantly higher (33.6) than in the second half (20.7) (p>0.999). It was established that in all types of shots recorded – in movement from under the shield, two-point

Table 2. Reliability of differences in technical indicators in the first and second half of the game for young basketball players aged 13-14 during the competition

Indicators	Half the game	Number
Throws in motion after 2 steps	p<0,95	p>0,99
Two-point shots	p>0,99	p>0,999
Three-point shots	p<0,95	p>0,999
Free throws	p<0,95	p<0,95

Source: prepared by the author

Table 1. The results of studies of technical indicators (throwing the ball into the basket) of young basketball players 13-14 years old

Indicators	Half the game	Number of throws	Number of hits	Hits percentage
		X±m; s	X±m; s	X±m; s
Throws in motion after 2 steps	I-a	7.2±1.8; 2.84	3.9±1.3; 2.20	51.6±10.4; 15.7
	II-a	6.9±1.04; 1.57	3.2±0.83; 1.26	46.6±9.63; 14.5
	Total	14.4±2.29; 3.46	7.1±1.04; 1.57	49.1±9.63; 14.5
Two-point shots	I-a	14.1±1.25; 1.89	5.3±0.83; 1.26	43.4±5.64; 8.5
	II-a	15.3±1.67; 2.52	6.5±1.04; 1.57	38.5±4.18; 6.3
	Total	29.4±2.71; 4.09	10.9±1.67; 2.52	40.8±3.55; 5.35
Three-point shots	I-a	3.5±0.62; 0.94	1.1±0.41; 0.63	33.6±3.55; 5.35
	II-a	3.1±0.62; 0.94	0.8±0.2; 1.89	20.7±3.55; 5.35
	Total	6.6±0.62; 0.94	1.9±0.41; 0.63	26.0±3.55; 5.35
Total two-point and three-point shots	I-a	17.0±2.09; 3.15	6.2±1.2; 1.89	36.5±6.06; 9.13
	II-a	17.8±1.88; 2.83	6.3±1.04; 1.57	35.4±4.39; 6.61
	Total	34.8±2.09; 3.15	12.04±1.67; 2.52	35.8±3.97; 5.98
Free throws	I-a	6.2±1.67; 2.52	3.2±1.04; 1.57	50.4±8.77; 13.2
	II-a	7.6±2.09; 3.15	3.9±0.83; 1.26	54.1±7.31; 11.0
	Total	14.1±2.71; 4.09	7.1±1.46; 2.2	52.2±8.77; 13.2

Source: prepared by the author

and especially three-point from the distance in the first half, the percentage of hitting is higher than in the second with a high degree of reliability of the difference (Table 2).

This is due to the growing fatigue of young basketball players and confirms the conclusion made analyzing the level of development of speed endurance in basketball players aged 13-14 that this level is low, and it is necessary to look for ways to improve the system of training speed endurance and throwing techniques in a state of fatigue in young basketball players.

Overall, the percentage of all types of throws hit by young basketball players aged 13-14 during the game averaged 33.4, which is close to the test figures.

Of particular interest are free throws. Studies have shown that, on average, basketball players 13-14 years old make 14.1 free throws, of which 7.1 hit, which is 52.2%.

Of great importance in the theory and practice of basketball is the recording of such technical-and-tactical indicators as a quick breakthrough, its effectiveness, the struggle for rebounds, the effectiveness of an attack under the shield, interception, loss of the ball and others.

Studies (Table 3) have shown that young basketball players aged 13-14 have an average of 8.45 per game (5.18 in the first half, 9.27 in the second). The number of ball possessions in the fight for rebound averages 14.9 times during the game on your shield, and 13.36 times on the opponent's shield. "Goal" assists averaged 4.36 per game, ball interceptions – 8.18. However, at this age, a large number of technical errors were recorded during the game – 15, other ball losses – 9.54. All this indicates an insufficient level of technical preparedness of young basketball players, on the one hand, and on the other – this indicates the need to introduce into the educational programs all technical-and-tactical indicators for all age groups participating in sports competitions.

Table 3. The results of studies of technical-and-tactical indicators of young basketball players aged 13-14

Indicators	Half the game	Number
		X±m; s
Quick breakthrough	I-a	5.18±1.08; 1.57
	II-a	3.27±0.87; 1.26
	Total	8.45±1.96; 2.83
Positional attack	I-a	12.27±1.96; 2.83
	II-a	9.27±1.74; 2.52
	Total	21.54±3.27; 4.72
Fight for rebound, your shield	I-a	7.81±1.74; 1.42
	II-a	7.09±1.08; 1.57
	Total	14.9±1.52; 2.2
Fight for rebound, opponent's shield	I-a	6.63±0.87; 1.26
	II-a	5.81±1.08; 1.57
	Total	13.36±1.74; 2.52
Interception of the ball	I-a	4.54±0.87; 1.26
	II-a	3.63±1.08; 1.57
	Total	8.18±1.74; 2.52
Goal assists	I-a	2.09±0.65; 0.94
	II-a	2.27±0.65; 0.94
	Total	4.36±1.08; 1.57
Technical errors	I-a	7.18±1.61; 2.83
	II-a	7.81±1.31; 1.89
	Total	15.0±3.49; 5.04
Other losses	I-a	5.63±1.74; 2.52
	II-a	3.9±0.87; 1.26
	Total	9.54±1.52; 2.2

Source: prepared by the author

Discussion

The problem of the system of training young basketball players has been studied by many coaches and scientists (Raiola, Altavilla, Tafuri, & Lipoma, 2016; Montgomery, Pyne, & Minahan, 2010; Koryahin et al., 2022).

The results of our research are consistent with the scientific research of many specialists and scientists (Demcenco, 2017; Khudolii, 2019; Tyshchenko, Hnatchuk, Pasichnyk, Bubela, & Semeryak, 2018) on the feasibility of improving the training system for young athletes, in particular, basketball players. In the practice of training young basketball players, the role of technical-and-tactical indicators is underestimated. We believe that our research has fully proved the need to include in the training programs in full all technical-and-tactical indicators, and especially throws to the basket in motion from under the shield, two- and three-point throws, "goal" assists, free throws, ball losses, interceptions, block shots, fight for rebound, indicators in a quick breakthrough and in a positional attack, the number of points conceded, etc.

Training programs (Poplavskyi, Maslova, Bezmylov, Mitova, Murzin, & Chetvertak, 2019) contain only recommendations on the amount of competitive training (number of competitive games / matches), assessment of the level of physical development, assessment of the physical and technical preparedness of young basketball players for enrollment and transfer to groups of basic and special training. The technical-and-tactical actions of basketball players are given in the model indicators of the effectiveness of the implementation of technical-and-tactical actions of highly qualified basketball players.

Obviously, the training programs should provide indicators of throwing accuracy not only for highly qualified basketball players, but also for other age groups, in particular for basketball players aged 13-14. Here it is also necessary to take into account, based on the results of research, the need to differentiate program standards for throws of a different nature to throws from under the ring, the rest of two-point throws and three-point throws. It should be borne in mind that it is necessary to introduce program standards in the halves of the game, since our studies have shown that the percentage of hits in the 1st and 2nd halves of the game has a significant reliable difference.

The need to improve the structure and content of the educational training process of young basketball players was pointed out in their works by a number of specialists (Onyshenko, 2017; Tymoshenko, 1999; Mitova & Ivchenko, 2014).

The results of our research complement the data on the state of training of young basketball players aged 13-14 and

the need to improve curricula for children's and youth sports schools.

Conclusions

Studies of technical-and-tactical indicators in young basketball players during the competition have shown that their role is underestimated in the practice of training young basketball players. In the training programs for basic training groups (13-14 years old), it is necessary to include in full all technical-and-tactical indicators, and especially throws in motion from under the shield, two- and three-point, "goal" assists, free throws, ball losses, interceptions, block shots, struggle for rebound, indicators in a quick breakthrough and in a positional attack, the number of points conceded, etc. It should be noted that there is a higher level of technical-and-tactical indicators in the first half of the game, compared to the second half, with a high level of reliability of the difference between the indicators. This indicates the growing fatigue of young basketball players and the need to find ways to improve the system of training speed endurance and throwing techniques in a state of fatigue.

Conflict of interest.

The authors declare no conflict of interest.

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ЗМІСТ ТА СТРУКТУРА ЗМАГАЛЬНОЇ ДІЯЛЬНОСТІ ЮНИХ БАСКЕТБОЛІСТІВ 13-14 РОКІВ

Віктор Корягін[1ABCDE], Галина Гребінка[1ABCDE]

[1]Національний університет «Львівська політехніка»

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

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Мета дослідження – визначення техніко-тактичних показників юних баскетболістів 13-14 років у процесі змагань і розробка рекомендацій з оцінки змагальної діяльності юних баскетболістів.

Матеріали та методи. У дослідженні був використаний метод педагогічних спостережень під час змагань із занесенням у спеціально розроблений протокол наступних показників змагальної діяльності юних баскетболістів, а саме: кидки у кошик у русі, дво- і триочкові кидки, штрафні кидки, швидкий прорив, позиційний напад, боротьба за відскок м'яча, перехоплення м'яча, «гольові передачі», технічні помилки, інші втрати м'яча.

Результати. Як показали результати досліджень такого технічного показника, як кидок м'яча у кошик у русі, юні баскетболісти 13-14 років мають саму високу точність попадання в цьому прийомі техніки гри – 49.1%. Причому, в першій половині гри процент влучення (51.6) вище, ніж у другій (46.6) при високому ступені достовірності різниці (p>0,99). Аналогічна ситуація спостерігається й під час виконання дво- і триочкових кидків з дистанції. Дослідження результативності штрафних кидків показали, що в середньому за гру баскетболісти 13-14 років виконують 14.1 штрафних кидків, з яких влучають 7.1, що становить 52.2 %. Дослідження показали, що кількість швидких проривів складає в середньому за гру 8.45 (в першій половині – 5.18, у другій – 3.27). Кількість оволодіння м'ячем у боротьбі за відскок на своєму щиті 14.9 разів, а на щиті суперника – 13.36. «Гольових» передач в середньому за гру – 4.36, перехоплень м'яча – 8.18, технічних помилок – 15, інших втрат м'яча – 9.54.

Висновки. Дослідження техніко-тактичних показників у юних баскетболістів в процесі змагань показали, що в практиці підготовки юних баскетболістів недооцінюється їхня роль. В навчальні програми необхідно включити в повному обсязі всі техніко-тактичні показники, а особливо кидки в русі з-під щита, дво- і триочкові, «гольові» передачі, штрафні кидки, втрати м'яча, перехоплення, блок-шоти, боротьба за відскок, показники у швидкому прориві і в позиційному нападі, кількість пропущених очок тощо.

Ключові слова: баскетбол, техніко-тактичні показники юних баскетболістів.

Information about the authors:

Koryahin, Viktor: koryahinv@meta.ua; https://orcid.org/0000-0003-1472-4846; Department of Physical Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

Hrebinka, Halyna: galija_grebinka@ukr.net; https://orcid.org/0000-0001-8681-3368; Department of Physical Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

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