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[Teorià ta Metodika Fìzičnogo Vihovannâ]



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EFFECT OF PHYSICAL DEVELOPMENT SELF-ASSESSMENT INDICATORS ON VALUE ORIENTATION STRUCTURE FORMATION IN SENIOR SCHOOL AGE STUDENTS

Ihor Bakiko^{1ABCD}, Tetiana Krutsevich^{2ABD} and Sergii Trachuk^{2ABCD}

¹Lutsk State Technical University

²National University of Physical Education and Sport of Ukraine

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

Corresponding Author: Sergii Trachuk, e-mail: trachuk_sergey@i.ua

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Abstract

Background. Physical education as a subject in general secondary education institutions aims not only to solve health and educational problems but also to form a value attitude to health, healthy lifestyle, fostering the interest in and the need for physical activity.

Research purpose. The study aims to investigate the relationship between senior school age students' value orientations and physical development self-assessment indicators to determine incentives to increase motivation for self-improvement by means of physical education.

Materials and methods. The research methods used to solve the tasks set in the paper were as follows: analysis and generalization of data of scientific and methodological literature; content analysis; comparison and juxtaposition method; Ye. Bochenkova's test-questionnaire Self-description of physical development, M. Rokych's technique for defining value orientations; methods of mathematical statistics.

Results. Based on examining correlations between the 11th grade students' terminal values and physical development self-assessment, a tendency was found to shift the priority of youth values towards life values, values of professional realization, and values of interpersonal relationships. Based on the results of the study, we found that the formation of value orientations in boys and girls in high school can affect self-esteem, which in turn is a stimulus for self-improvement and, through an effective component of physical activity, increases the importance of "health" for senior school age boys. On the other hand, girls have no such pattern, and the value of "health" is declarative for them.

Conclusions. It has been determined that the formation of value orientations through an effective component of physical activity can affect the self-esteem of boys and girls, which in turn is an indicator of self-awareness and expresses the individual's attitude to himself and is the basis for regulating their own behavior.

Keywords: physical culture, physical education, school, secondary school students, physical development self-assessment, value orientations..

Introduction

Physical education as a discipline in general secondary education institutions aims not only to solve health and educational problems but also to form a value attitude to health, a healthy lifestyle, cultivating interest, and the need for physical activity (Maievskiy, 2016; Krutsevich, 2017).

Despite the fact that the school is an educational institution that focuses on the harmonious development of children, there is a clear decline in the physical activity of students and – as a consequence – a decrease in their physical condition and morbidity (Krutsevich, Pangelova, Trachuk, & Ivanik, 2019; Andrieieva et al., 2019).

Among all categories of student youth, the attention of scientists is attracted by the senior school age, as a transitional period in the physical, intellectual and spiritual development of the individual (Back, 2015; Maievskiy, 2016; Marchenko, 2018).

Formation of value orientations in the field of physical culture is possible first of all under conditions of the orientation of the student on the possibility of realization of the certain, most important personal needs which, in turn, will become the main factor of the formation of value attitude, and further – humanistic and culturological value orientations in the researched sphere (Erikson, 2006; Krutsevich, Trachuk, Ivanik, Panhelova, Brychuk, & Kedrych, 2021).

Most often in psychology, values are revealed through a person's perception of the most desirable, attractive, and important for him. A clear system of value orientations allows a person to be more active and live their own lives more productively. A person consciously chooses life priorities for the first time in adolescence (Amorose, 2001; Ostrovska, 2003; Gest, Molloy & Ram, 2015; Fliarkovska, 2020).

The degree of acceptance of one's own bodily image "I" affects the formation of self-concept in adolescence and determines the ways of forming adequate self-esteem of adolescents (Borozdina, 2009; Bekh, 2010; Golbert & Tolstykh, 2018).

In the context of our study, the most interesting are those related to the coverage of various aspects of the formation of value orientations in the field of physical culture and sports (Krutsevich & Marchenko, 2017).

However, today, unfortunately, there are no thorough comprehensive studies to identify interdependent content characteristics of self-assessment of physical development of high school students and their choice of values, which reflects their personal development and can be useful for further development of recommendations for optimizing physical education of senior school age students.

The above confirms the relevance of the problem, determines its choice as a topic of research and is the basis of a separate study of this problem, which has theoretical, practical and social significance.

The purpose of the study – to study the interdependence of value orientations and indicators of self-assessment of physical development of senior school age students to determine incentives to increase motivation for self-improvement by means of physical education.

Materials and methods

Study participants

The research was conducted in a secondary school No 17 in Lutsk with the participation of senior school age students in the number of 60 students (boys – 30; girls – 30).

Study organization

To solve the problem set in the work, the following research methods were used: analysis and generalization of data from scientific and methodological literature; content analysis; method of comparison and juxtaposition; Ye. Bochenkova's test-questionnaire "Self-description of physical development", M. Rokych's method of revealing value orientations, methods of mathematical statistics.

The test questionnaire of "Self-description of physical development" (Bochenkova, 2000) consists of 70 statements that relate to the field of physical development of a person and sets 10 indicators of physical development and an indicator of general self-esteem of a person.

The indicators are: health, coordination of movements, physical activity, harmony of the body, athletic abilities, physical "I", appearance, strength, flexibility, endurance, self-esteem.

Evaluation of the results was carried out by correlating the results with generally accepted norms of the level of personality self-esteem, in accordance with which the personality self-esteem scale was used for the following indicators:

- a very high level of self-esteem (overstated) – 75-100% of the maximum number of points;
- high level of self-esteem – 60-74% of the maximum number of points;
- the average level of self-esteem – 45-59% of the maximum number of points;
- low self-esteem – below 45% of the maximum number of points.

To study the peculiarities of the formation of value orientations of schoolchildren, we used the method of M. Rokych (adapted by Yadov, 2007), which took into account the age characteristics of students that determine the functioning of the mechanism of differentiation of values and character choice of certain values.

Statistical analysis

The statistical analysis of the obtained data was performed using the Statistica ver. 10.0 (Stat Soft, USA) statistical software and the Microsoft Excel 2016 spreadsheets (Microsoft, USA). Only licensed software was used to perform the analysis.

Results

The results of the study show that between boys and girls of senior classes there are some differences in indicators of self-esteem of physical development and priority in the choice of value orientations.

We suggest that the level of self-esteem of physical development and health of boys and girls may have some influence on the formation of their value orientations.

To determine the interdependence of value orientations and indicators of self-assessment of physical development of boys and girls of senior school age, a correlation analysis was conducted (table 1, 2).

According to the results of the study of the interdependence of correlations between terminal values and indicators of the questionnaire "Self-description of physical development" of 11th grade boys, we note the largest number of correlations around the terminal value "interesting work", namely moderate correlation with: "health" ($r = 0.32$, $p < 0.05$), "slender body" ($r = 0.32$, $p < 0.05$) and "self-esteem" ($r = 0.28$, $p < 0.05$); value-goal "love" correlates with self-esteem "health" ($r = 0.27$, $p < 0.05$), "coordination of movements" ($r = 0.41$, $p < 0.05$), "slim body" ($r = 0.31$, $p < 0.05$), "athletic ability" ($r = 0.29$, $p < 0.05$), "strength" ($r = 0.26$, $p < 0.05$), "flexibility" ($r = 0.31$, $p < 0.05$) and "self-assessment of physical development" ($r = 0.53$, $p < 0.01$) (Table 1).

In the context of our study, a significant correlation between the terminal value of "health" and "self-esteem" ($r = 0.35$, $p < 0.05$) as an indicator of self-description of physical development deserves special attention. Young people believe that in order to achieve a high level of health, you need to have high self-esteem of physical development.

Table 1 Correlation between the indicators of the test “Self-description of physical development” and value orientations in 11th grade students (n=30)

Value orientations	Indicators of the test “Self-description of physical development”										
	Health	Coordination of movements	Physical activity	Slim body	Athletic abilities	Global physical. I	Appearance	Power	Flexibility	Endurance	Self-esteem
	Terminal values										
Self-sufficiency as independence	-0.10	-0.14	-0.07	-0.11	-0.16	0.10	0.17	0.10	0.05	0.15	-0.10
Self-confidence	0.08	0.16	-0.05	0.09	0.12	0.02	0.40	0.19	0.16	0.05	0.31
Material support	0.08	0.08	-0.34	0.25	0.03	0.20	0.39	0.26	0.12	0.01	0.35
Health	0.18	0.38	0.02	0.06	0.32	-0.15	0.13	0.23	0.37	0.22	0.45
Pleasure in life	0.29	0.32	-0.03	0.23	0.18	-0.05	0.22	0.18	0.29	0.15	0.50
Interesting job	0.32	0.16	-0.20	0.32	0.15	-0.03	0.02	0.06	0.15	0.07	0.28
Love	0.27	0.41	-0.13	0.31	0.29	-0.01	0.24	0.26	0.31	0.13	0.53
Freedom as independence	0.03	0.12	-0.16	0.26	-0.04	0.19	0.14	0.07	0.10	0.02	0.16
The beauty of nature	0.05	0.23	0.10	-0.04	0.25	-0.17	-0.12	0.05	0.19	0.31	0.05
Good and loyal friends	0.16	0.31	-0.06	0.14	0.13	0.13	0.33	0.32	0.32	0.14	0.55
cognition	0.20	-0.22	0.31	-0.31	0.03	-0.34	-0.32	-0.33	-0.22	-0.12	-0.23
Happy family life	-0.02	0.32	0.31	-0.09	0.35	-0.17	0.08	0.18	0.23	0.09	0.45
Art	0.23	0.00	-0.05	0.04	0.04	-0.13	0.00	-0.17	-0.06	-0.13	0.12
Public recognition	-0.10	0.16	0.23	-0.02	0.12	-0.19	-0.01	-0.08	0.00	-0.06	0.14
Active life	0.30	0.11	-0.11	-0.03	0.15	-0.11	0.00	-0.05	0.06	-0.01	0.13
Equal opportunities for all	-0.13	0.35	0.17	0.07	0.31	-0.13	0.09	0.15	0.14	0.06	0.34
total Σ	2.54	3.47	2.34	2.37	2.67	2.12	2.66	2.68	2.77	1.72	4.69
r Arithmetic mean	0.15	0.21	0.14	0.14	0.16	0.13	0.16	0.16	0.17	0.10	0.29

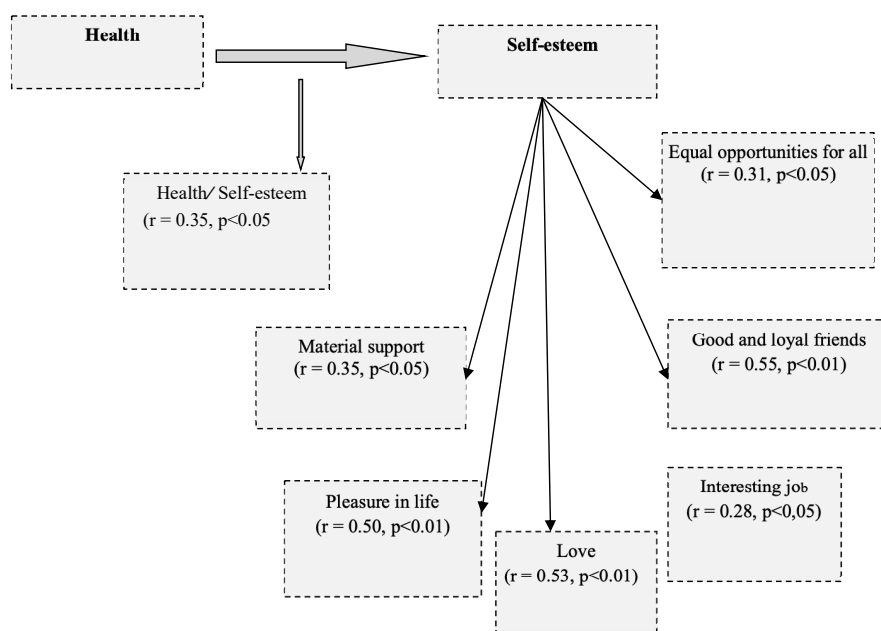


Fig. 1. Correlations of the questionnaire “Self-description of physical development” “self-assessment”

Table 2. Correlation between the indicators of the test “Self-description of physical development” and value orientations in 11th grade girls (n=30)

Value orientations	Indicators of the test “Self-description of physical development”										
	Health	Coordination of movements	Physical activity	Slim body	Athletic abilities	Global physical. I	Appearance	Power	Flexibility	Endurance	Self-esteem
Terminal values											
Self-sufficiency as independence	0.22	0.36	0.37	-0.37	0.31	-0.20	-0.34	0.13	0.33	0.37	-0.31
Self-confidence	0.20	0.31	0.33	-0.32	0.27	-0.18	-0.34	0.23	0.29	0.32	-0.37
Material support	-0.09	-0.04	-0.04	0.04	-0.03	0.02	0.04	-0.03	-0.03	-0.04	0.04
Health	-0.02	0.16	0.17	-0.17	0.14	-0.09	-0.18	0.12	0.15	0.17	-0.20
Pleasure in life	0.00	0.13	0.14	-0.13	0.11	-0.07	-0.14	0.09	0.12	0.13	-0.15
Interesting job	0.08	0.27	0.29	-0.28	0.24	-0.16	-0.30	0.20	0.25	0.28	-0.33
Love	0.09	0.23	0.24	-0.24	0.20	-0.13	-0.25	0.17	0.22	0.24	-0.28
Freedom as independence	0.08	0.27	0.29	-0.28	0.24	-0.16	-0.30	0.20	0.25	0.28	-0.33
Beauty	0.09	0.23	0.24	-0.24	0.20	-0.13	-0.25	0.17	0.22	0.24	-0.28
Good and loyal friends	0.09	0.23	0.24	-0.24	0.20	-0.13	-0.25	0.17	0.22	0.24	-0.28
Knowledge	0.24	0.22	0.23	-0.23	0.19	-0.12	-0.16	-0.03	0.20	0.22	-0.08
Happy family life	0.12	0.26	0.28	-0.27	0.23	-0.15	-0.29	0.19	0.25	0.27	-0.31
Art	0.17	0.23	0.24	-0.24	0.20	-0.13	-0.25	0.17	0.22	0.24	-0.28
Public recognition	0.12	0.26	0.28	-0.27	0.23	-0.15	-0.29	0.19	0.25	0.27	-0.31
Active life	0.20	0.24	0.25	-0.25	0.21	-0.14	-0.26	0.05	0.22	0.25	-0.29
Equality	0.26	0.12	0.08	-0.06	0.00	0.09	-0.02	-0.03	0.11	0.09	-0.10
Total Σ	2.07	3.56	3.71	3.63	3.00	2.05	3.66	2.17	3.30	3.65	3.94
rArithmetic mean	0.12	0.22	0.23	0.23	0.18	0.12	0.22	0.13	0.21	0.22	0.24

Given the interdependence of health values and self-esteem of young people, we made a detailed analysis of the correlations of self-esteem of physical development and found the maximum number of positive correlations with the following values-goals of young men: “self-confidence” ($r = 0.31$, $p < 0.05$), “health” ($r = 0.45$, $p < 0.01$), “life satisfaction” ($r = 0.50$, $p < 0.05$), “interesting work” ($r = 0.28$, $p < 0.05$), “love” ($r = 0.53$, $p < 0.05$), “good and faithful friends” ($r = 0.55$, $p < 0.01$), “happy family life” ($r = 0.45$, $p < 0.05$), “equal opportunities for all” ($r = 0.31$, $p < 0.05$) and “self-confidence” ($r = 0.31$, $p < 0.05$) (Figure 1).

Thus, through the formation of value orientations, we have the opportunity to influence the self-esteem of young people, which in turn has an impact on increasing the importance of the value of “health” through an effective component of physical activity. The above values are a stimulating factor in increasing young people’s motivation to self-improvement. In turn, human self-improvement can be a means of physical education, which aims to improve physical fitness, functional state of the body and the level of physical health of young people.

In the context of considering the correlations between value orientations and indicators of self-description of physical development of girls of senior school age, it should be

noted that the results of the study differ significantly from those of boys. We found negative correlations between the terminal value of “public recognition” and indicators of “Self-description of physical development” of girls: “slim body” ($r = -0.27$, $p < 0.05$), “appearance” ($r = -0.29$, $p < 0.05$) and “self-assessment” ($r = -0.31$, $p < 0.05$) (Table 2).

From this we conclude that the desire of girls for public recognition is quite ambitious, but not due to good appearance and slim body, but due to the development of certain physical qualities, such as: “coordination of movements” ($r = 0.26$, $p < 0.05$), “physical activity” ($r = 0.28$, $p < 0.05$), “flexibility” ($r = 0.25$, $p < 0.05$) and “endurance” ($r = 0.27$, $p < 0.05$). And a negative connection suggests that low self-esteem of high school girls’ appearance prevents them from fully realizing their career ambitions and reduces communicative activity in communicating with peers.

It is worth noting that this can also be manifested in the suppression of leadership qualities of girls. This assumption is also consistent with the need of girls for freedom as independence and the need for public recognition, as evidenced by the correlations of the terminal value “freedom as independence” with the following indicators of self-assessment of physical development: “coordination of movements” ($r = 0.27$, $p < 0.05$), “physical activity” ($r = 0.29$, $p < 0.05$),

“flexibility” ($r = 0.25$, $p < 0.05$) and “endurance” ($r = 0.28$, $p < 0.05$), “sports abilities” ($r = 0.24$, $p < 0.05$).

The value orientation towards a happy family life, which they also associate with good physical development, turned out to be quite predictable for high school students. We trace a slight correlation between the value of “happy family life” with the following indicators of physical development: “coordination of movements” ($r = 0.26$, $p < 0.05$) and “physical activity” ($r = 0.28$, $p < 0.05$).

Analyzing the obtained results of correlations between the indicators of the test “Self-description of physical development” and value orientations in 11th grade girls, we also note an unprecedented case when the indicators of the questionnaire “Self-description of physical development” “slim body” and “appearance” received only negative correlations connections with the following terminal values: “interesting work”, “public recognition”, “self-confidence”, “self-sufficiency as independence” (Table 2).

This fact can be explained by the fact that the 11th grade in the life of schoolchildren is a very difficult period and a responsible moment in the life of teenagers. This is a period of increased workload and moral pressure from teachers and parents because the decisive year ahead is the passing of exams and the entrance campaign. Therefore, dissatisfaction with the indicators of self-esteem of physical development (“slim body” and “appearance”) have a negative impact on the social activity and communication of girls in their microenvironment and on the above life values. Interest in one’s appearance grows sharply, a new image of the physical “I” is formed.

Discussion

The formed value orientations are the most important regulator of vital activity of the person in society, and provide stability to the person’s display of its behavior, interest, needs, and beliefs on the basis of which the hierarchy of values of the individual is built (Bekh, 2010).

Mdivani (1991) predicted that “I-physical” has its own structure and meaning, but due to the formation of gender and role stereotypes in boys and girls, “I-physical” may partially change. The object of self-esteem can be various aspects of personality: features of construction and course of activity, its results, behavior and relationships, existing abilities, interests and needs, features of character, temperament, intelligence, etc.

During this period, the attitude of young high school students to physical activity changes somewhat, which determines the concentration of efforts on the formation of values, including the values of physical culture. According to scientists, the emotional background of adolescents becomes uneven and unstable. The teenager is forced to constantly adapt to physical and physiological changes in his body.

We present the results of correlations between terminal values and self-assessment of physical development of 11th grade students, which indicate a trend of shifting the priority of youth values towards life values, values of professional realization, and values of interpersonal relationships. Note that the interdependence of these indicators with self-assessment of physical development.

In our study, self-esteem is seen as the ability of young people to analyze their own physical condition, and this can

affect the formation of the inner world and on this basis to form appropriate value orientations because they give the opportunity to express certain individual characteristics of adolescents and influence motivation to exercise and sports.

In the context of our study, we found the interdependence of “self-esteem” as one of the indicators of the questionnaire “Self-description of physical development” and the value of “health” in young people, which is confirmed by a strong correlation between them. In turn, it should be noted that young people’s self-esteem has a large number of positive correlations with other terminal values. This suggests that young people’s high self-esteem affects both their relationships with friends, improving their perceptions of life and helping them to enjoy life, and adds confidence by influencing their health and family relationships. Thus, through the formation of value orientations, we have the opportunity to influence the level of self-esteem, which in turn, through an effective component of physical activity affects the importance of the value of “health” (Krutsevych & Marchenko, 2017).

In this regard, it is worth noting the negative correlation between good looks, slim body in girls and their value choices for interesting work, the desire for public recognition, self-confidence and independence.

Back (2015) as a result of research, positive correlations were found between participation and attitude to school physical education, sports competence, appearance, physical activity, self-esteem, flexibility, endurance, strength and body as a whole; however, a negative correlation was found with fat deposits (obesity) and the health of senior school age students.

The self-esteem of physical development of schoolchildren is influenced by internal and external factors which are connected with fashion for good appearance, development of physical qualities, on various types of motor activity (Krutsevych & Marchenko, 2017b).

Marchenko et al. (2021) determined the general level of self-esteem of boys and girls of different age groups of their physical development and critical periods of boys and girls were identified, where self-esteem of physical development has the lowest indicators, as well as those age periods in which students are confident in their strengths and physical qualities in a high level of general self-esteem of physical development.

Self-assessment of physical development functions as part of self-awareness and expresses the individual’s attitude to himself and is the basis for regulating his own behavior, has some influence on the formation of values and value orientations of man. This is especially true of adolescence, when the completion of a very important stage of personal formation (Bochenkova, 2000; Krutsevich, Marchenko, Trachuk, Panhelova, Napadij, & Dovgal, 2021; Krutsevich, Marchenko, Trachuk, Priymak, Panhelova, & Kholodova, 2021).

We are convinced that special attention needs to be paid to the need to take into account the individual characteristics of girls, to develop individual exercise programs for them during physical education classes, which in turn will contribute not only to the harmony of physique, but also to the formation of girls’ values for them proved to be a priority, namely, aimed at independence and autonomy in judgments and public recognition, thereby increasing their self-esteem.

Conclusions

Certain interdependencies of value orientations and the level of self-assessment of physical development of senior school age students and the impact on this process of physical culture and sports, of course, do not cover all aspects of solving this problem. However, it is determined that the formation of value orientations through an effective component of physical activity can affect the self-esteem of boys and girls, which in turn is an indicator of self-awareness and expresses the individual's attitude to himself and is the basis for regulating their own behavior and self-improvement.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ВПЛИВ ПОКАЗНИКІВ САМООЦІНКИ ФІЗИЧНОГО РОЗВИТКУ НА ФОРМУВАННЯ СТРУКТУРИ ЦІННІСНИХ ОРІЄНТАЦІЙ УЧНІВ СТАРШОГО ШКІЛЬНОГО ВІКУ

Ігор Бакіко^{1ABCD}, Тетяна Круцевич^{2ABD}, Сергій Трачук^{2ABCD}

¹Луцький національний технічний університет

²Національний університет фізичного виховання та спорту України

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

Реферат. Стаття: 7 с., 2 табл., 1 рис., 24 джерела.

Метою дослідження було вивчення особливостей взаємозв'язку ціннісних орієнтацій школярів 11-их класів з показниками самооцінки фізичного розвитку.

Матеріали та методи. Для вирішення поставлених в роботі задач використовувалися наступні методи дослідження: аналіз та узагальнення даних науково-методичної літератури; контент-аналіз; метод порівняння та зіставлення; тест-опитувальник Є. Боченкової «Самоопис фізичного розвитку», методика визначення ціннісних орієнтацій М. Рокича; методи математичної статистики.

Результати. За результатами дослідження кореляційних зв'язків між термінальними цінностями та самооцінкою фізичного розвитку юнаків 11-го класу виявлено тенденцію зміщення пріоритетності цінностей юнаків у бік життєвих цінностей, цінностей професійної реалізації та цінностей міжособистісних відносин. На підставі результатів дослідження нами виявлено, що через форму-

вання ціннісних орієнтацій юнаків і дівчат старших класів можна впливати на самооцінку, яка в свою чергу є стимулом до самовдосконалення та через дієву складову фізичної активності підвищує значущість цінності «здоров'я» для юнаків старших класів. Натомість у дівчат такої закономірності не виявлено, цінність «здоров'я» для них має декларативний характер.

Висновки. Визначено, що при формуванні ціннісних орієнтацій через дієву складову фізичної активності можна впливати на підвищення самооцінки юнаків і дівчат, яка в свою чергу є індикатором самосвідомості і виражає ставлення особистості до самої себе та є основою для регуляції нею власної поведінки.

Ключові слова: шкільне фізичне виховання, учні старшого шкільного віку, самооцінка, фізичний розвиток, ціннісні орієнтації, старшокласники.

Information about the author:

Bakiko I.: bakiko_igor@ukr.net; <https://orcid.org/0000-0002-8835-8781>; Department of Physical Education, Lutsk State Technical University, Lutsk, Ukraine.

Krutsevich T.: tmfv@ukr.net; <https://orcid.org/0000-0002-4901-6148>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Trachuk S.: trachuk_serгей@i.ua; <https://orcid.org/0000-0002-5580-0510>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF MOVEMENT GAMES ON PHYSICAL FITNESS OF CHILDREN WITH INTELLECTUAL DISABILITIES

Larysa Kuznetsova^{1ABCD}, Sergii Trachuk^{1ABCD}, Viacheslav Semenenko^{1ABCD}, Olha Kholodova^{1ABCD}, Liudmyla Podosinova^{1ABCD}, Mariia Brychuk^{1ABCD}, Oleg Varenik^{1ABCD} and Halyna Kedrych^{2ABCD}

¹National University of Ukraine on Physical Education and Sport

²Taras Shevchenko Regional Humanitarian Pedagogical Academy in Kremenets

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

Corresponding Author: Sergii Trachuk, e-mail: trachuk_sergey@i.ua

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Abstract

Research purpose. The study was aimed at investigating the effect of the proposed technology using movement games on the physical and psychomotor fitness of young schoolchildren with intellectual disabilities.

Materials and Methods. Forty children from an orphan asylum in Smila, Cherkasy region (Ukraine) participated in the study. All children were divided into two groups: control and experimental; all of them had been diagnosed with moderate-grade oligophrenia and were 2nd and 3rd graders (age 9–12 years). The control group consisted of 22 pupils, including 11 boys and 11 girls. The experimental group consisted of 18 pupils, including 9 boys and 9 girls. The following research methods were used to solve the problems set in the paper: analysis and generalization of information from special scientific literature, pedagogical research methods, method of comparison and similitude, psychoemotional state and psychomotor development research methods, methods of mathematical statistics.

Results. The study results set forth in the paper will allow stating the fact that lessons with the use of movement games have a positive effect on the physical and psychomotor fitness of young schoolchildren with intellectual disabilities, which ensures their social adaptation in the context of growth.

Conclusions. Increasing the time spent on playing games not only in classes but also in extracurricular activities had a positive effect that found expression in the improvement of the children's health and psychoemotional condition, which is the main component of the behavior of a child with mental disabilities. It can be stated that, after using the proposed movement games, the indicators of the pupils' psychomotor and mental condition, memory, perception of reality and attention improved in the positive dynamics of their physical fitness. It was found that the number of nervous breakdowns, depressive states and symptoms of stress decreased during the selected movement games.

Keywords: movement games, physical fitness, psychomotor development, mental condition.

Introduction

Today, in the society there is a tendency for increasing the number of children born with intellectual disabilities, the determinant of this is quite a lot (Imas, Dutchak, & Trachuk, 2013; Alosyna, Bychuk, & Alosyna, 2015; WHO, 2015).

Having studied the influence of physical education on mentally retarded schoolchildren, Hammeken (2000), Kenneth (2007), and world practice (WHO, 2015) note that the

number of children with hearing, visual, musculoskeletal disorders has not changed significantly over the last decade, while the number of children with intellectual disabilities became twice bigger.

The variety of health disorders, impaired coordination abilities, low levels of physical development and physical performance, low levels of emotional life of children with intellectual disabilities need special attention in the setting of tasks of the adaptive physical education, starting from the junior school age (Kuznetsova, 2015; Krutsevich et al., 2020).

In her research, Giagazoglou et al. (2013) notes that the children with disabilities have impaired motor function, intellectual and cognitive development, regulation of emotions

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directly related to low levels of physical fitness and decreasing the participation in physical activity at all stages of life.

The experts' studies (Pelyh, 2011; Kuznetsova, 2015; Krutsevich, 2017) have generally recognized that one of the best means of promoting the health and social adaptation of such children is the exercise of the adaptive physical education, because physical exercises promote the acquisition of necessary skills and extension of range activity and forming positive character traits.

The adaptive physical education plays an extremely important role in developing daily patterns of physical activities, as there is evidence that children with disabilities have lack access to physical activities and lower level of physical fitness in structured and unstructured settings (Aharoni, 2005).

It is known that the successful social adaptation of children with intellectual disabilities requires a sufficiently high level of developing physical qualities, which will be a prerequisite for the correcting their movement disorders (Viskova-tova, 2012; Kuznetsova, 2015; Alosyna et al., 2015).

It should be noted that mentally retarded children are not capable for long, monotonous training, which is often necessary to develop certain compensatory skills. Therefore, all work must be done in such a way that the correction is done out not obsessively, during the most attractive activities. The analysis of the scientific and methodological literature and pedagogical practices testified (Hammeken, 2000; William, 2005; Kenneth, 2007; Dedeliuk, 2014; Shapkova, 2009; Osadchenko, Semenov, & Tkachenko, 2014) that there are many programs and methods of the adaptive physical education for working with children with intellectual disabilities. Undoubtedly, their contribution to correcting the deficiencies of mentally retarded children's physical development and physical fitness is great.

According to the UN High Commissioner for Human Rights, the 'Game' has been recognized as an important component in the optimal development of a child and the right of every child to it. Every child deserves the opportunity to develop his (her) unique potential, children's defenders must consider all factors that interfere optimal development, and insist on circumstances allowing each child to fully use the benefits of game (Office of the United Nations High Commissioner for Human Rights, 1989).

It is important to note that while there is an experience in this area, in the process of the adaptive physical education the use of moving games for children with intellectual disabilities and their influence on improving the physical and psycho-emotional condition remain poorly substantiated in the context of social adaptation, which caused the actuality of our research.

The purpose of the research was to learn the influence of the proposed technology using moving games on the physical and psychomotor fitness of young schoolchildren with intellectual disabilities.

Materials and Methods

Study participants

40 pupils of a special educational institution for children with mental retardation, in Smila, Cherkasky region, took part in the research. All children of mental age 9-12 years according to the Diagnostic and Statistical Manual of

Mental Disorders and the International Statistical Classification of Diseases and Related Health Problems were divided into two groups, control and experimental, with a diagnosis of oligophrenia of moderate severity and studied in 2 and 3 grades. The control group consisted of 22 pupils, including 11 boys and 11 girls. The experimental group consisted of 18 students, 9 boys and 9 girls.

Study organization

Research methods: the theoretical analysis and generalization of the scientific literature, the pedagogical, sociological, anthropometric; physiological research methods, the method of copying from medical cards; methods of research of the psycho-emotional condition, the level of physical fitness and psychomotor development, methods of mathematical statistics.

Statistical analysis

The statistical analysis of the obtained data was performed using the Statistica ver. 10.0 (Stat Soft, USA) statistical software. Only licensed software was used to perform the analysis.

Legal representatives and authorized persons gave written informed agree about participating this children in research, which was approved by the local ethics committee and by the Declaration of Helsinki.

Results

Moving games held at physical education lessons, twice in a week, on walks, during excursions, during the adaptive physical education classes and occupied 60 % of students' time. So much attention has been paid to the moving games, because the existing curriculum for the physical education used in educational institutions of this type in our opinion and in the light of current trends, needs modernization for children's good.

To confirm the expediency of the selected moving games and their practical effectiveness, we conducted an expert evaluation of used moving games. Twenty-one staff members of the orphanage were interviewed for this purpose: teachers, educators, medical staff and support staff (Table 1).

The analysis of the answers and the calculation of the coefficient of concordance indicate the agreement of experts ($W = 0.785$): about 98% of employees consider that the children's behaviour has improved, 76% – the children's mood has improved, 86% – children have become less aggressive, 74% – children have improved friendship skills. 57% have noticed a decrease in morbidity, 89% have noticed that children have begun to show interest in physical education, 95% of employees believe that children have improved self-care skills. This demonstrates the effectiveness and correct selection and holding of moving games with a thematic focus on solving the health problems of the adaptive physical education (APE) of children with intellectual disabilities. Table 2 shows a list of moving games used during the experiment.

Table 3 presents the average indicators of developing motor skills of schoolchildren with moderate degree intellectual disabilities of the experimental and control groups before and after the experiment.

Table 1. The expert evaluation regarding moving games with children with intellectual disabilities (point)

№	Content of the issue	Σ	X, point	SD
1	Get acquainted with the list of moving games	210	10	1.0
2	Active games help improve schoolchildren's behavior	206	9.8	1.1
3	Active games help improve schoolchildren's mood	160	7.6	0.8
4	Active games, depending on the orientation, contribute to reducing the state of aggression	180	8.6	0.8
5	Active games improve the formation of friendship	155	7.4	0.8
6	Active games are an undeniably positive influence on improving health	150	7.2	1.1
7	Active games are a means of reducing morbidity	120	5.7	0.7
8	Active games are an increase in attention	120	5.7	0.7
9	Active games and confidence outside the boarding school	160	7.6	0.9
10	Active games and irritation reduction	118	5.6	0.8
11	Interest in the environment	130	6.2	1.1
12	Interest in physical education lessons	186	8.9	1.1
13	The value of games in improving self-care skills	199	9.5	0.9
14	The advisability of using moving games in practice	210	10	1.0

Table 2. Divides games into categories that help increase social adaptation of schoolchildren with intellectual disabilities

No.	Category	Games name	Game content	Pedagogical task
1	"Nature"	"Elephant", "Wolf and goats", "Pigeons", "Funny birds", "Bunnies", "Ravens", "Fox and chickens", "Catch a mosquito", "Teddy bear", "Flowers and wind", "Grasshoppers"	Different types of movements: running, walking, jumping, simulating sounds and movements of animals	Adaptation to natural conditions, development of attention, language, improvement of mental and physical condition
2	"Sport"	"The sea is splashing", "We are fun guys", "Fisherman", "Potatoes", "Run through the hoop", "Owl", "Path", "Tunnel"	Different types of movements	Improving basic motor qualities (strength, speed, endurance, flexibility, agility)
3	"Transport"	"Traffic lights", "Train", "Wheelchair racing", "Tractors", "Steam across the road", "Bus", "Merry scooter"	Various movements, application of transport paraphernalia	Getting acquainted with the basics of traffic rules, education of attention, ability to find a way out of a situation, education of endurance, development of orientation
4	"Hygiene and self-care"	"Wash To Holes", "Who will help us?", "Quick Boots", "Who washes your hands faster?", "Help a friend", "Who will clasp buttons faster?"	Multiple repetitions of the same actions in a certain sequence	Forming ability to independently carry out morning and evening hygienic measures, to put clothes and footwear correctly (not to confuse right and left), to eat
5	"Consistency in actions"	"Owl", "Have time to jump", "Replace hoops", "Hold the item", "Let's walk in a circle", "Pass the flag"	Various games, relay races with and without equipment	Improving coordination abilities, performing complex movements, developing orientation in space.
6	"Good mood"	"Dwarves and giants", "Bells", "Planes", "Catch the ball", "Circle to circle"	Using simple and complex movements, various equipment and fitments, various venues	Improving overall health, mood, positive and friendly attitude among schoolchildren.
7	"Smart game"	"Grandpa Mazai", "Polar bear", "Falling stick", "Quick step, look, don't yell", "The clap hands"	Using a variety of visual aids, pictures, videos, conducting games in different conditions	Forming general ideas about the environment, developing memory, language, attention, education of initiative.

Developing basic motor qualities: the speed of local actions, speed, the speed-force qualities, flexibility, and endurance – positive dynamics is observed in the children of the experimental group.

The local action speed rates were improved on 4.4% compared to those observed before the experiment.

Speed has been improved on 2.9%, which can be considered as a good achievement. Considering that speed is one of

Table 3. Indicates the development of motor skills of children with intellectual disabilities in the control and experimental groups before and after the experiment

Test exercises		group			
		experimental n = 18		control n = 22	
		X	SD	X	SD
Speed of local actions (clap overhead, clap on hips, several times per second)	before	6.28	3.92	5.64	2.34
	after	8.22*	4.15	6.5	2.82
Speed (20 m run, sec.)	before	28.5	13.25	29.82	13.68
	after	27.94	13.68	29.84	9.29
Speed-power qualities (throwing the ball, m)	before	2.01	1.48	1.77	0.9
	after	2.61*	1.92	2.07	1.03
Stamina (squats, number of times)	before	8.94	4.44	6.86	2.93
	after	11.17*	5.09	8.64	4.14
Flexibility (holding the toes with two hands from a sitting position, sec.)	before	2.28	0.89	2.23	0.81
	after	2.76	0.94	2.23	0.81
Speed-power qualities (long jump from place, cm)	before	1.02	0.33	0.72	0.32
	after	1.17	1.01	0.83	0.33
Strength (hanging on the crossbar with bent arms, sec.)	before	2.26	0.91	1.79	0.63
	after	2.39	0.02	1.86	0.71

Note. CG – control group, EG – experimental group, * $p < 0.05$ significant differences before and after the experiment (Student's t-test)

Table 4. Presents the values of indicators of developing psychomotor qualities for children with intellectual disabilities in the control and experimental groups before and after the experiment

Test exercises		group			
		experimental n = 18		control n = 22	
		X	SD	X	SD
Simultaneous movements (hands clenching and stretching, multiple times)	before	5.39	1.69	4.64	1.89
	after	6	2.1	5.45	1.84
Dynamic coordination (jump on 360° turn)	before	135	88.67	95	57.52
	after	175.00*	109.02	120	71.62
Rhythmic movements (rhythm beats, point)	before	1.43	0.51	1.28	0.46
	after	1.67	0.49	1.56	0.51
Dynamic co-ordination (from the floor to stand without hands, point)	before	1.56	0.86	1.45	0.67
	after	1.98*	0.94	1.82	0.96
Mimic test (Alternate right and left eye closure, point)	before	6.36	1.99	5.89	1.84
	after	7.34	2.26	7.23	2.33
Static coordination (on the right leg, s)	before	2.06	1.06	2.09	0.87
	after	2.28	0.89	1.95	1.95
Static coordination (on the left leg, s)	before	2.28	0.89	2.23	0.81
	after	2.44	0.78	2.27	0.78

Note. CG control group, EG experimental group, * $p < 0.05$ significant differences before and after the experiment (Student's t-test)

the physical qualities that is less developed in children with mental retardation due to existing disorders of the nervous processes, strength was improved by 1.5%.

It is possible to notice the improvement of flexibility indicators (on 6.2%) and speed-force qualities (on 7.1%), while in schoolchildren of the control group the local actions speed indicators, velocity, speed-force qualities (throwing a ball) have improved slightly, and the indicators of flexibility and speed-power (long jump from place) remained practically unchanged.

As the experiment showed the schoolchildren of the experimental and control groups are not ready to accept time intervals and muscle efforts, incorrectly reproduce the spatial parameters of movements.

Thus, the performed tests allow us to conclude that the dynamics for young schoolchildren with intellectual disabilities of the experimental and control groups corresponds to the involved contingent, the level of developing their motor skills and can be considered positive after the use of the selected moving games.

Table 4 presents the indicators developing the psychomotor qualities of children with intellectual disabilities of moderate degree of the experimental and control groups.

Almost all schoolchildren were showed different coordination disorders, but all the children of the experimental group can be seen the positive dynamics of developing psychomotor qualities after the applied technology of moving games.

The simultaneity of movements improved by 13.3% compared to the beginning of the experiment, dynamic coordination – by 15.1%, rhythmic motion – by 4.7%, dynamic coordination – by 10.1%.

The average mimic test scores (alternate closure of the right and left eyes) were improved by 13.2%. As the static coordination, we can note slight improvements, both in the experimental and control students' groups.

There were improved the simultaneity of movements by 3.6%, the dynamic coordination – by 11.3%, the rhythmic movements – by 1.3%, the dynamic coordination (from the sitting on the floor to stand up without the help of hands) – by 1.6%, the mimic test – by 3.9%.

We noted that the psychomotor development indicators of the experimental students' group, who were more involved in game activities, have much better positive results than the children from the control group have.

This indicates that we have correctly selected such moving games and in such quantities that are appropriate to the mental and physical health of students with intellectual disabilities and have provided a positive effect.

Discussion

Yun and Beamer (2018) they say, promoting engagement in lifelong physical activity for all children with disabilities should be an important goal of the adaptive physical education. This can be accomplished by developing IEPs (individualized education program) with physical activity goals; carefully considering the class content, the location and instruction methods that maximize physical activity engagement; and cooperating with other programs within the school to encourage physical activity participation in and outside of physical education classes.

Before, U.S. Department of Education (USDE) defined physical education within its regulation. Section 121.a.14 (b) (2) defined physical education as the development of physical and motor fitness, fundamental motor skills and patterns and skills in aquatics, dance, and individualized and group games and sports (including intramural and lifetime sports). The term includes the special physical education, the specialized physical education, the movement education, and the motor development (Federal Register, 1977, p. 42480).

There proved the data of native and foreign scientists (Gorskaia, 2000; Evseev, 2007; Vinnik Dzhozef P., 2010; Moskalenko et al., 2014; Krutsevych, 2017) that the adaptive physical education as a system of views and techniques aiming to improve the condition of disabled people and to solve the problem of their integration into the society. This approach is directly related to the philosophy of humanism and is with the society in the relationship of mutual influence with the society, which was confirmed in October 2013 in Ukraine by the All-Ukrainian Conference "Status and

Prospects of Implementation the UN Convention on the Rights of the Disabled in Ukraine".

Chudnaia (2000) believes that the tendencies of the modern adaptive physical education should be oriented to a more thorough the analysis and correction of both motor and cognitive abilities of children with deviations in order to increase the effectiveness of their education. According to the level of their development, formation of motor activity, physical and psychological abilities allowing their adaptation to the environment and society with different activities.

Jin and Yun (2010) presented the evidentiary practice in the adaptive physical education and identified it in integrating individualized learning strategies with the best factual available data to satisfy the special needs of students in physical education.

Kenneth (2007) points out that a game is necessary for development because it promotes the cognitive, physical, social and emotional well-being of children and young people. The game also offers an ideal opportunity for parents to participate with their children.

The results of the Kosmakova's (2018) study, who has integrated the elements of basic aerobics, football aerobics, yoga fit, suggests that it helps increase the level of the physical development, physical fitness, psychomotor development and correction of concomitant diseases of children with intellectual disabilities, but the information of the physical education wellness programs were used for middle school-aged children.

In the Mozgovyi et al. (1996, 2006) and Sermeev's (1990) works there noted that many students with this nosology have potential motor abilities, and to some extent, a number of basic motor qualities indicators after the use of technology tends to improve, in particular strength endurance, speed of local movements, coordination abilities, velocity, speed power qualities, flexibility.

According to Gorskaia (2000), Deriabin and Kalmykov's, (2017) researches, the age-related growth rates of all types of mentally retarded students' coordination abilities have the same dynamics as in healthy schoolchildren, but with a lag of 2-3 years. Most sensitive periods of development of coordination abilities are in the range of 9-12 years.

According to Litosh (2002) the level of developing the coordination abilities are determined by the mobility and balance of the central nervous system, the degree of maturity and individual structure of individual areas of the cerebral cortex, the properties of analyzers (visual, auditory, motor, vestibular), productivity of processes of perception, memory and thinking.

Asonitou's et al. study (2018) found that the adaptive physical activity programs for the physical fitness of adults with intellectual disabilities can improve their physical shape, especially muscular strength and endurance, balance, flexibility, speed and cardio-respiratory endurance, to promote a more active and healthy lifestyle.

The indicators of basic motor qualities improved due to the fact that a large number of moving games of different orientation and intensity were used in the classes, and many new types of motor activity were used for children.

However, Golubović et al. (2011) examining the effect of exercise on physical fitness of children with intellectual disabilities suggests that the results in physical training tests were much lower than in healthy children, a study found an

association between the degree of the intellectual disability (ID) and physical training.

As a result of the experimental work, the theoretical positions of scientists (Shapkova, 2009; Baikina & Viedernikova, 2014; Alosyna, 2015) have been supplemented on the influence of moving games on the mental and physical condition of young students with intellectual disabilities.

Conclusions

It can be stated that after using the proposed moving games were improved that the indicators of students' psychomotor and mental condition, memory, perception of the surrounding reality, attention are in the positive dynamics according to their physical fitness were improved. It was found that during the chosen moving games the number of nervous breakdowns, depressive states, and symptoms of stress decreased.

The process of social adaptation by using the moving games is quite difficult and time-consuming, so it requires much more investment to achieve the best result than is allowed by the limits of our study.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ВПЛИВ РУХЛИВИХ ІГОР НА ФІЗИЧНУ ПІДГОТОВЛЕНІСТЬ ДІТЕЙ З ВІДХИЛЕННЯМИ РОЗУМОВОГО РОЗВИТКУ

Лариса Кузнецова^{1ABCD}, Сергій Трачук^{1ABCD}, В'ячеслав Семененко^{1ABCD},
Ольга Холодова^{1ABCD}, Людмила Підосінова^{1ABCD}, Марія Бричук^{1ABCD},
Олег Вареник^{1ABCD}, Галина Кедрич^{2ABCD}

¹Національний університет фізичного виховання та спорту України

²Кременецька обласна гуманітарно-педагогічна академія імені Тараса Шевченка

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

Реферат. Стаття: 8 с., 4 табл., 1 рис., 34 джерела.

Метою дослідження було вивчення впливу запропонованої технології з використанням рухливих ігор на фізичну і психомоторну підготовленість дітей молодшого шкільного віку з відхиленнями розумового розвитку.

Матеріали та методи. У дослідженнях взяли участь 40 вихованців Смілянського дитячого будинку-інтернату Черкаської області. Всі діти були розділені на дві групи – контрольну і експериментальну за наявним діагнозом «олігофренія помірного ступеня» і навчалися у 2 і 3 класах. Контрольна група складалася з 22 учнів, з яких 11 хлопчиків і 11 дівчаток. В експериментальну групу входили 18 учнів, з яких 9 хлопчиків і 9 дівчаток. Для вирішення поставлених завдань використовували наступні методи дослідження: аналіз та узагальнення даних спеціальної наукової літератури, педагогічні методи дослідження, метод порівняння та зіставлення, методи дослідження психоемоційного стану; психомоторного розвитку; методи математичної статистики.

Результати. Представлені в статті результати досліджень дозволять констатувати той факт, що заняття

з використанням рухливих ігор позитивно впливають на фізичну і психомоторну підготовленість дітей молодшого шкільного віку з відхиленнями розумового розвитку, що забезпечує їх соціальну адаптацію в контексті становлення.

Висновки. Збільшення часу на проведення рухливих ігор не тільки на уроках, а й у позаурочних формах занять мало позитивний ефект, який проявився в зміцненні здоров'я дітей і поліпшенні їх психоемоційного стану, що є головною складовою поведінки дитини з вадами розумового розвитку.

Можна констатувати, що після використання запропонованих рухливих ігор покращилися показники психомоторного і психічного стану дітей, пам'яті, сприйняття навколишньої дійсності, уваги, в позитивній динаміці їх фізичної підготовленості. Виявлено, що під час обраних рухливих ігор зменшувалася кількість нервових зривів, депресивних станів і симптомів стресу.

Ключові слова: рухливі ігри, фізична підготовленість, психомоторний розвиток, психічний стан.

Information about the authors:

Kuznetsova L.: l.kuznetsova@meta.ua; <https://orcid.org/0000-0001-9322-8984>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Trachuk S.: trachuk_sergey@i.ua; <https://orcid.org/0000-0002-5580-0510>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Semenenko V.: smart.semenenko@gmail.com; <https://orcid.org/0000-0002-5931-7729>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Kholodova O.: holodova2007@ukr.net; <https://orcid.org/0000-0002-7939-3542>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Podosinova L.: podosinova@meta.ua; <https://orcid.org/0000-0002-7579-818X>; Department of Water Sports; National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Brychuk M.: maxa.brychuk@gmail.com; <https://orcid.org/0000-0002-9094-0527>; Department of Theory and Methods of Physical Education, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Varenyk O.: varvoley18@gmail.com; <https://orcid.org/0000-0002-5246-8065>; Department of Management and Economics of Sports; National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03150, Ukraine.

Kedrych H.: kedruch90@gmail.com; <https://orcid.org/0000-0002-1333-1226>; Department of Sports Games and Tourism, Taras Shevchenko Regional Humanitarian Pedagogical Academy in Kremenets, Litseina St, 1, Kremenets, Ternopil region, 47003, Ukraine.

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ORIGINAL SCIENTIFIC ARTICLE

COMPARISON OF THE EFFECT OF HIGH IMPACT AEROBIC DANCE EXERCISE VERSUS ZUMBA ON INCREASING MAXIMUM OXYGEN VOLUME IN ADOLESCENT WOMEN

Puspodari^{1ABD}, Hari Setijono^{1ABD}, Oce Wiriawan^{1ABD}, Poppy Elisano Arfanda^{1BC}, Slamet Raharjo^{2BD}, Nur Ahmad Muharram^{3CD}, Wasis Himawanto^{3BC}, M. Akbar Husein Allsabab^{3BCD} and Susilatrochman Hendrawan Koestanto^{4BD}

¹Universitas Negeri Surabaya

²Universitas Negeri Malang

³Universitas Nusantara PGRI Kediri

⁴Universitas Kahuripan Kediri

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

Corresponding Author: Puspodari, E-Mail: puspodari.20012@mhs.unesa.ac.id

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Abstract

The study purpose was to compare high impact aerobic dance exercise versus Zumba to increase Maximum Oxygen Volume (VO₂max) in adolescent women.

Materials and methods. This research is quasi-experimental with a two-group pretest-posttest design research design. A total of 30 adolescent women from the Student Activity Unit (UKM) aerobic gymnastics at Universitas Nusantara PGRI Kediri, aged 18-24 years, body mass index (BMI) 18.5-24.9 kg/m², normal blood pressure participated in the study. Respondents were randomly divided into two groups, namely ZADE (n = 15, Zumba aerobic dance exercise) and HADE (n = 15, High impact aerobic dance exercise). HADE and ZADE were conducted for 30 minutes/session, with an intensity of ≥ 85% HRmax, as often as 3 times/week, and both types of training were performed for 8 weeks. Measurements of VO₂max, oxygen saturation (SpO₂), and heart rate at rest (HRrest) were pre-test and 1×24 hours post-test after 8 weeks of training intervention. Statistical analysis used Paired Sample t-Test with a significance level of 5%.

Results. Paired Sample T-Test results showed significant differences in average VO₂max, SpO₂, HRrest between pretest vs. posttest in both groups (p ≤ 0.001).

Conclusions. Based on the study results, we have concluded that both HADE and ZADE increase VO₂max, SpO₂, and decrease HRrest. But HADE is more effective in increasing VO₂max, SpO₂, and lowering HRrest than ZADE in adolescent women.

Keywords: aerobic dance, exercise, high impact, maximum oxygen volume, zumba.

Introduction

A person who experiences fatigue while carrying out daily activities can be caused by a lack of physical activity, resulting in a decrease in fitness levels. Physical activity has benefits in health development and positively impacts

challenging things, such as exploration, skills building, and social integration (Barber & Weichold, 2007). Aerobic fitness is the maximum capacity when inhaling, channeling, and using oxygen. Aerobic capacity is a major component of the element of success in sporting achievement. Maximum oxygen volume (VO₂max) is the best indicator of an athlete's physical capacity (Rankovic et al., 2010). VO₂max is the maximum amount of oxygen that can be consumed during intense physical activity until fatigue occurs. Physical freshness is a person's ability to perform physical activities that require strength, endurance, and flexibility. The element

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that affects physical health is cardiorespiratory endurance (Kusnanik et al., 2019). During exercise there is an increase in motor units, increased strength, and frequency of muscle contractions, this is important because it shows changes in muscle function during development towards exercise with intensity approaching VO_{2max} (Robergs, 2001).

Endurance is needed for daily activities, with good endurance then daily activities will not experience fatigue that is so heavy. Endurance is strongly related to breathing, heart, and circulatory (Irwandi & Aprizalmi, 2016). Physical freshness is an interpretation of the heart's endurance ability to maintain maximum body performance without fatigue for a while. Parameters as a marker of a person's physical fitness can be assessed from high VO_{2max} levels (Widodo et al., 2021). VO_{2max} is the maximum amount of oxygen that can be consumed during intense physical activity until fatigue occurs. A person with a good level of VO_{2max} means having good physical fitness as well. Physical fitness gives a person the ability to do productive daily work without excessive fatigue. Low cardiorespiratory fitness can increase the risk of death from heart disease and hypertension (Irianto & Hasnah, 2018).

Aerobic gymnastics is very popular in various parts of the world (Schroeder, 2017). Aerobic exercise can be done anywhere and anytime. Aerobic gymnastics in addition to being able to train endurance is also able to increase motivation so that individuals who do it are more excited. Aerobic exercise can also help break away from the routine (Wang & Wu, 2016). Aerobic exercise performed 30-45 minutes, 3x/week for 10 weeks significantly increases physical work capacity and cardiovascular function (Dowdy et al., 2015). Aerobic gymnastics is one of the most common adult fitness activities performed (Aleksandra et al., 2016). Based on its intensity, aerobic gymnastics is divided into three types low impact, high impact, and mixed impact. High impact aerobic gymnastics has benefits to help boost the immune system, heart, and blood circulation. High impact aerobic exercise is an aerobic exercise with foot movements that do not touch the floor (Suminar et al., 2018). In addition to aerobic dance, doing zumba dance activities is also able to increase flexibility, respiratory endurance, cardiovascular endurance, and abdominal strength. Zumba is also a rhythmic aerobic fitness program. Zumba involves dance and all the aerobic components (Bandopadhyay, 2018). Zumba is a new type of dance practice, inspired by Latin American music and Latin American dance. This exercise combines the basics of merengue dance, salsa, samba, cumbia, reggaeton, and other Latin American dances, using basic aerobic steps, but also has the advantages of other dance variations such as hip hop, belly dance, India, African dance, etc (Perez, 2009).

High blood pressure is one of the riskiest factors for cardiovascular disease and is one of eight causes of death worldwide (Punia et al., 2016). Hypertension is a multifactorial chronic disease that affects more than one billion adults worldwide (Mills, 2016). This is considered an important cardiovascular risk factor, as it is closely related to the occurrence of cardiovascular disease (Rapsomaniki et al., 2014) and the risk of premature death (Pan, 2020). In addition to treatment, lifestyle changes are very important in the treatment of hypertension, in addition to regular physical exercise also includes the prevention of hypertension (Whelton et al., 2020). Variable variations of exercise can be an impor-

tant strategy in maintaining health (de Barcelos et al., 2022). One way to assess a person's cardiorespiratory endurance is to measure VO_{2max} values to measure the capacity of the heart, lungs, and blood to hold oxygen to working muscles and measure muscle oxygen use (Nugraheni et al., 2017). The most common measurement for VO_{2max} prediction is the Multi-Stage 20-m Shuttle Run Fitness Test. This test is widely used by sports scientists, teachers, trainers, and fitness advisors because it requires limited equipment, is relatively easy to perform, and is suitable for the assessment of a large number of subjects. As is the case with all tests and measurements used to assess the physical fitness component, critical questions must be asked regarding the repetition and validity of MFT (Cooper et al., 2005). Maximal oxygen absorption is assessed by establishing an oxygen recovery curve based on the Multi-Stage 20-m Shuttle Run Fitness Test (Paradisi et al., 2014).

The goal of the study was to compare high-impact aerobic dance exercise versus Zumba aerobic dance exercise against the increase in VO_{2max} in adolescent girls. Increased VO_{2max} can be useful in health, such as the diagnosis of potential heart disease in the elderly to measuring peak performance in elite athletes (Snarr et al., 2018).

Materials and Methods

Study participants

This research is Quasi-Experimental with a two-group pretest-posttest design. A total of 30 adolescent women from the Student Activity Unit (UKM) aerobic gymnastics at Universitas Nusantara PGRI Kediri, aged 18-24 years, body mass index (BMI) 18.5-24.9 kg/m², normal blood pressure participated in the study. Randomly respondents were divided into two groups, namely ZADE (n = 15, Zumba aerobic dance exercise), HADE (n = 15, High impact aerobic dance exercise). Before participating in the research, all respondents obtain information both orally and in writing about the research to be carried out. All respondents expressed willingness to participate in the research by signing informed consent. All procedures carried out in our research have complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects.

Study organization

The high-impact aerobic dance exercise and Zumba program are applied and supervised by professional officers from the Faculty of Health and Science, Universitas Nusantara PGRI Kediri. High impact aerobic dance exercise and Zumba for 30 minutes/training session with intensity $\geq 85\%$ HRmax with a frequency of 3x/week for 8 weeks. Monitoring heart rate during high impact aerobic dance exercise and Zumba using polar heart rate monitor (Polar H7 Bluetooth Heart Rate Sensor & Fitness Tracker, Inc., USA).

Data collection for body height (BH) measurement using a Stadiometer (Portable Seca® Stadiometer, North America). Body weight (BW) is measured using digital scales (OMRON HN-246, Osaka, JAPAN). BMI is calculated using BW (kg) divided by BH (m²). Blood pressure measurement using digital meter tension (OMRON Model Deluxe HEM-8712 BASIC, JAPAN) on the non-dominant arm 3 times in a

row with a break interval of 2 minutes between the two measurements then take the average value of the three measurements. Measurements of heart rate rest (HR-rest) and oxygen saturation (SpO₂) using the Beurer Pulse Oximeter PO-30. Measurement of maximum oxygen volume (VO₂max) using Multi-Stage 20-m Shuttle Run Fitness Test (Paradisis et al., 2014). VO₂max, SpO₂, and HR-rest measurements were pre-test and 1×24 hours post-test during 8 weeks of high-impact aerobic dance exercise and Zumba interventions.

Statistical analysis

The technique of data analysis used the Statistical Package for Social Science (SPSS) version 21 software. The Shapiro-Wilk test was used for normality test analysis with a significant level ($p \geq 0.05$). Paired Sample t-Test was used to compare the mean VO₂max, SpO₂, and HR-rest between pretest vs. posttest, while the Independent Samples t-Test was used to compare the mean VO₂max, SpO₂, and HR-rest between ZADE vs. HADE at the pretest, posttest, and delta observation points. All statistical analyzes used a significant level ($p \leq 0.05$).

Results

Preliminary measurement results of the characteristic parameters of study respondents which include age, body height, body weight, body mass index, blood pressure are shown in Table 1 below.

Based on Table 1, the results of the Independent Samples t-Test analysis showed that there was no significant difference in the average parameter characteristics of study respondents between ZADE vs. HADE ($p \geq 0.05$). The results of the analysis of the average maximum oxygen volume (VO₂max), oxygen saturation (SpO₂), heart rate rest (HR-rest) between pretest vs. posttest on ZADE and HADE can be seen in Figure 1.

Based on Figure 1 it is seen that there is an average change in VO₂max, SpO₂, HR-rest between pretest vs. posttest on ZADE and HADE. Paired Sample T-Test results showed significant differences in average VO₂max, SpO₂, HR-rest between pretest vs. posttest in both groups ($p \leq 0.001$). The results of the analysis of the average VO₂max, SpO₂, HR-rest between ZADE vs. HADE at the pretest, posttest, delta observation points can be seen in Table 2.

Table 1. Initial measurement results of characteristic parameters of study respondents

No	Parameter	ZADE (n = 15)	HADE (n = 15)	p-value
1	Age (years)	20.73±1.58	20.60±1.59	0.820
2	Body height (m)	1.55±0.04	1.54±0.06	0.662
3	Bodyweight (kg)	55.40±4.75	54.33±8.52	0.675
4	Body mass index (kg/m ²)	23.11±2.15	22.78±2.60	0.710
5	Systolic blood pressure (mmHg)	117.87±3.02	116.60±2.56	0.225
6	Diastolic blood pressure (mmHg)	78.87±3.76	77.40±3.78	0.295

Description: ZADE: Zumba aerobic dance exercise, HADE: High impact aerobic dance exercise. p-value is obtained using the Independent Samples t-Test. Data presented with Mean ± SD.

Table 2. Average analysis results VO₂max, SpO₂, HR-rest between ZADE vs. HADE

No	Observation Point	ZADE (n = 15)	HADE (n = 15)	p-value
1	VO ₂ max (mL/kg/min)			
	Pretest	26.37±2.72	26.23±3.57	0.905
	Posttest	30.49±2.31	32.91±3.31*	0.029
	Delta (Post – Pre)	4.12±2.02	6.67±1.25**	0.000
2	SpO ₂ (%)			
	Pretest	96.60±0.91	96.80±0.77	0.522
	Posttest	98.00±0.93	98.87±0.92*	0.015
	Delta (Post – Pre)	1.40±0.74	2.07±0.88*	0.033
3	HR-rest (bpm)			
	Pretest	79.07±4.13	79.60±3.64	0.710
	Posttest	76.40±4.07	73.07±2.81*	0.014
	Delta (Post – Pre)	-2.67±1.05	-6.53±2.67**	0.000

Description: ZADE: Zumba aerobic dance exercise, HADE: High impact aerobic dance exercise. *Significant vs. ZADE ($p \leq 0.05$).

**Significant vs. ZADE ($p \leq 0.001$). p-value is obtained using the Independent Samples t-Test. Data presented with Mean ± SD.

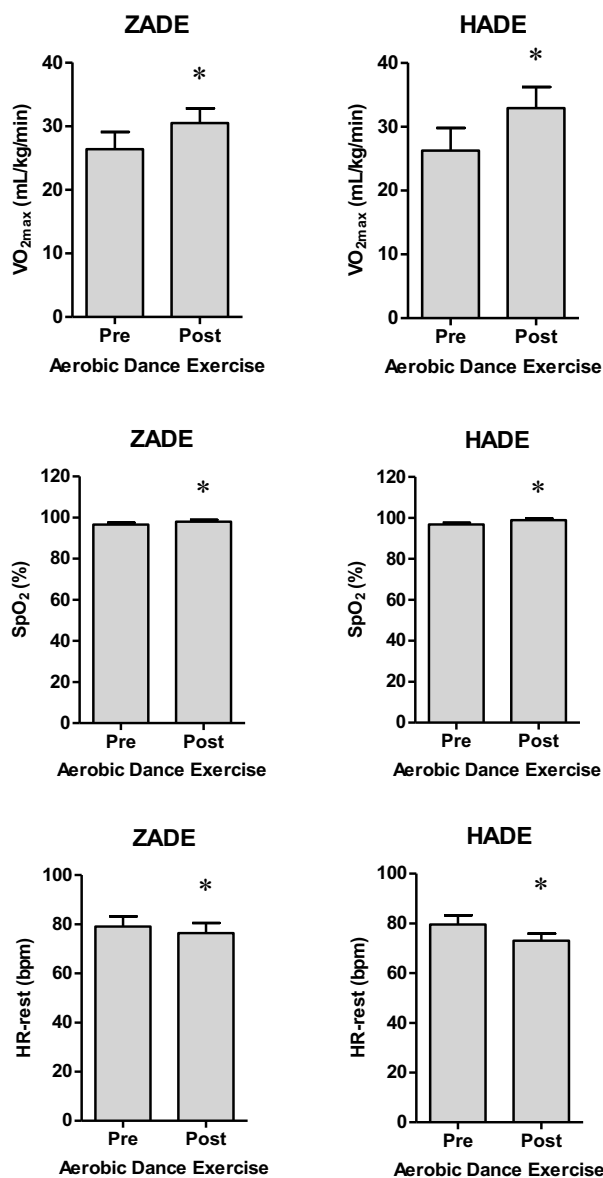


Figure 1. Average VO_{2max} , SpO_2 , HR-rest between pretest vs. posttest on ZADE and HADE

Description: ZADE: Zumba aerobic dance exercise, HADE: High impact aerobic dance exercise. *Significant vs. Pretest ($p \leq 0.001$). p-value is obtained using the Paired Sample t-Test. Data presented with Mean $\pm$ SD

Independent Samples t-Test analysis showed no significant difference in average VO_{2max} , SpO_2 , HR-rest between ZADE vs. HADE at the pretest observation point ($p \geq 0.05$), while at the posttest and delta observation points there was a significant difference in average VO_{2max} , SpO_2 , HR-rest between ZADE vs. HADE ($p \leq 0.05$).

Discussion

Aerobic dance exercise is one form of physical activity that can improve health and please many people around the world (Vijayalakshmi et al., 2021). Currently, aerobic dance exercise has become a lifestyle, this is because aero-

bic dance exercise can improve heart health (Donath et al., 2014), overall muscle strength, balance, and coordination, and reduce depression (Santos-Silva et al., 2021). Our research aims to gain insight into the comparison of the effects of high-impact aerobic dance exercise (HADE) and Zumba aerobic dance exercise (ZADE) to maximal oxygen volume (VO_{2max}), heart rate rest (HR-rest), oxygen saturation (SpO_2). Based on the results of the study showed that there was a significant difference in the average increase in VO_{2max} and SpO_2 between pre-test vs. post-test on (HADE and ZADE). While the average HR-rest between pretest vs. posttest on HADE and ZADE decreased significantly (Figure 1). These results are in line with the results of research conducted by Suminar et al. (2018) reported that high-impact aerobics exercise, and Zumba fitness increase VO_{2max} and decrease heart rate recovery. Research of Nandhini (2013) also reported an increase in VO_{2max} after aerobic dance training. Samba dance performed with moderate to heavy intensity improves cardiorespiratory fitness (Santos-Silva et al., 2021). Likewise, Zumba training (group fitness based on salsa and aerobics) improves aerobic fitness (Donath et al., 2014). The 8-week Low Impact Aerobic Dance Program significantly improved VO_{2max} (Olufemi & Adaeze, 2012). The increase in VO_{2max} is likely due to high-impact aerobic dance exercise increasing Fast-twitch muscle fibers, thus causing an increase in muscle contractions faster than Zumba aerobic dance exercise. Muscle fibers are designed to produce powerful explosive power with the use of more energy sources. Fast-twitch muscle fibers require more energy than slow-twitch muscle fibers, so the recovery process after aerobic dance exercise is more effective (Malleesh et al., 2017).

Heart rate is one of the foundations in determining the dose of physical activity. Heart rate can describe a person's intensity in doing a physical activity so that it can show how hard the heart works. A person who has a normal pulse and tends to be low can have good VO_{2max} and will not easily experience fatigue while doing aerobic exercise. This is supported by our results which showed an increase in VO_{2max} and a decrease in HR-rest after 8 weeks of high-impact aerobic dance exercise and Zumba. High levels of VO_{2max} affect the body's ability to recover optimally. Maximum oxygen volume (VO_{2max}) can provide important information about an individual's capacity in the long-term energy system and maximum oxygen consumption can be increased with long-term aerobic exercise (Bandopadhyay, 2018). Aerobic exercise has been shown to lower the risk of cardiovascular disease in women with sedentary lifestyles characterized by improvements in systolic and diastolic blood pressure as well as increasing high-density lipoprotein (HDL) and lowering total cholesterol (TC), low-density lipoprotein (LDL), and triglyceride (TG) (İmamoğlu et al., 2017).

Endurance is needed for daily activities, with good endurance then daily activities will not experience fatigue that is so heavy. Endurance is strongly related to breathing, heart, and circulatory (Irwandi & Aprizalmi, 2016). Physical freshness is an interpretation of the heart's endurance ability to maintain maximum body performance without experiencing fatigue for a period of time. The parameter that can be used as a marker of a person's physical fitness level is VO_{2max} (Widodo et al., 2021). VO_{2max} is the maximum amount of oxygen that can be consumed during intense physical activity until fatigue occurs. A person with

a good level of VO_2max means also having a good level of physical fitness. Physical fitness gives a person the ability to do productive daily work without excessive fatigue. A person with a low level of physical fitness can increase the risk of death from heart disease and hypertension (Irianto & Hasnah, 2018). Based on the results showed that Zumba aerobic dance exercise and high impact aerobic dance exercise conducted 30 minutes/training sessions with a frequency of 3x/week for 8 weeks increase VO_2max , but high impact aerobic dance exercise is more effective in increasing VO_2max than Zumba aerobic dance exercise (Table 2). Therefore, high-impact aerobic dance exercise can be used as a method in improving physical fitness, to reduce the risk of heart disease and hypertension.

Conclusion

Based on the results of the study concluded that Zumba aerobic dance exercise and high impact aerobic dance exercise conducted 30 minutes/training session with a frequency of 3x/week for 8 weeks increase VO_2max , SpO_2 and decrease HR-rest. But high impact aerobic dance exercise is more effective in increasing VO_2max , SpO_2 , and lowering HR rest than Zumba aerobic dance exercise in adolescent women.

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Conflict of interest

All authors declare no conflict of interest.

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ПОРІВНЯННЯ ВПЛИВУ ВПРАВ ІЗ ВИСОКОУДАРНОЇ ТАНЦЮВАЛЬНОЇ АЕРОБІКИ ТА ЗУМБИ НА ПІДВИЩЕННЯ ПОКАЗНИКА МАКСИМАЛЬНОГО СПОЖИВАННЯ КИСНЮ В ЮНИХ ЖІНОК

Пусподари^{1ABD}, Харі Сетіжоно^{1ABD}, Оце Віріаван^{1ABD}, Поппі Елісано Арфанда^{1BC}, Сламмет Рахарджо^{2BD}, Нур Ахмад Мухаррам^{3CD}, Васіс Хімаванто^{3BC}, М. Акбар Хусейн Аллсабах^{3BCD}, Сусілатуроохман Хендраван Коестанто^{4BD}

¹Державний університет Сурабаї

²Державний університет Маланг

³Кедірський університет Нусантара Асоціації вчителів Індонезії

⁴Університет Кахуріпан в Кедірі

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

Реферат. Стаття: 7 с., 2 табл., 1 рис., 32 джерела.

Метою дослідження було порівняння вправ із високоударної танцювальної аеробіки та зумби за їхнім впливом на підвищення показника максимального споживання кисню (VO_{2max}) у юних жінок.

Матеріали та методи. Це дослідження є квазіекспериментальним, при цьому план проведення дослідження включає попереднє та заключне дослідження в рамках двох експериментальних груп. У дослідженні брали участь загалом 30 юних жінок із секції студентської діяльності зі спортивної аеробіки, які навчаються в університеті Нусантара Асоціації вчителів Індонезії в місті Кедірі (Індонезія), віком 18-24 роки, індекс маси тіла (IMT) 18,5–24,9 кг/м², нормальний кров'яний тиск. Учасниць випадково розподілили на дві групи, а саме: ZADE (n = 15, вправа з танцювальної аеробіки зумби) та HADE (n = 15, вправа з високоударної танцювальної аеробіки). Вправи HADE та ZADE виконувалися протягом 30 хв/заняття з інтенсивністю $\geq 85\%$ максимальної ЧСС (HRmax), із частотою 3 рази/тиждень, і обидва типи тренувань проводилися протягом 8 тижнів. Вимірювання показників максимального споживання кисню (VO_{2max}), насиченості крові киснем (SpO_2) і частоти серцевих скорочень у стані спокою (HRrest) проводили до

початку та 1х24 години після завершення експериментальної частини після 8 тижнів тренувального втручання. Статистичний аналіз даних було проведено з використанням t-критерію Стьюдента для парних вибірок показали значні відмінності в середніх значеннях показників максимального споживання кисню (VO_{2max}), насиченості крові киснем (SpO_2) і ЧСС у стані спокою (HRrest) між даними до та після експериментальної частини в обох групах ($p \leq 0,001$).

Результати. Результати аналізу даних із використанням t-критерію Стьюдента для парних вибірок показали значні відмінності в середніх значеннях показників максимального споживання кисню (VO_{2max}), насиченості крові киснем (SpO_2) і ЧСС у стані спокою (HRrest) між даними до та після експериментальної частини в обох групах ($p \leq 0,001$).

Висновки. На підставі одержаних результатів дослідження ми дійшли висновку про те, що і вправи з високоударної танцювальної аеробіки (HADE), і вправи з танцювальної аеробіки зумби (ZADE) підвищують показники максимального споживання кисню (VO_{2max}), насиченості крові киснем (SpO_2) та знижують показник ЧСС у стані спокою (HRrest). Проте вправи з HADE ефективніші за вправи ZADE для підвищення показників VO_{2max} , SpO_2 та зниження показника HRrest у юних жінок.

Ключові слова: танцювальна аеробіка, вправа, високоударний, максимальне споживання кисню, зумба.

Information about the authors:

Puspodari: puspodari.20012@mhs.unesa.ac.id; <https://orcid.org/0000-0002-1753-4127>; Doctoral Program of Sport Science, Faculty of Sport Science, Universitas Negeri Surabaya, Lidah Wetan Street, Surabaya, East Java 60213, Indonesia.

Hari Setijono: harisetijono@yahoo.co.id; <https://orcid.org/0000-0001-8305-4933>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Surabaya, Lidah Wetan Street, Surabaya, East Java 60213, Indonesia.

Oce Wiriawan: ocewiriawan@unesa.ac.id; <https://orcid.org/0000-0003-1830-9519>; Department of Sport Coaching Education, Faculty of Sport Science, Universitas Negeri Surabaya, Lidah Wetan Street, Surabaya, East Java 60213, Indonesia.

Poppy Elisano Arfanda: poppy.20014@mhs.unesa.ac.id; <https://orcid.org/0000-0002-8191-6912>; Doctoral Program of Sport Science, Faculty of Sport Science, Universitas Negeri Surabaya, Lidah Wetan Street, Surabaya, East Java 60213, Indonesia.

Slamet Raharjo: slamet.raharjo.fik@um.ac.id; <https://orcid.org/0000-0002-0708-867X>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Semarang No. 5 Street, Malang, East Java 65145, Indonesia.

Nur Ahmad Muharram: nurahmad.2019@student.uny.ac.id; <https://orcid.org/0000-0002-8741-0664>; Faculty of Health and Science, Universitas Nusantara PGRI Kediri, Ahmad Dahlan No. 76 Street, Kediri, East Java 64112, Indonesia.

Wasis Himawanto: himasis_23@unpkediri.ac.id; <https://orcid.org/0000-0001-5139-2452>; Study Program of Sports Teacher, Postgraduate Program, Universitas Nusantara PGRI Kediri, Ahmad Dahlan No. 76 Street, Kediri, East Java 64112, Indonesia.

M. Akbar Husein Allsabab: akbarhusein@unpkediri.ac.id; <https://orcid.org/0000-0001-9639-2149>; Faculty of Health and Science, Universitas Nusantara PGRI Kediri, Ahmad Dahlan No. 76 Street, Kediri, East Java 64112, Indonesia.

Susilaturachman Hendrawan Koestanto: susilaturachman@kahuripan.ac.id; <https://orcid.org/0000-0002-8064-015X>; Study Program of Physical Education, Health, and Recreation, Universitas Kahuripan Kediri, Ahmad Dahlan No. 76 Street, Kediri, East Java 64112, Indonesia.

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THE VALIDITY AND RELIABILITY OF THE PHYSICAL ACTIVITY QUESTIONNAIRES (PAQ-A) AMONG INDONESIAN ADOLESCENTS DURING ONLINE AND BLENDED LEARNING SCHOOLING

Atikah Rahayu^{1ABCDE}, Sumaryanti^{1ABCDE} and Novita Intan Arovah^{1ABCDE}

¹Yogyakarta State University

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

Corresponding Author: Novita Intan Arovah, E-mail:novita@uny.ac.id

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Abstract

Research objectives. This study aimed to validate the use of the Physical Activity Questionnaire Adolescent (PAQ-A), a physical activity instrument widely used in a school setting, among Indonesian adolescents, particularly during blended learning or online schooling due to COVID-19 restrictions.

Materials and methods. This study was a cross-sectional survey of 370 Indonesian adolescents (62.2% female, mean 15±2 years) participating in online and blended learning. Participants completed the Indonesian version of the PAQ-A online. Sixty-three (17%) participants completed the same questionnaire one week later (second survey) for the test-retest reliability, from which the intraclass correlation coefficients (ICC) were calculated. Internal consistency reliability was calculated in both surveys, while confirmatory factor analysis (CFA) was analyzed from the data in the first survey.

Results. The Cronbach alpha of the PAQ-A for the first and second surveys was 0.78 and 0.82, thus indicating the acceptability of internal consistency reliability. The ICC for all PAQ-A items ranged from 0.40 to 0.81, indicating fair to excellent test and retest reliability. The root means square error of approximation was 0.033 suggesting acceptable construct validity of the instrument.

Conclusions. In conclusion, sufficient evidence shows the validity and reliability of the PAQ-A to justify the use of the questionnaires for measuring physical activity levels in the Indonesian adolescents in the blended learning or online schooling setting.

Keywords: validity, reliability, physical activity questionnaire, adolescents, Indonesia.

Introduction

One of the objectives of physical education in school is to promote physical activity, as an important aspect of growth and development among children and adolescents (Trudeau & Shephard, 2008). Moreover, regular physical activity has been found to provide various benefits for physical, mental, and psychosocial health, all of which are essential for optimizing learning, thus, it fosters improved academic performance among children and adolescents (Erwin et al., 2012). Regular physical activity also plays a critical role in health maintenance (WHO, 2018; Chooi et al., 2019), and in preventing non-communicable diseases (NCD) (Badr et al., 2017; Choukem et al., 2020; Geidl et al., 2020), such as

diabetes mellitus, hypertension, heart disease, cancer, and stroke (Kinlen et al., 2018; Longo et al., 2019). For optimum health benefits, the World Health Organization (WHO) recommends at least 60 minutes per day of moderate or high-intensity physical activity for adolescents (WHO, 2018). Despite this recommendation, however, physical activity level is declining among adolescents globally and in Indonesia (WHO, 2020; Ministry of Health Republic of Indonesia, 2018), while physical inactivity increased from 70% in 2018 to 81% in 2020 in Asian countries (WHO, 2018; WHO, 2020). Therefore, physical activity promotion should be a public health priority among Indonesian adolescents.

Interventions to promote physical activity are essential in this age group because adolescents experience rapid physical, psychosocial, and cognitive development (Regwelski et al., 2019), affecting their physical activity. Moreover, behavioral interventions in this stage are critical since physical activity

is likely to continue into adulthood (Psaltopoulou et al., 2019; Chaudhry et al., 2020; Flodgren et al., 2020). These interventions require valid and reliable instruments for measuring physical activity. However, although several instruments have been widely used to measure physical activity, such as the International Physical Activity Questionnaire (IPAQ) and Global Physical Activity Questionnaire (GPAQ) (Keating et al., 2019), only a few instruments were available for assessing physical activity among adolescents.

One of the instruments is the Physical Activity Questionnaire-Adolescent (PAQ-A), which is considered a brief and comprehensive instrument which is widely used in the school setting. The validity of the PAQ-A during the instrument development was reported by Kowalski et al. (1997) among eighty-five students in grades 8 to 12. They demonstrated a significant correlation of the PAQ-A with physical activity rating ($r = 0.73$), the leisure time training ($r = 0.57$), a caltrac motion sensor ($r = 0.33$), and the seven days of physical activity recall interview ($r = 0.59$) (Kowalski et al., 1997).

However, while the PAQ-A has demonstrated good validity and reliability in the countries such as Canada (Kowalski et al., 2004), England (Aggio et al., 2016), Poland (Wyszyńska et al., 2019), Turkey (Polat et al., 2021), Malaysia (Koh et al., 2020), Ethiopia (Andarge et al., 2021), and Thailand (Pratanaphon et al., 2020), the validation of the instrument during online or blended learning due to school closure or social restriction associated with COVID-19 preventive measures have not been reported in the literature, including in Indonesian setting. This study, therefore, aimed to evaluate the validity and reliability of the Indonesian version of the PAQ-A in the Indonesian adolescent population during blended learning or online schooling due to the COVID-19 restriction. It is expected that the validated instruments could be used as a basis for evaluating physical activity levels among adolescents in this setting.

Materials and methods

Study participants

This research was a cross-sectional study assessing the psychometric properties of the Indonesian version of PAQ-A among adolescents in the school setting (online and blended learning). The research involved 370 Indonesian adolescents between 11-18 years old. Of those, 63 (17%) participated in the second survey for the test and retest analysis the following week. Participants were provided with written consent and parental consent. The research protocol was approved by the Human Ethics Committee of Universitas Gadjah Mada (approval No. KE/FK/1052/EC/2021).

Instrument and Scoring Procedures

PAQ-A assesses physical activity levels for adolescents in grades 9 to 12 or ages 11 to 18 in a school setting. PAQ-A consists of nine questions about daily physical activity during the week, in and outside the school for the last week. The first question contains sixteen questions that specifically discuss the time used for specific types of physical activity/sports usually carried out by adolescents. Question #2 to #7 ask for their physical activity during leisure time, physical education, lunch, after school, evening, weekend. Item #8

ask the frequency of physical activity during each day of the last week, while the ninth question review changes in physical activity compared to the previous week. For the first eight items, the score ranges from 1-5, in which the highest score indicates a higher physically active level. Scores for item #1 and item #8 are the average of the responses. The final score if PAQ-A is the average of items #1 to #8.

Statistical Analysis

Participants completed the Indonesian version of the PAQ-A online (first survey). They were again contacted in the following week to complete the online questionnaire (second survey). In the first survey, they have also completed questionnaires asking their age, weight, height, family history of obesity, study mode (online or blended), type of school (public or private), and duration of time they spend engaging in moderate-vigorous physical activity.

Age data were categorized into two groups (i.e., early adolescents ranging from 11 to 14 years old, and middle adolescents from 15 to 18 years old). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and was categorized into underweight (<18.5), normal ($18.5-23.5$), and overweight (>23.5). The family history of obesity was organized into two: the presence and absence of obesity in both the father and or mother, grandfather, and grandmother. Time engaging for physical activity was divided into <60 minutes/day and 60 minutes/day. Group comparisons were made between participants who completed only the first survey and completed twice based on those characteristics using the Pearson Chi-Square test.

Internal reliability consistency of PAQ-A was assessed using Cronbach Alpha, with less than 0.70 to indicate acceptable reliability (Sharma, 2016). We also calculated one-week- test and retest reliability on both the PAQ-A by calculating each item's intra-class correlation (ICC) (single oneway model). The ICC 0.4 to 0.59 was considered fair, >0.60 was considered good, and the ICC >0.75 was considered excellent (Schreiber, 2006). To assess the construct's validity, confirmatory factor analysis (CFA) was used to determine the goodness of fit of the observed data using the hypothesized model structure. Several goods of fit criteria indices were used. First, chi-square (χ^2) of less than 3.00 indicated a good fit (Schreiber, 2006). Second, the Root Mean Square Error of Approximation (RMSEA) less than 0.08 indicated a good fit (MacCallum et al., 1996). Next, the Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) of >0.90 , and the standard value of the root mean Square Residual (SRMR) of <0.08 were also indicators of a good fit (Hu & Bentler, 1999). We also calculated the loading factor for each PAQ-A with factor loadings of 0.30 to 0.50 considered low, 0.50 to 0.70 considered moderate, and 0.70 considered good (Shevlin & Miles, 1998). Data were analyzed using SPSS® version 21.0 (IBM Corp., Armonk, NY, USA), except the CFA uses Lisrel version 8.80 (Jöreskog, 2006., by Karl Jöreskog and Dag Sorbom. Scientific Software International, Inc, Copyright©2006) (Jöreskog, & Sorbom, 1993).

Results

Participants Social Demographic Characteristics

Three hundred and seventy participants completed the first survey, and 63 of them completed the second survey

Table 1. Comparisons of Participants Sociodemographic in the First and Second Surveys

Characteristics	Total * (n = 370)	Only completed the 1 st survey (n = 307)	Also completed the 2 nd survey (n = 63)**	p-value#
Teenage Age (years)	15 ± 2	15 ± 2	15 ± 2	0.897
11-14 (early)	176 (47.6%)	147 (47.9%)	29 (46.0%)	
15-18 (middle)	194 (52.4%)	160 (52.1%)	34 (54.0%)	
Sex				0.811
Female	230 (62.2%)	190 (61.9%)	40 (63.5%)	
Male	140 (37.8%)	117 (38.1%)	23 (36.5%)	
Body mass index				0.554
Underweight <18.5	150 (40.5%)	122 (39.7%)	28 (44.4%)	
Normal weight (18.5-23.5)	170 (45.9%)	141 (45.9%)	29 (46.0%)	
Overweight >23.5	50 (13.5%)	44 (14.3%)	7 (9.5%)	
Family history of obesity				0.475
Yes	147 (39.7%)	125 (40.7%)	22 (34.9%)	
No	223 (60.3%)	185 (59.3%)	41 (65.1%)	
Type of school				0.060
Public	280 (75.7%)	226 (73.6%)	54 (85.7%)	
Private	90 (24.3%)	81 (26.4%)	9 (14.3%)	
Learning Mode				0.378
Mix	170 (45.9%)	146 (47.6%)	24 (38.1%)	
Full online	200 (54.1%)	161 (52.4%)	39 (61.9%)	
Duration of time for physical activity/sports				0.213
< 60 minutes/day	281 (75.9%)	237 (77.2%)	44 (69.8%)	
≥ 60 minutes/day	89 (24.1%)	70 (22.8%)	19 (30.2%)	

Table 2. Descriptive Statistics and Reliabilities Assessments

No	Characteristics	First Survey (n = 370)			Second Survey (n = 63)			ICC
		Mean ± SD	Corrected item-subscale	α if item deleted	Mean ± SD	Corrected item -subscale	α if item deleted	
PAQ-A								
1.	Physical activity in your spare time: Have you done any of the following activities in the past 7 days (last week)? If yes, how many times?	1.47 ± 0.37	0.49	0.76	1.49 ± 0.29	0.55	0.77	0.79
2.	In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)?	3.70 ± 0.88	0.25*	0.77	3.76 ± 0.96	0.37*	0.78	0.73
3.	In the last 7 days, what did you normally do at lunch (besides eating lunch)?	1.70 ± 1.05	0.12*	0.80	1.95 ± 1.29	0.22*	0.82	0.83
4.	In the last 7 days, on how many days right after school, did you do sports, dance, or play games in which you were very active?	2.40 ± 0.96	0.52	0.73	2.85 ± 1.12	0.69	0.72	0.65
5.	In the last 7 days, on how many evenings did you do sports, dance, or play games in which you were very active?	2.26 ± 1.13	0.63	0.71	2.92 ± 0.85	0.59	0.74	0.64
6.	On the last weekend, how many times did you do sports, dance, or play games in which you were very active?	2.15 ± 1.02	0.54	0.73	2.58 ± 0.69	0.45	0.76	0.40
7.	Which one of the following describes you best for the last 7 days?	2.14 ± 1.11	0.69	0.70	2.42 ± 1.03	0.70	0.72	0.79
8.	Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week	2.31 ± 0.87	0.68	0.70	2.52 ± 0.81	0.68	0.73	0.81

*=corrected item-total correlation item deleted <0.4

for the retest reliability assessment (17%). Table 1 summarizes and compares the characteristics of participants who completed only the first survey ($n = 307$) and those who completed both surveys in both the first and second surveys ($n = 63$). Overall, the age of the participants ranged from 11-18 years with a mean of 15 ± 2 years. The majority were women, average weight, had no history of obesity in the family, attended public school, learned online, had less than 60 minutes/day of physical activity, and lived in Java Island in Indonesia. Participants who completed only the first survey and completed both surveys were similar in these characteristics ($p > 0.05$).

Descriptive Statistics, and Reliability of PAQ-A

Table 2 summarizes the descriptive statistics of each PAQ-A item as well as the internal consistency and test and retest reliabilities. As seen in Table 2, the Cronbach alpha for the PAQ-A was 0.77 and 0.78 in the first and second surveys. As seen in Table 2, the corrected item subscale of one item of the PAQ-A was below 0.4. However, the ICC for each PAQ-A from 0.40 to 0.81, thus indicating fair to excellent test and retest reliability.

Confirmatory Factor Analysis

The findings from the confirmatory factor analysis are presented in Table 3 and Figure 1.

Table 3 demonstrates that all fitness indexes of the Indonesian translated versions of PAQ-A indicated a good fit

Table 3. Goodness-of-fit statistics of the original and PAQ-A structure ($n=370$)

Characteristics	PAQ-A
χ^2/df	1.35
RMSEA (90%CI)	0.033 (0.000-0.059)
CFI	0.991
TLI	0.987
SMSR	0.062

Note: df, degree of freedom; RMSEA, root mean square approximation; CFI, comparative fit index; TLI, Tucker Lewis index; SMSR, standardized root mean square residual.

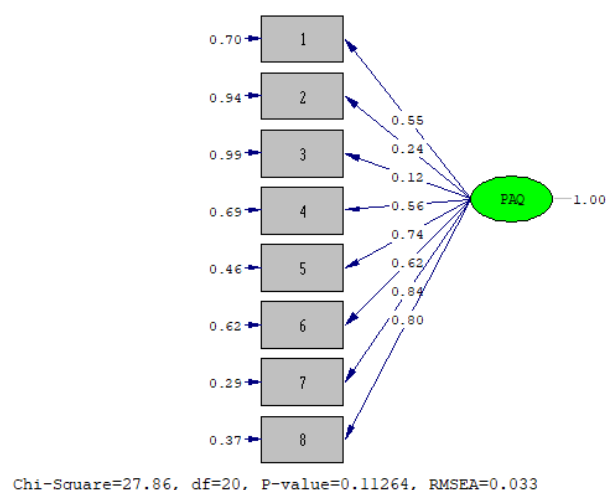


Figure 1. Factor loading PAQ-A

with the original factor structure. Figure 1 further indicates that all items except for items #2 and #3 on the PAQ-A have acceptable factor loadings.

Discussion

This study was the first to validate the PAQ-A in Indonesia and the first to report the validity and reliability of the instrument in the online or blended learning school setting. The overall finding of this study indicates an acceptable internal consistency and test and retest reliability well as a good construct validity of the instrument. The finding from this study suggests that the Indonesian translated version of the PAQ-A questionnaire shows a good and acceptable internal reliability consistency (α -Cronbach of 0.77 and 0.78 in the first and second surveys) and an excellent total intraclass correlation coefficient ($ICC = 0.40-0.83$).

The findings from this study are in line with findings by Aggio et al. (2016) in 169 adolescents with the mean age 14.8 ± 1.7 years in England, which reported α -Cronbach of 0.72 and ICC value of 0.78. It is also in line with findings reported by Wyszynska et al. (2019) in adolescents in 78 Poland age ranged 14-19 years, reporting α -Cronbach of 0.93; $ICC = 0.97$; $r = 0.94$ and $ICC = 0.97$. Our findings are also in corroboration with Polat et al. (2021), who studied PAQ-A among 150 adolescents aged 14-18 years in Turkey, which reported α -Cronbach of 0.86 $ICC = 0.71-0.99$ (Polat et al., 2021). Our findings also support the findings from Koh et al. (2020), who validated PAQ-A in 60 adolescents in Malaysia, age ranged from 15-17 years, which reported with $ICC = 0.72$. It also supports the findings by Pratanaphon et al. (2020) in 96 adolescents in Thailand reporting α -Cronbach of 0.84 and ICC of 0.78, and a study by Andarge et al. (2021) among 110 adolescents aged between 14-19 years old in Southern Ethiopia, which reported α -Cronbach α of 0.74 in their first study and 0.76 in their follow up study. However, the intraclass correlation from the Andarge et al. (2021) study was 0.34 was lower than the finding of our research. The discrepancy might be due to the different intervals of the test and retest study. Their study test and retest interval were 5 weeks, compared to only 1 week in our study thus may be attributed to the discrepancy of these findings.

These previous studies were paper-based surveys conducted during offline schooling, while ours was an online survey conducted during online schooling and blended learning. The findings of this present study, therefore, extend the applicability of the PAQ-A within an online environment. In addition, the overall goodness and fitness test indicate a good fit of the data, thus supporting the use of this instrument in this population. Two items in the PAQ A, however, indicate low factor loadings. These items asked about physical activity during physical education lessons and lunchtime. Participants with full online schooling might have difficulties in answering these questions. Therefore, further studies are required to confirm this finding. Attempt to compare this finding with confirmatory factor analysis on other studies in PAQ-A is limited as studies to validate PAQ-C in the literature are lacking (Cuberek et al., 2021). The finding from this study thus extends the evidence of the PAQ-C construct validity among adolescents in developing countries such as Indonesia during online schooling.

The main strength of our study was that we assessed the validity of the Indonesian version of PAQ-A using standard-

ized guidelines (Kowalski et al., 2004; Johnson et al., 2002). Another strength was that the sample size in our study exceeds the sample size for factor analysis, thereby increasing the accuracy of the estimates (Jackson, 2003). We, however, acknowledge several limitations. First, the study sample was recruited using internet access and social media, so there are limitations in generalizing our findings to adolescents who do not have access to social media. Second, with a cross-sectional design in the study, due to resource limitation, we did not conduct convergent validity of the PAQ-a with the gold standard such as accelerometers, further research to confirm the validity of the PAQ-A compared to the accelerometers, therefore, are recommended.

Conclusions

Preliminary evidence indicates the validity and reliability of the Indonesian version of PAQ-A in Indonesian adolescents to justify the use of the Indonesian translated version of these questionnaires among Indonesian adolescents in blended learning or online school settings. Further research, however, is recommended to confirm the finding of this study.

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Conflict of interest

All authors declare no conflict of interest.

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ВАЛІДНІСТЬ І НАДІЙНІСТЬ АНКЕТ ІЗ ФІЗИЧНОЇ АКТИВНОСТІ (PAQ-A) СЕРЕД ІНДОНЕЗІЙСЬКИХ ПІДЛІТКІВ ПІД ЧАС ДИСТАНЦІЙНОГО ТА ЗМІШАНОГО НАВЧАННЯ В ШКОЛІ

Атіках Рахаю^{1ABCDE}, Сумарянті^{1ABCDE}, Новіта Інтан Арова^{1ABCDE}

¹Державний університет Джок'якарти

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

Реферат. Стаття: 7 с., 3 табл., 1 рис., 33 джерела.

Мета дослідження. Це дослідження мало на меті обґрунтування використання анкети з фізичної активності для підлітків (PAQ-A), тобто засобу вимірювання рівнів фізичної активності, який широко використовують у шкільному середовищі, серед індонезійських підлітків, особливо під час змішаного або дистанційного навчання в школі через обмеження внаслідок пандемії COVID-19.

Матеріали та методи. Це дослідження становило собою перехресне опитування 370 індонезійських підлітків (62,2% жіночої статі, середній вік 15 ± 2 роки), які брали участь у процесі дистанційного та змішаного навчання. Учасники заповнювали анкету PAQ-A індонезійською мовою онлайн. Шістьдесят три (17%) учасники заповнили ту саму анкету через тиждень (повторне опитування)

для оцінки надійності результатів повторного тестування, із якого були розраховані коефіцієнти внутрішньогрупової кореляції (ICC). Надійність внутрішньої узгодженості було розраховано в обох опитуваннях, тоді як підтверджувальний факторний аналіз (CFA) було проведено на основі даних, одержаних у першому опитуванні.

Результати. Коефіцієнт альфа Кронбаха анкет PAQ-A для першого та повторного опитувань становив 0,78 та 0,82, таким чином указуючи на прийнятність показників надійності внутрішньої узгодженості. Коефіцієнти внутрішньогрупової кореляції (ICC) для всіх пунктів анкети PAQ-A коливалися в межах від 0,40 до 0,81, показуючи на-

дійність результатів повторного тестування від задовільної до відмінної. Середньоквадратична похибка апроксимації становила 0,033, що дає підстави вважати конструктивну валідність зазначеного вище засобу прийнятною.

Висновки. Як висновок, достатні докази показують валідність і надійність анкет PAQ-A для обґрунтування використання цих анкет для вимірювання рівнів фізичної активності в індонезійських підлітків у шкільному середовищі в умовах змішаної або дистанційної форми навчання.

Ключові слова: валідність, надійність, анкета з фізичної активності, підлітки, Індонезія.

Information about the authors:

Atikah Rahayu: atikah.rahayu@uny.ac.id; <https://orcid.org/0000-0002-2478-794X>; Department of Sports Science, Faculty of Sports Science, Universitas Negeri Yogyakarta, Indonesia.

Sumaryanti: sumaryanti@uny.ac.id; <https://orcid.org/0000-0002-5989-5326>; Department of Sports Science, Faculty of Sports Science, Universitas Negeri Yogyakarta, Indonesia.

Novita Intan Arovah: novita@uny.ac.id; <https://orcid.org/0000-0002-0779-3344>; Department of Sports Science, Department of Sports Science Faculty of Sports Science, Universitas Negeri Yogyakarta, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

CONFIDENCE, ACADEMIC STRESS, COPING STRATEGIES AS PREDICTORS OF STUDENT ACADEMIC ACHIEVEMENT IN PHYSICAL EDUCATION CLASSES DURING COVID-19

Aria Kusuma Yuda^{1ABCDE}, Citra Resita^{1ACDE}, Rhama Nurwansyah^{1ACD},
Ruslan Abdul Gani^{1ABC}, Zsolt Németh^{2ABD} and Edi Setiawan^{3ABCD}

¹University of Singaperbangsa Karawang

²University of Pécs

³University of Suryakencana

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

Corresponding Author: Aria Kusuma Yuda, E-mail: aria.kusumayuda@fkip.unsika.ac.id

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Abstract

Research purpose. In this COVID-19 pandemic era, the psychological aspect takes an important role in achieving optimal academic results among students, but the factors that correlate with academic achievement are not yet known accurately. Thus, this study aims to assess the relationship between self-confidence, academic stress, coping strategies and academic achievement.

Materials and methods. This study used a correlation method with subjects from among students in grades 7 to 9 at Ibtidaiyah Junior High School (N = 90). The instrument used in this study was a self-confidence, academic stress and coping strategy questionnaire, while the average score for the final semester examination was used as an indicator that showed progress of student academic achievement. Data was analyzed using IBM SPSS to find out descriptive statistics, data normality. Meanwhile, bivariate correlation and regression analysis were used to test the relationship between variables. The following conclusions can be drawn from this study.

Results. First, self-confidence was related to academic achievement, second, academic stress was related to academic achievement, and third, the coping strategy was related to academic achievement.

Conclusions. Thus, to obtain high academic achievement in physical education classes, contribution from self-confidence, academic stress and coping strategies are highly needed. The findings from this study make several contributions to the development of science in the physical education field in terms of psychology to improve student academic achievement.

Keywords: self-confidence, academic stress, coping strategies, academic achievement.

Introduction

In December 2019 a new variant virus named Corona (SARS-CoV-2) appeared in the city of Wuhan (China) has infected millions of people around the world and the World Health Organization (WHO) has declared the novel coronavirus (COVID-19) outbreak a global pandemic (Torales, O'Higgins, Castaldelli-Maia & Ventriglio 2020; Pawar, 2020; Leal Filho et al., 2021). Based on warning issued by WHO, the governments in all countries have implemented a num-

ber of measures to prevent COVID-19 from spreading massively in the society, for example applying social distancing, physical distancing (Hu, Zhang, Sun & Li, 2021; Yomoda & Kurita, 2021), lock down (Morgül et al., 2020), then prohibit daily activities in groups with relatively large numbers in public places, shops, industry and schools (Chen, Byne & Vélez, 2021). The existence of these policies often triggers negative effects on the psychological aspects of society (Saladino, Algeri & Auriemma, 2020; Li et al., 2020; Cielo, Ulberg & Di Giacomo, 2021). The physical education learning process is one of the areas that has been significantly affected by COVID-19 and currently often triggers a negative impact on the psychological aspects of students, such as the emergence of laziness, depression, stress, frustration,

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anxiety (Spinelli, Lionetti, Pastore & Fasolo, 2020; Nearchou et al., 2020; Alzween, Bashatwa & Hamadneh, 2021), loss of self-confidence (Malureanu, Panisoara & Lazar, 2021), and most fatally caused academic achievement to slowly decline (Hammerstein, König, Dreisörner & Frey, 2021).

Academic achievement is an essential part and must be achieved as high as possible by students when undergoing the physical education process in the long term. High academic achievement could support students to gain their potential, so they will much easier to get a job and be successful in living his life in the future (Moore, 2019). High academic achievement assists students more motivated to develop their ability in obtaining a job during this difficult COVID-19 pandemic and conversely, if students have low academic achievement, it will cause students difficult to get a job (Tentama & Abdillah, 2019). Several factors are claimed to have a relationship with the high or low academic achievement of a student, including self-confidence, academic stress, and coping strategies.

Self-confidence is the first factor that is claimed to be closely related to student academic achievement in school. Self-confidence is one of the psychological aspects that generally has a definition as a student's belief in own ability to do the best assignment in a school or sports activities (Hays et al., 2009; Besharat & Pourbohloul, 2011; Kuloor & Kumar, 2020). Self-confidence is one of the aspects that must be developed in students' character. Possessing a high level of self-confidence will help them become more enthusiastic about studying at school and at home during the COVID-19 pandemic (Malureanu et al., 2021). Recent studies reported that crises in most current education systems were due to low self-confidence, which causes low participation in learning activities (Ravichandran et al., 2021). Self-confidence is needed for a student to be implicated in learning activities. The results of another study found that the self-confidence factor is the key for students to achieve optimal performance in a competition (Ibrahim, Jafar, Kassim & Isab, 2016). However, when someone has a low level of self-confidence, it often leads to higher levels of anxiety, depression, and stress and impacts decreased performance (Marshall & Gibson, 2017). In addition, low levels of self-confidence will greatly affect motivation and academic achievements (Malureanu, Panisoara & Lazar, 2021). Even the biggest disadvantage is when a person has a low level of self-confidence, it is possible to trigger extreme stress (Litwic-Kaminska, 2020).

Academic stress is a psychological aspect that currently often appears during learning process in the COVID-19 era (Mahapatra, 2021; Chandra, 2021; Clabaugh, Duque & Logan, 2021; Fuente et al., 2021; Basheti, Mhaidat & Mhaidat, 2021). Academic stress is a condition in which a student experiences a mental disorder or pressure caused by learning activities at school (Basith, Syahputra, Fitriyadi, Rosmaiyadi, Fitri & Triani, 2021). A student who experienced high stress might have feelings of fear, anxiety, panic and worse can lead to weakness, nausea, dizziness, shaking, loss of concentration, and decreased motor skills (Runswick, Roca, Williams, Bezodis & North, 2016). A recent study reported that students' academic stress levels while taking lessons in the COVID-19 era increased by 12% (Moeller et al., 2020). Recent studies have reported that several factors that cause the increment in stress levels are online learning which has various obstacles is a trigger for stress symptoms in students (Basheti, Mhaidat & Mhaidat, 2021). Another factor is students are afraid of being

infected by COVID-19, students must undergo isolation/lock down (Sundarasan et al., 2020), or the difficulty of carrying out physical education lessons online (Jumareng, Setiawan, Patah, Aryani, Asmuddin & Gani, 2021). Thus, these factors will trigger the low academic achievement of students (Basith, Syahputra, Fitriyadi, Rosmaiyadi, Fitri & Triani, 2021).

A coping strategy is one of the methods that can be used in sports and in the context of physical education learning to reduce stress levels in students and is claimed to have the power to trigger self-confidence (Radochonski, Cynarski, Perenc & Siorek-Maślanka, 2011). According to Skapinakis et al., (2020) coping is a psychological response to a threat, loss, or negative things and through coping strategies, all problems that attack aspects can be overcome. Several studies have reported that there was a link between academic stress and coping strategies with academic (Gustems-Carnicer et al., 2019). However, not all coping strategies were effective in reducing stress (Basith, Syahputra, Fitriyadi, Rosmaiyadi, Fitri & Triani, 2021). Research on coping strategies had been extensively studied internationally and reported by previous studies (Kaplánová, 2019; Gustems-Carnicer et al., 2019; Morales & Pérez-Mármol, 2019; Kaplánová, 2020; Muthmainah, Purwanta, Suwarjo & Mariani, 2021). However, there are no studies that try to explain the relationship between self-confidence, academic stress, coping strategies, and academic achievement that have been reported. Therefore, our main objective was to examine the relationship between self-confidence, academic stress, and coping strategies with academic achievement.

Materials and methods

Study participants

This study adopted a descriptive correlation method, which investigated the correlation between independent variables and another (Jumareng & Setiawan, 2021).

Table 1. Demographic of Subject

Demographic Information		Frequency	Percentage
Gender	Male	60	66.7
	Female	30	33.3
Age	<13	21	23.3
	14-15	42	46.7
	16>	27	30.0
Class	7	19	21.1
	8	48	53.3
	9	23	25.6

The subjects involved in this study were Ibtidaiyah Junior High School located in Karawang Regency, West Java Province (Indonesia) which was selected using a random sampling technique and obtained 90 students from 120 students who were willing to participate in this study. The characteristics of the subjects are presented in Table 1.

Instrument

Self-Confidence. The instrument for measuring self-confidence was a questionnaire that was adopted from Ibrahim,

Jaafar, Kassim & Isab, (2016) with 7 items, and researchers developed it into 30 question items. Items are scored using a Likert scale ranging from 1 ("strongly disagree"), 2 ("disagree"), 3 ("agree") to 4 ("strongly agree") and this instrument had been validated, so it has a value alpha coefficient 0.85.

Academic Stress. In order to measure the level of academic stress among students, the researcher used the academic stress rating scale (SAAS). Indicators consist of cognitive, affective, physical, social/interpersonal, and motivational. There were 30 questions (Basith, Syahputra, Fitriyadi, Rosmayadi, Fitri & Triani, 2021) which was developed by researcher reference to the academic stress felt by students when undergoing the physical education learning process during the COVID-19 pandemic. Items were scored using a Likert scale ranging from 1 ("strongly disagree") to 4 ("strongly agree"). A Cronbach's α of 0.78 was found in this study.

Coping strategy. Coping strategy instrument adopted from previous research (Genc, 2016; Muthmainah, Purwanta, Suwarjo & Mariani, 2021). This instrument has two aspects, namely, problem-focused coping with indicators (a) seeking instrumental support, (b) problem solving, (c) confrontive coping, the second aspect is emotion-focused coping with indicators (a) seeking social support, (b) self-control, (c) accepting responsibility, (d) optimistic thinking. Question items were scored using a Likert scale ranging from 1 ("strongly disagree"), 2 ("disagree"), 3 ("agree") to 4 ("strongly agree"). The number of questions in this study was 28 items. This instrument has an alpha coefficient value of 0.81.

Academic achievement. The score of final semester exam results in the form of a knowledge test was calculated based on the points obtained by students. The average score on the final semester exam was considered an indicator of the progress in academic achievement among students (Gustems-Carnicer et al., 2021).

Study organization

This research has received permission from the Ibtidaiyah Junior High School with approval date 08/11/2021 and approval number E 255/K-45/2021. In addition, this study has followed the Ethics guidelines from the World Medical Association (Helsinki Declaration). Prior to this research, the researcher had explained the implementation and the rules in the research. Then all subjects had to sign a consent form to participate in this research activities and all of them were informed that this research was voluntary. All subjects were given 30 minutes to fill in the self-confidence, academic stress, coping strategies, and academic achievement instruments. After completing the questionnaire, data were collected and analyzed by the research team and 3 psychology experts.

Statistical analysis

All data in this study were analyzed using the IBM SPSS version 25.0 application. The first analysis was performed to find descriptive statistics (mean, standard deviation), then tested the normality of the data (Kolmogorov-Smirnov). While, the third analysis was using Pearson correlation to assess the relationship between self-confidence, academic stress, coping strategies, and academic achievement. A multiple regression analysis was used to examine the strongest

predictor of self-confidence, academic stress, and coping strategies with academic achievement (Asakereh & Yousofi, 2018). The significance level used was 0.05.

Results

The results of the data normality test show that the self-confidence variable has ($p = 0.189$). While the academic stress variable ($p = 0.221$), for the coping strategies variable ($p = 0.249$) and academic achievement ($p = 0.321$), thus it can be interpreted that all data were normally distributed.

Table 2 shows statistical descriptive of each variable and Table 3 shows that academic stress was positively correlated with self-confidence ($r = 0.767$, $p < 0.05$), coping strategies was positively correlated with self-confidence ($r = 0.645$, $p < 0.05$), and academic stress ($r = 0.638$, $p < 0.05$), academic achievement was positively correlated with self-confidence ($r = 0.747$, $p < 0.05$), academic stress ($r = 0.711$, $p < 0.05$), and coping strategies ($r = 0.763$, $p < 0.05$).

Table 4 shows the results of regression analysis obtained self-confidence ($\beta = 0.206$; $p < 0.05$), academic stress ($\beta = 0.128$; $p < 0.05$) and coping strategies ($\beta = 0.307$; $p < 0.05$), which have a high correlation with academic achievement, ($\beta = 32.087$; $p < 0.05$).

Discussion

This study aims to assess the relationship between self-confidence, academic stress, coping strategies and student academic achievement in the physical education process during the COVID-19 pandemic.

This study shows the following results. First, the self-confidence aspect was a predictor of students' academic achievement in participating in the physical education learning pro-

Table 2. Descriptive statistics (N = 90)

Variable	M	SD
Self-confidence	88.89	12.141
Academic stress	91.22	10.914
Coping strategies	91.77	10.910
Academic achievement	90.16	7.661

Notes. M = Mean; SD = Standard deviation

Table 3. Correlations bivariate self-confidence, academic stress, coping strategies with academic achievement (N = 90)

Variable	C. Pearson (r) p-value	SC	AS	CS	AA
SC		1			
AS	r	0.767**	1		
	p	0.000			
CS	r	0.645**	0.638**	1	
	p	0.000	0.000		
AA	r	0.747**	0.711**	0.763**	1
	p	0.000	0.000	0.000	

Notes. **Correlation is significant at the 0.05 level (2-tailed). SC = Self-confidence; AS = Academic stress; CS = Coping strategies; AA = Academic Achievement

Table 4. The regression coefficients (N = 90)

Predictor Variable	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	32.087	4.175		7.685	0.000
SC	0.206	0.061	0.326	3.397	0.001
AS	0.128	0.067	0.282	2.907	0.006
CS	0.307	0.056	0.437	5.457	0.000

Notes. SC = Self-confidence; AS = Academic stress; CS = Coping strategies; Dependent Variable = Academic Achievement

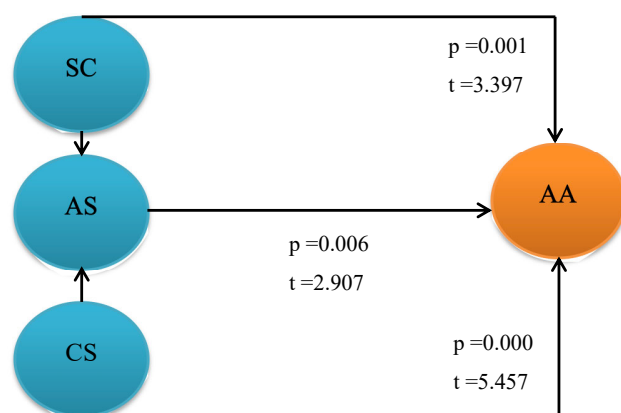


Figure 1. Relationship Model between Self-confidence (SC), Academic stress (AS), Coping strategies (CS) and Academic Achievement (AA)

cess during the COVID-19 pandemic. Self-confidence is one of the psychological aspects that play an important role for students when undergoing the physical education learning process before as well as during the COVID-19 pandemic (Blanco et al., 2020; Malureanu, Panisoara & Lazar, 2021) ease of use, and usefulness of eLearning platforms in corporate training. The present research explored the relationship among the employees' beliefs regarding self-confidence, grit, ease of use, self-efficacy, and usefulness of eLearning platforms in their workplace during the COVID-19 pandemic. In total, 307 responses from Romanian employees who used eLearning platforms in corporate training (females = 60.3%, males = 39.7%, age range of less than 24 years = 12.1%). For example, students with high self-confidence had more interest, motivation, mental toughness, and confidence in learning physical education and sports. The results of research by, Ibrahim, Jaafar, Kassim and Isa (2016) reported that self-confidence was an important aspect that supports the level of achievement in physical education and sports activities. Meanwhile, if students have a low level of self-confidence, they will become quitters and not motivated to participate in any activities (Toktas & Bas, 2019). In addition, students with low confidence tend to have greater anxiety and stress, which in turn will affect student performance and academic achievement (Sari et al., 2015; Misra, 2021). The results of this study are in line with previous research which reported that success or failure in academics was closely related to the level of self-confidence of a student (Malureanu, Panisoara

& Lazar, 2021) ease of use, and usefulness of eLearning platforms in corporate training.

Second, the academic stress aspect was also a predictor of student academic achievement in participating in the physical education learning process during the COVID-19 pandemic. Academic stress is currently often experienced by students when participating in learning activities during the COVID-19 pandemic. For example, students felt bored and frustrated with an online learning system which is claimed more difficult for students (Yang, Chen & Chen, 2021). A recent study reported that poor internet network, costly internet quota, and subject matter that was not delivered optimally were factors that caused student stress to increase in the current era (Jumareng, Setiawan, Patah, Aryani, Asmuddin & Gani, 2021). Therefore, academic stress becomes an important aspect for students, if academic stress can be managed properly then the academic achievement will be much more optimal (Gustems-Carnicer, Calderon, Calderon-Garrido & Martin-Piñol, 2021), but on the other hand, when academic stress cannot be overcome, it will cause students' academic achievement to decrease drastically. The results of this study contradict previous studies which reported that there was no significant relationship between academic stress and academic achievement (Basith, Syahputra, Fitriyadi, Rosmayadi, Fitri & Triani, 2021).

Third, similar to the previous result, the coping strategy was a predictor variable that closely related to the high or low academic achievement of students when undergoing physical education during the COVID-19 pandemic. For example, previous research has proven that coping is an effective way to reduce stress levels and prevent negative academic outcomes (Neveu et al., 2012; Gustems-Carnicer & Calderon, 2013). According to, Gustems-Carnicer, Calderón, and Calderón-Garrido (2019) coping that focuses on problems (overcoming, managing the source of the problem by finding solutions) and emotions (controlling emotions) are the main tools used to minimize the impact of stress on students (Chandra, 2021), which subsequently delivered a better performance (Morales Rodríguez, Torres, Páez & Inglés, 2016). Coping is a strategy-oriented to avoid situations that can potentially cause stress, for example, involving students to carry out interesting and fun activities (e.g., yoga, listening to music, dancing, playing hula hoop, cycling, swimming, playing with family, watching movies, playing games), which can promote relaxation and calmly in facing their problem. When stress can be overcome through coping strategies, it will increase student academic achievement. This is also reinforced by previous research which reported that there was a significant relationship between coping strategies and academic achievement (Genc, 2016; Yazon, Ang-Manaig & Tesoro, 2018; Gustems-Carnicer, Calderón & Calderón-Garrido, 2019). In addition, the results of this study contradict other studies which show that there is no relationship between academic stress and coping strategies with academic achievement (Basith, Syahputra, Fitriyadi, Rosmayadi, Fitri & Triani, 2021).

Conclusions

The three psychological aspects including self-confidence, academic stress, and coping strategies were proven in this study to have a positive relationship with students' aca-

ademic achievement when undergoing the physical education process during the COVID-19 pandemic. Students who have high self-confidence and good management of coping strategies were able to cope with academic stress, which in turn has an impact on high student academic achievement. Similar to other studies, this study also has limitations, the lack in subjects size, which is relatively small from one Junior High School in Karawang Regency (Indonesia), adds further caution regarding the generalisability of these findings. Further research is expected to be able to use more subjects and cover several schools to test other psychological factors that are predicted to have a relationship with student academic achievement.

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Conflict of interest

As the authors of this manuscript, we declare that there is no conflict of interest whatsoever in this research.

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УПЕВНЕНІСТЬ У СОБІ, АКАДЕМІЧНИЙ СТРЕС, СТРАТЕГІЇ ПОДОЛАННЯ ЯК ПРЕДИКТОРИ АКАДЕМІЧНОЇ УСПІШНОСТІ УЧНІВ НА ЗАНЯТТЯХ ФІЗИЧНОГО ВИХОВАННЯ ПРОТЯГОМ ПЕРІОДУ ПАНДЕМІЇ COVID-19

Арія Кусума Юда^{1ABCDE}, Сітра Ресіта^{1ACDE}, Рама Нурванся^{1ACD},
Руслан Абдул Гані^{1ABC}, Жолт Немет^{2ABD}, Еді Сетіаван^{3ABCD}

¹Університет Сінгапербангса Караванг

²Печський університет

³Університет Сур'яканчана

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

Реферат. Стаття: 7 с., 4 табл., 1 рис., 54 джерела.

Мета дослідження. У нинішню еру пандемії COVID-19 психологічний аспект набуває важливої ролі в досягненні оптимальних академічних результатів серед учнів, але фактори, які корелюють з академічною успішністю, поки що точно не відомі. Отже, це дослідження має на меті проведення оцінки взаємозв'язку між упевненістю в собі, академічним стресом, стратегіями подолання та академічною успішністю.

Матеріали та методи. У цьому дослідженні використовували кореляційний метод, а набір учасників здійснювали з числа учнів 7–9 класів конфесійної мусульманської молодшої середньої школи (Індонезія) (N = 90). Як засіб вимірювання в цьому дослідженні використовували анкету на тему впевненості в собі, академічного стресу та стратегій подолання, а як показник зростання академічної успішності учнів використовували середню оцінку, одержану на екзаменах за останній семестр навчання. Для встановлення описової статистики, перевірки нормальності розподілу даних дані було проаналізовано з використанням програм-

ного забезпечення IBM SPSS. При цьому для перевірки взаємозалежності між змінними використовували двовимірну кореляцію та регресійний аналіз. Із цього дослідження можна дійти наступних висновків.

Результати. По-перше, було встановлено зв'язок між упевненістю в собі та академічною успішністю, по-друге, було встановлено зв'язок між академічним стресом та академічною успішністю, і, по-третє, було встановлено зв'язок між стратегією подолання та академічною успішністю.

Висновки. Таким чином, для досягнення високих показників академічної успішності на заняттях із фізичного виховання дуже потрібна участь таких сприятливих факторів, як упевненість у собі, академічний стрес і стратегії подолання. Одержані за результатами цього дослідження дані роблять декілька внесків у розвиток науки у сфері фізичного виховання в аспектах психології для покращення академічної успішності учнів.

Ключові слова: упевненість у собі, академічний стрес, стратегії подолання, академічна успішність.

Information about the authors:

Aria Kusuma Yuda: aria.kusumayuda@fkip.unsika.ac.id; <http://orcid.org/0000-0002-0497-967X>; Faculty of Teacher Training and Education, University of Singaperbangsa Karawang, Karawang, Indonesia.

Citra Resita: citra.resita@yahoo.co.id; <http://orcid.org/0000-0001-9917-8375>; Faculty of Teacher Training and Education, University of Singaperbangsa Karawang, Karawang, Indonesia.

Rhama Nurwansyah: rhama.nurwansyah@fkip.unsika.ac.id; <http://orcid.org/0000-0003-3150-1740>; Faculty of Teacher Training and Education, University of Singaperbangsa Karawang, Karawang, Indonesia.

Ruslan Abdul Gani: ruslan.abdulgani@staff.unsika.ac.id; <http://orcid.org/0000-0002-7608-1658>; Faculty of Teacher Training and Education, University of Singaperbangsa Karawang, Karawang, Indonesia.

Zsolt Németh: zsolt.nemeth@gamma.ttk.pte.hu; <https://orcid.org/0000-0003-4656-2618>; Faculty of Sciences, Institute of Sport Science and Physical Education, University of Pécs, Hungary.

Edi Setiawan: edisetiawanmpd@gmail.com; <http://orcid.org/0000-0001-7711-002X>; Faculty of Teacher Training and Education, University of Suryakencana, Cianjur, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTIVENESS OF COMPLEX AGILITY TRAINING PROGRAM FOR AMATEUR MALE SOCCER PLAYERS

Pattarapol Thongnum^{1ABCD} and Yanyong Phanpheng^{2ABCDE}

¹Surindra Rajabhat University

²Loei Rajabhat University

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

Corresponding Author: Yanyong, Phanpheng, E-mail: yanyong.pha@lru.ac.th

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Abstract

Background. The ability to quickly change direction has been considered an important physical quality related to success in youth soccer.

The study purpose was to investigate the training effect of a complex agility training program on amateur male soccer players.

Materials and methods. The participants were 60 amateur male football players (aged 18-22) divided into two groups and selected by using purposive random sampling. Thirty athletes aged 19.7 ± 1.34 , BMI 21.8 ± 1.75 performed a complex training program (CTG) combined with sprint, agility or CoD, and plyometric session. While 30 participants of the control group (CG) aged 19.3 ± 1.31 , BMI of 21.2 ± 1.02 followed a general football training program. In both groups, each training session lasted 120 minutes, a 30-minute period, 3 times a week, a total of 6 weeks. The Arrowhead Agility Test was scheduled at the baseline, for the 4th and 6th weeks. The mean and standard deviation of the data was calculated. The inferential statistic was repeated measure ANOVA. A Newman-Keuls post hoc test was calculated if the group x time interactions were significant ($p < 0.05$).

Results. After training, agility was a statistical difference within the CTG, when comparing baseline and the 6th week ($p = 0.03$), there were no significant changes in agility when comparing between-group. Therefore, this shows that complex training programs can improve agility in amateur male soccer players.

Conclusions. This integrated training program can be applied to amateur male soccer players. The training program should be specific and varied. It can help soccer players improve their agility that is related to overall soccer performance.

Keywords: complex training, agility, amateur male soccer players.

Introduction

Soccer is characterized by an intermittent-activity profile with metabolic contributions from both the aerobic and anaerobic systems (Rampinini et al., 2007). Players cover distances of 10-13 km during matches and perform approximately 1,350 activities (every 4-6 seconds) (Mohr et al., 2005), such as acceleration and deceleration, change of direction (CoDs) and jump, all of which are interspersed with short recovery periods (Asadi et al., 2016). In modern soccer, the appropriate development of neuromuscular capabilities is an important fundamental for players' performance (Barnes et al., 2014; Jeffreys et al., 2018). The ability to quickly change directions is

considered an important physical quality, related to success in youth soccer (Hachana et al., 2017; Altmann et al., 2019). In this context, coaches and fitness specialists have been facing a great challenge to progressively increase strength, speed, and power capacities in soccer athletes, from the early stages of development to professionalism (Hammami et al., 2017; Loturco et al., 2017). Optimal training techniques designed to maximize strength receive considerable interest among strength and conditioning specialists, strength coaches, and researchers (Duthie et al., 2002). It is accepted by most industry professionals that athletes should incorporate both resistance training (RT) and plyometric training (PT) into their regimens to increase the probability of developing higher muscular power (Ebben & Blackard, 1997; Fatouros et al., 2000).

Complex training has gained popularity as a training strategy combining weight training and plyometric training

(Faigenbaum et al., 1999; Burger et al., 2000; William, 2002). A form of combination training can be described as training that alternates between traditional resistance (heavy resistance exercise) and plyometric exercises (light resistance exercise) within a single exercise session (Chu, 1996). Previously, Ebben and Watts (1998) reviewed the complex training literature and described the effectiveness of combining weight training and plyometrics. These authors offered suggestions for designing complex training programs, and recommended further research to assess the potential effectiveness of complex training. Interestingly, recent research has examined complex training as well as the ergogenic warm-up benefits associated with weight training exercises performed prior to explosive movements such as jumping (Burger et al., 2000; Ebben et al., 2000; MacDonald et al., 2012). Complex training may be an optimal training strategy for developing sport-specific athletic strength, if it is true that this form of training is more effective than other training programs at enhancing strength (possibly strength-power) production because of enhanced neuromuscular activity (Docherty et al., 2004; Ebben, 2002).

Research has also examined the effect of complex training while combining total body or lower body strength, power exercises and some form of jumping. Training studies have also been conducted to examine the effectiveness of complex training. For example, the effects of a three-week complex training program with seven division I college female basketball players. Pre and post test results revealed improvement in the 300 m shuttle, 1 mile run, VO_2max , 20 yd dash, pro agility run and the T-test, reverse leg press and back squat. The data showed that the complex training program was effective in eliciting statistically significant improvement in the 300-meter shuttle (Zepeda & Gonzalez, 2000). And there was other research showing that improving significantly in the change of direction (CoD) or agility and soccer shooting precision was supported (Fiorilli et al., 2017). In many team sports (e.g., ice hockey, soccer, handball, basketball, etc.), the ability to quickly change direction while running, also known as a cutting move or CoD, is a significant performance deter-

minant (Paul et al., 2016). It was previously proved that faster athletes had greater strength in the leg responsible for the push-off movement during CoD activities to one side (Young et al., 2002). The support leg (i.e., the non-dominant leg) was found to have better static balance and reactive strength. There is evidence that soccer players kick the ball with their dominant leg faster and more accurately (Carey et al., 2001).

Currently, the evidences about short-term (8 weeks) training effects are very limited in the scientific literature in both plyometric and directional training using elite young players during the competitive season (Taylor et al., 2016). Moreover, the effect of a single plyometric session a week when combined with CoD training is not well known. Therefore, *the aim of this study was to assess the effects of a CoD and a complex CoD and jumps protocol within a 6-week duration in amateur male soccer players.*

Materials and methods

Study participants

The subjects were 60 amateur male soccer players of Surindra Rajabhat University, aged 18-22 years with an average height, body weight and body mass index of 174.13 ± 4.47 cm, 68.27 ± 6.86 and 21.8 ± 1.75 respectively, obtained from a random of the best time of Arrowhead Agility Test, and volunteered to experiment and had no severe injuries. Each participant signed a written informed consent form before the study began. The study was approved by the Surindra Rajabhat University's Ethical Committee on Human Research according to the current edition of the Declaration of Helsinki (HE 642011).

Study organization

All of them tested their agility by using the standardized Arrowhead agility test, and the best time statistics were recorded. Then, the results were ranked 1-60 in order from those with the lowest running time statistics to the highest,

Table 1. The protocol of training

Day	Training session	Unit of training	Reps/Set	Duration of training
CTG	General warm up	Basic drills movement		5 minutes
Monday	Sprint & accelerations 30 meter	30% Sprint		
Wednesday		50% Sprint		
Friday		70% Sprint	1/5	5 minutes
		90% Sprint		
		100% Sprint		
	Agility or change of direction (CoD) 3 patterns	Forward zigzag direction (FZD) 10 meter	2/3	
		Backward zigzag direction (BZD) 10 meter	2/3	10 minutes
		Lateral zigzag direction (LZD) 10 meter	2/3	
	Lower body plyometric workout 3 patterns	Forward double legs jump + 100% Sprint 5 m + FZD 5 meter	6/3	
		Lateral double legs jump + 100% Sprint 5 m + LZD 5 meter	6/3	15 minutes
		Combine 4 direction double legs jump + 100% Sprint 10 meter	6/3	
CG	General warm up	Basic drills movement		5 minutes
Monday	Keeping up their regular training schedule	Running and dribbling drills, passes, and goal-scoring drills		
Wednesday				90 minutes
Friday				

respectively. Using the ability to sort from least to most used time statistics (seconds) after matching individual (matched subjects) was arranged for people with similar speed to match and then separated into each group until the number was reached. The groups were divided into 2 groups of 30 of the complex training group (CTG) and 30 of the control group (CG) using the matching group method, each group comprised of 9 defenders, 12 midfielders, and 9 strikers. The protocol of training was held 48 hours before testing to allow for adequate recovery. The testing sessions were held within 2 hours to reduce the effects of diurnal variation. For all sessions, players were required to wear the same footwear. Eyedness, handedness, and footedness were determined prior to the start of the study to evaluate the soccer player's laterality profile (Azémar et al., 2008). CTG and CG were instructed by professional coaches and sport scientists during the intervention period. Only CTG underwent the complex training program 30 minute alongside a regular football training program.

Statistical analysis

Data processing was conducted using SPSS Version 17 software. The normal distribution of variables was tested using the Shapiro Wilk test. Descriptive statistics were mean and standard deviation to express demographic characteristic. Inferential statistic was repeated measure ANOVA used to compare differences within and between groups at 95% confidence interval. A Newman-Keuls post hoc test was calculated if the group x time interactions were significant.

Results

The participant group was no baseline differences in demographic characteristics findings between the experimental and control groups.

Table 2. Demographic characteristics at base line

Group	Age		Weight		Height		BMI		P
	X	SD	X	SD	X	SD	X	SD	
CTG (n=30)	19.7	1.34	68.27	6.86	174.13	4.47	21.8	1.75	.184
CG (n=30)	19.3	1.31	67.67	6.70	171.67	4.75	21.2	1.02	.471

The ability test of agility by arrowhead agility test in the complex training group showed a significant difference when comparing within group from baseline after training in 4th week and 6th week ($p = 0.03$). Meanwhile, there was no significant difference ($p = 0.82$) in the control group.

Table 3. Comparison of the ability test of agility by arrowhead agility test variable of the subjects

Variance	SS	df	MS	F	Sig.
Within group : Complex training group					
Time	1.11	2	0.56	4.18	0.03*
Error	3.59	27	0.13		
Within group : Control group					
Time	0.13	2	0.07	0.21	0.82
Error	8.77	27	0.33		

* $p < 0.05$ statistically significant difference when compared within group, mean scores at point comparisons from baseline.

A Newman-Keuls post hoc test was utilized if the group x time interactions were significant. The agility variable of the complex training group was a significant difference ($p = 0.02$) when comparing between baseline and after the 6th week.

Table 4. The agility variable of the complex training group.

Time	Mean Difference	Sig.
Baseline X 4 th week	0.18	0.52
4 th week X 6 th week	0.29	0.20
Baseline X 6 th week	0.47	0.02*

* $p < 0.05$ statistically significant difference when compared within group, mean scores at point comparisons from baseline.

Discussion

Soccer is a sport that requires a variety of skills and abilities. The integrity of the gongs inevitably affects the performance of excellent physical fitness during competition. Having good physical mechanics can be advantageous for movement required in a sport. Change of direction ability (CoD) is an essential physical component for soccer. More specifically, change of direction ability seems to have an essential role in determining the success of soccer players (Brughelli et al., 2008; Goral, 2015). Agility is a key performance indicator in professional soccer and it's also utilized to discover young, talented players (Goral et al., 2012; Kaplan et al., 2009). According to this study research, it was found that a 6-week complex training program with integrated skill sessions considerably increased agility performance in amateur soccer players in Surindra Rajabhat University from baseline after training in 4th week and 6th week ($p = 0.03$). From the integration of complex training programs, training steps were sequenced to have the quality of training volume. The intensity of the training is related to the recovery between sets. The coaches were supervised and controlled by focusing on athletes to show their skills with accuracy including details of the rhythm of movement relative to each other while in motion. The correct factors in training will have a positive effect on the CoD tasks in the athlete. There are various muscle responses and mechanisms involved in controlling movement. There is a planned movement.

These findings show that the complex training program was helpful in improving agility performance. Linear speed and lower limb strength and power qualities are associated with agility performance (Little & Williams, 2005; Asadi et al., 2016). Therefore, Training to develop agility in the soccer must be a training that has similar movement mobility to that skill, thus it directly affects the force caused by the muscles action of hips, knees and ankle action. When muscle fibre works and responds quickly, it affects the effectiveness of movements agility.

The data in this study were consistent with Markovic and Mikulic (2010) that after a 6-week training program consisting of workouts with one or more CoD, professional football players increased their agility. The reaction force of the lower limbs, on the other hand, can be improved by training. While, Miller et al. (Miller et al., 2006) found that after six weeks of plyometric training, adult athletes performed much better on the Illinois test. In addition, Attene et al. (2015) re-

vealed that jump performance increased after 4 weeks of repeated sprint ability with one CoD in male basketball players. There are suggestions for the development of CoD training performed with a horizontal application of force enhances agility performance, whereas CoD training performed with a vertical application of force does not (Young & Farrow, 2006). It can be concluded that both ability to respond to a stimulus and ability to alter direction are important in agility. It is vital to exercise these physical aspects while taking into account the athlete's laterality (e.g., slower and quicker direction) in order to increase agility performance.

The results of the agility test, in terms of performance, are as follows: there were no significant changes in the agility in the current investigation at pre- and post-tests of CG ($p = 0.82$). Therefore, designing a training program in the form of complex training to have a variety of specific skills will affect the skill performance and individual abilities of each athlete. Coaches should have an understanding and systematic training plan and build a commitment to the athletes in the correct and safe cadence of movements that may cause injury while practicing. A longer training period, on the other hand, could reduce the agility during the agility test (Keiner et al., 2014). The cognitive determinants of agility are the perception-action coupling. The visual, auditory, or kinesthetic systems detected stimuli first, then the sensory information was processed by the central nervous system, and ultimately decision-making leads to an appropriate neuromuscular response (Sheppard et al., 2006). A limitation of this study is that the applied agility test has not yet been employed in correlational studies to see if there are any connections between agility test performance and important match-related key performance indicators in soccer that are related to overall soccer performance.

Conclusions

This study shows that the designation of a variety of training styles is defined, and the association of skills in complex training has a positive impact on the efficiency of mobility agility in football. Therefore, for further studies, to develop effective training styles for different sports, the trainer should apply the training style and test by applying dribbling techniques along with movement in the form of agility tests, which will reveal the ability to move while possession and other skills-related factors are more clearly available.

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Conflict of interest

The authors declared no potential conflicts of interest.

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ЕФЕКТИВНІСТЬ КОМПЛЕКСНОЇ ПРОГРАМИ ТРЕНУВАННЯ ДЛЯ РОЗВИТКУ СПРИТНОСТІ У ФУТБОЛІСТІВ-АМАТОРІВ ЧОЛОВІЧОЇ СТАТІ

Паттараполь Тонгнум^{1ABCD}, Яньонг Пханфен^{2ABCDE}

¹Університет Суріндри Раджабхат

²Університет Лоей Раджабхат

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

Реферат. Стаття: 6 с., 4 табл., 39 джерел.

Базова проблематика. Для успішної гри у футбол здатність юних гравців швидко змінювати напрямок руху вважається важливою фізичною якістю.

Метою дослідження було вивчення ефективності тренування футболістів-аматорів чоловічої статі за комплексною програмою тренування для розвитку спритності.

Матеріали та методи. Учасниками були 60 футболістів-аматорів чоловічої статі (віком 18–22 роки), розподілені на дві групи та відібрані методом цільової випадкової вибірки. Тридцять спортсменів віком $19,7 \pm 1,34$, ІМТ $21,8 \pm 1,75$ виконували комплексну програму тренування (ГКТ) у комбінації зі спринтом, вправами на розвиток спритності або швидкості зміни напрямку руху, а також заняттями з пліометрики. Тоді як 30 учасників контрольної групи (КГ) віком $19,3 \pm 1,31$, ІМТ $21,2 \pm 1,02$ займалися за загальною програмою тренування з футболу. В обох групах кожне тренування тривало 120 хвилин, заняття по 30 хвилин, 3 рази на тиждень, загалом 6 тижнів. Тест на спритність «Вістря стріли» був передбачений графіком на момент початку дослідження, на 4-й тиждень і на 6-й тиждень. Було розраховано середнє та стандартне відхилення

цих даних. Статистикою висновку був дисперсійний аналіз повторних вимірювань. У випадках, коли взаємодії факторів «група $\times$ час» були значущими ($p < 0,05$), за одержаними результатами було розраховано апостеріорний критерій Ньюмана-Кеулса.

Результати. Після завершення тренування показник спритності в ГКТ становив статистично значущу різницю, порівнюючи результати на момент початку дослідження та на 6-й тиждень ($p = 0,03$), а в міжгруповому порівнянні значних змін показника спритності не було. Таким чином, це показує, що комплексні програми тренувань можуть покращувати спритність футболістів-аматорів чоловічої статі.

Висновки. Цю комплексну програму тренування можна застосовувати до футболістів-аматорів чоловічої статі. Програма тренування має бути спеціальною та різноманітною. Вона може сприяти розвитку спритності футболістів, що відбивається на загальній результативності гри у футбол.

Ключові слова: комплексне тренування, спритність, футболісти-аматори чоловічої статі.

Information about the authors:

Pattarapol Thongnum: jeffyswucukku@sru.ac.th; <https://orcid.org/0000-0001-8178-5732>; Department of Sports Science, Faculty of Education, Surindra Rajabhat University, 186, Surin-Prasat Rd., Nokmuang subdistrict, Muang district, Surin, 32000, Thailand.

Yanyong Phanpheng: yanyong.pha@lru.ac.th; <https://orcid.org/0000-0002-9290-2479>; Sports and Exercise Science Program, Faculty of Science and Technology, Loei Rajabhat University, 234, Loei-Chiangkhan Rd., Muang district, Loei, 42000, Thailand.

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ORIGINAL SCIENTIFIC ARTICLE

PRACTICAL GROUP DEFENSE EXERCISE DESIGN IN FOOTBALL GAME FOR 13-YEAR-OLD STUDENTS

Nurul Ihsan^{1BD}, Ardo Okilanda^{1ABC}, Donie^{1CD}, Dede Dwiansyah Putra^{2AD},
Sugar Wanto^{2CD} and Arisman^{3BDE}

¹Universitas Negeri Padang

²Universitas PGRI Palembang

³Universitas Mitra Karya Bekasi

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

Corresponding Author: Ardo Okilanda, E-mail: ardo.oku@gmail.com

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Abstract

Research purpose. Football is popular in the society across the world. Everyone always watches football matches. Nowadays, there are many football schools for kids or young athletes. Thus, there is a need for a model of exercise that is appropriate for young athletes. This study aimed to create a model of group defense exercise in a football game. It referred to 13-year-old football school students. It was designed using psychological and physiological characteristics of the 13-year-old.

Materials and methods. The study participants were 120 football players aged 12 to 13. The study used a research and development method (R&D) through Borg and Gall model. Data was obtained from observation, interview and questionnaires. Data analysis techniques used expert judgments and three steps from Miles and Huberman, namely reduction of data, display of data, and making conclusions.

Results. The findings show that the model of defense exercise in football for a 13-year-old football school player has 13 variations of the exercise. It was created based upon the psychological and physiological characteristics of a young player.

Conclusions. The result of the study is a recommendation for teachers or coaches to improve the defense exercise in football as player needs.

Keywords: defense, exercise, football, group playing, 13-year-old.

Introduction

Football is favoured by all levels of society in the world from children to parents, including Indonesia (Luxbacher, 2011). Even, football is also played by women with game designs according to women's physical conditions (Martínez-Lagunas et al., 2014). Football is not merely a physical activity in sports, but football also has a function as a form of entertainment, even football has become a lucrative business because of its huge profits. Football players are not only professional players, but also can use their football playing skills to enter the entertainment business. Many football schools for children and adolescents have been held in various regions as a form of non-formal education. They learn many technical forms to play football (García-Angulo et al., 2020).

However, Indonesia still has weaknesses in scoring football achievements. The fundamental national problem of football is the lack of attention to development at an early age (grassroots) and youth. Even though, the key to the success of a country's football takes care of the coaching process at an early age and youth level. FIFA and AFC through the program Vision Asia emphasizes the importance of coaching issues, especially at the grassroots level aged 6 to 13 years (Weinberg, 2015). It is a long-term athlete development (Balyi et al., 2013). So, what is the main important target in the Age-13 group is to prepare a better future football team and it is not only in an instant way through naturalizing foreigners (foreign nationals).

Football requires a lot of energy in every situation, both defensive and attacking. The basic technique is fundamental which all players must master to play football skillfully based on the multilateral ability of motion. Therefore, the aspect of training that needs to be developed in young children becomes the basis, especially the correct basic movement skills (techniques) with the application of good defence and attack,

good basic physical abilities also support the achievement of good football games. Some factors affect the fundamental competencies of Motor Skills, including training, teaching, and experience (Valentini et al., 2016). It is very important that in defence, the interaction between players in defence is needed (Sautov et al., 2015). Creating of defence exercise model is be as a solution to build football skills for the young player.

Some previous research has related to the football finding. Many tactics are used to interact with training activities as a form of changing behaviour towards football (Travassos, Gonçalves, Marcelino, Monteiro, & Sampaio, 2014; Pulling, Twitchen, & Pettefer, 2016; Pulling et al., 2016). Interactive group transfer their characteristic in football playing (Ryoo et al., 2018). Visual interactive has been done to analyze the model of soccer learning (Bernard et al., 2017). To get interactive playing, it needs motivation. It is important motion in defence of football player (Okilanda et al., 2020). Therefore, model defence exercise has to design as young player psychology and characteristic (Najah & Rejeb, 2016) because each age level has different and competitive types of exercise football matches (Harley et al., 2010; Hary & Firdiansyah, 2019). Every player must make the right decisions in carrying out various defensive techniques (González-Villora et al., 2013). But, the success of defensive technique needs teamwork. The coach has to monitor the team coordination (Silva et al., 2016) in order the group exercise is a meaningful way in football playing. One of the model defence exercises in football is ergonomics model of exercise. This model demands the fitness of the player so that the players can develop different physiological exercise (Reilly, 2005). However, the development of a training program must differ according to the age identification of the football player (Williams, 2000; Tenga, Holme, Ronglan, & Bahr, 2010). Those researches describe the way of making a defence exercise program and comprehending the concept of young player age.

Currently, the study documented about developing a group defence exercise model in football and can contribute to solving the problems faced for the professional development and talent of football players aged 13 years. This research should be done for several reasons, namely: (1) providing an understanding of the exercises provided can be programmed properly. Trainers can provide defence training. (2) The coach has not used a specific training model to improve defence skills in playing football. (3) Trainers often apply the exercises after a direct warm-up to the technique without providing an understanding of the relevance of the defence situation. (4) The training given has not focused on one of the elements of the defence technique needed. (5) Not carrying out corrections when an error occurs or not giving examples by stopping corrections so that coaching learning occurs, (6) The training model used by the players lacks an impression of enthusiasm. Meanwhile, students have a lot of contact between the ball and the field and the number of players is reduced such as playing 5 against 5 in a field size of 40×30 m.

Therefore, this study aims to create a defensive exercise model in football activities referred to 13-year-old players. The model designed is adapted to the concept of psychological and physiological conditions for players aged 13 years and the playing environment for children aged 13. Thus, football players aged 13 years can develop skills in playing football appropriately according to their age development to become professional football players.

This research is also expected to provide practical benefits to the trainer regarding the concept of training that must be designed according to the physiological and psychological conditions of the players. Besides, each player from different countries has different character features and the development of players aged 12 or 13 is also very vulnerable to various changes. So, this research can be a reference in developing a defensive training model in football.

Materials and methods

Participants

The research was conducted at the South Sumatra football school from December 2019 until July 2020. Participants consisted of 120 football players aged 12 to 13 years. In trial phase 2 used 40 participants and trial phase 3 used 120 participants. The participants are taken from 16 football schools. The selection of participants from 16 schools as the subject of the product trial was based on the consideration of the similarity of characteristics with the same level of active practice. Besides, the participant in this study are football coach, and football expert.

Study organization

The study uses a research and development method (R&D). Development research creates new products or modifies existing products in education or other disciplines (Creswell, 2012). It used Borg and Gall theory in doing the research (Gall et al., 2010). This study designed a model of group defence exercise in football activity that is suitable for the characteristics of football players aged 13 years.

Process of collecting data used observation, interview, and questionnaire. Observation activities were carried out in preliminary research to collect needs analysis data and during trial product. Interviews are used to obtain additional data to support trial data analysis. Meanwhile, the questionnaire was used to determine the needs of group defence exercise models in football activities.

Table 1. Procedure of Study That Adapted from Borg and Gall Model

Steps	Activities
Preliminary Step	1. Initial data collection 2. Needs analysis process 3. Product planning
Development Step	1. Exercise defence modelling 2. Formative Evaluation, referring to the Borg & Gall model 3. Trial phase (1) 4. Peer assessments who have competence in football playing, materials, technology and exercise programs 5. Revised stage (1) and judgment expert 6. Revised stage
Evaluation Step	1. Trial phase (2) 2. The evaluation scale is limited to 40 subjects 3. Operational model revised (1) 4. Trial phase (3) used 120 subjects 5. Revised final model 6. Dissemination of product

Procedures

The procedure of research used the Borg and Gall model. Here are the development research steps (table 1).

Statistical analysis

Research data must be valid and can be trusted. Therefore, the process of verification of research data used triangulation checking. This study used triangulation of theory that refers to use more than one theoretical framework in analyzing data. The technique of data analysis has three steps, namely 1) data reduction is done by data selecting,

abstracting, and delivering the data that got from the field, 2) data display used to make category or classification of data and in this study, the data divided as a sequence of research procedure needed, and 3) conclusion drawing used to analyze the data and take conclusion (Miles & Huberman, 1994). Besides, the process of data analysis used judgment expert in the initial until the end.

Results

The result of data analysis which has taken from needs analysis, documentation, interview, and observation describe in the table below:

Table 2. Recapitulation of Finding Data

Components	Finding
Preliminary study	1. The defence ability in football takes the form of group defensive exercise.
1. Literature study	2. The exercise model is consisting of exercise the core technical skills of small games and in the end, the exercises are carried out with situation games. 3. Learning football game is by repeating skills as a group will get the results of changes in playing performance for the better. For better technical skills, it is best to start with the development of the basic elements needed by practising and learning. 4. Defence skills learning is easier if it is learned in the form of pictures and simple visuals can also be analyzed when implemented
2. Needs analysis is taken from interview and questionnaire)	1. The teaching process is carried out by basic techniques of passing, dribbling and shooting. 2. Football defence exercise patterns have not been taught intensively 3. The exercise material has not been prepared before going to the field and learning activities so far are suddenly remembered in the field. 4. The exercise model is not yet specific, such as warm-ups do not have a dynamic pattern. It is still with a pattern long static. 5. The material in warm-up exercises still limited with playing patterns 11 vs 11 which has an impact on ability mastery hold still low 6. The training element does not have a target-specific exact defensive ability 7. The coach does not provide direct corrections to defensive abilities, because the correction is more directed at attacking patterns. Activities in the field have not provided special treatment for group defence exercise.
Expert Validation	1. The validation of three licensed football experts concluded that the 13-year-old football defensive exercise model was appropriate for use on the field.
1. Validation from football coach expert	2. From the questionnaire given to the three experts, the percentage was 93.83%. As for the advice from the three expert football coaches, namely organizing a defensive exercise model according to the number of people on the field and exercise activities can be carried out by all football players. 3. Three expert football coaches suggest that the assignment of game value rules can use a score on the game rules to be the goal of the exercise can increase the ability to survive as desired. 4. In the initial concept developed by the researcher, there were as many as 45 variations of the exercise model, after discussion with the experts, they suggested that it be simplified again. It presented the variety and number of players involved.
2. Peer assessment is taken from the football school coach	The football coaches in the school suggest that the model of defence exercise can be used by players. The success of the players in doing defence exercise in football must be given score so that they know the development of their defensive abilities in playing football.
1. Trial phase	1. The results of the small group trial provide suggestions, namely 1) the coach should be able to reward players who have done defensive exercise in football well, this can motivate a group. 2) Additional repetition of the exercise in implementing the previous model 3 times to 5-8 times. 3). Provide a sample program daily exercise.
a. Field trial results in a small group by sample as many as 40 people with the maximum score instrument 28	2. The results of observations in the field concluded that during the transition phase, players are still slow in changing the principle character from defence to attacking principle, and vice versa. 3. It needs to be additional game rules that make this transition phase appear in exercise sessions. 4. Starting Point in an exercise session is very crucial because when the coach will train players to defend, the player is given the ball to attack and after he loses the ball, then the coach will see if the change in attitude from attacking to defensive principles takes place quickly or slow.
b. Field trial results in a large group by sample as many as 120 people with the maximum score instrument 28	5. The result of the test in large group trial shows that player has a good score after using the model of group defence exercise. 6. The player has a high enthusiasm for football playing because the model of defence exercise is a new concept in the exercise of football. 7. Players can understand the instruction of defence exercise
4. Final model	The result of the trial and judgment expert concluded that model group defence exercise for player 13 ages called the model using "Do" and the final defence exercise model included 14 models.

The following is the creating of defence exercise in football playing. It is a final model that has been evaluated by expert and trial (table 3).

Discussion

Table 2 know that the defensive exercise model has provided opportunities according to the needs of football players aged 13 in developing their talents and abilities to play football. The equipment used in this research is a ball, cone,

marker, pole, goal small, target banner, whistle and vest. The area used for conducting research must be considered a safety factor and the perfection of the field and away from objects, any harm to the football field is checked before starting exercise. The order of the game modes from the warm-up game to the core game has been systematic. The exercise models that are presented have their characteristics leading to exercise the football defence for player 13-ages. Besides, the involvement of coaches is to become an active part of children/athletes in exercise necessary for enthusiastic

Table 3. Group Defence Exercise Model in Football Game

Name if group defence exercises model "DO"	New Finding	Level
Model DO 1; Group Keeps Opponents In	It can be used in the game. The player must have speed and communication skills. Pros: The cooperation of the last defender can communicate Cons: If the key target is not known, it will find it difficult.	Moderate
Model DO 2; Group Holds one ball to reach the target	It can be used in the game. The player must have a good concentration and communication skills Pros: Eliminates the player's fear of the ball used the actual game situation. Cons: Lack of communication loses momentum to hold the ball/block	Difficult
Model DO 3; Group Holds the ball two goals	It can be used in the game. The player must divide the job description in football playing to fail the enemy Pros: Players have a way of thinking carefully about goals, cooperative communication is done by the defender Cons: If one of the defenders is not ready the ball, it is easily overlooked because the attacker has two targets	Easy
Model DO 4; Two-ball two-goal	It can be used in the game. The player must focus on the ball Pros: Sharpen focus by sharing defender duties. Cons: If there is no communication, an error occurs and the ball is lost block the ball	Moderate
Model DO 5; Holds the ball to target	It can be used in the game. Players must work together to thwart the opponent's attack Pros: like the real game, the defender has the main target of removing the ball to the left or right side Cons: the ball is not predictable in actual playing situations	Difficult
Model DO 6; Retrieves lost balls	It can be used in the game. Players have the right way of dealing with opponents through solid teamwork. Quick moves to retrieve the ball or take responsibility for lost balls from entering dangerous areas.	Moderate
Model DO 7; Holds front and side attacks	It can be used in the game. The player knows the opponent's attack from the front and the side The anticipation left and front of the player must kick the ball away.	Difficult
Model DO 8; holds off attacks in the zone	It can be used in the game. Players have cooperation to anticipate the opponent's movement into the defence area Located in their respective zones and can win the ball	Difficult
Model DO 9; Keeps your opponent in the zone	It can be used in the game. Players have cooperation with anticipation of speed and agility. Keeping the zone by pressing the opponent.	Difficult
Model DO 10; Hold the ball into the area of the shot	It can be used in the game. The player has the anticipation of a second attack by holding the ball in Stop the ball is from entering the area of the shot so that the defensive position is safe. Block if there is dangerous / fire.	Moderate
Model DO 11; Hold Shot Group	It can be used in the game. Players have their focus and work together Coordinate quickly with defenders to block attacks from opponents.	Moderate
Model DO 12; Group withstand side shots	It can be used in the game. Players have cooperation and anticipation with the speed of holding the ball The red one and two defenders share left or right block duties and the red three players work hard with a quick motion holding the left and right balls.	Difficult
Model DO 13; Group Keeping four goals	It can be used in the game. Collaboration players with joint strategy anticipation movements. Defensive players focus with the goal zone in the corner of the movement area blocking the ball and removing the ball from the area is the key to the defence	Difficult

players/athletes and become more focused during exercise. This study presented the collective action in each exercise (Gréhaigne et al., 1997). They have awareness of resource in the team (Feigean et al., 2018)

The findings of this study are relevant to other research that shows the concept of developing exercise in playing soccer for the age of 21. The coach has given the procedural knowledge in using the model of exercise football (García López et al., 2010). The variety of football defensive training in this product also provides variations in the number and position of goalposts as an exercise aid. This is in line with previous research that coaches must vary the use of exercise aids and various exercise patterns so that technical and tactical actions can be felt the same as in real game (Pulling et al., 2016; Gréhaigne & Godbout, 2014). However, this research is oriented to the basis of a drill (Jarrett, 2011). In simple terms, drill defensive football training is very effective in improving the defensive ability of Age-21 football players.

New findings in this study can be seen from the results of the analysis of the needs of football players aged 13 years, which refers to the development of individual abilities to perform the defensive exercise (Chan et al., 2016), but it implemented in group physical exercise. Besides, this product is oriented towards the development of psychology, physiology and talent of players at the age of 13 years, so that the level of speed, accuracy and coordination in playing the ball has been adjusted to the minimum limit of their exercise ability. It is the requirement of a professional player (Webb et al., 2020). Psychology aspect also determines the performance of football playing tactics (Vaz et al., 2019). Thus, increasing the ability to practice defensive can continue to the maximum extent of the player's ability. It means that the player is trained to be the leader for themselves in doing the sport. It is important to face the future challenge (Gould, Voelker, & Griffes, 2013; Cotterill & Fransen, 2016). Besides, the leadership can influence effective teamwork (Fransen et al., 2017). Besides, this study documented the creativity of the player in football playing. Because the effectiveness of sport creativity has developed but it is still limited with the role (Fardilha & Allen, 2020; Zahno & Hossner, 2020) and creativity is adaptation process on the environment (Obouef et al., 2020). It means that the players are allowed to make decisions about tactics should be used when facing different conditions in a match and unlike the theoretical concepts that are learned during exercise. It is intended for players to be professional and understand contextual factors that influence action during the game (Levi & Jackson, 2018; Furley & Memmert, 2018).

Therefore in exercise activities, it is necessary to describe the tactics of playing football so that it can influence decisions and skill application (González-Víllora et al., 2013). Football defensive tactics have a special portion that must be repeated in exercise. So exercise activities must have a programmed exercise guide so that defence can be successfully achieved. DO defensive exercise model in the game of football for players aged 13 years which was developed and has been developed by researchers as a superior product for football schools. The purpose of creating this model is for coaches, lecturers and teachers in developing football exercise, and also to reference a defensive exercise model. DO defensive exercise model for players 13 years is made based on the level of need in activity practice in a football school.

Thus, the result of study recommended using the physical and technical skill in small games, like an 8-a-side game in the under 12 football player. It can build the young player ability (Bravo-Sánchez et al., 2017)

The product has advantages, namely: a) To reference the defence exercise model in-game football which has the character of a player aged 13. b) There are many types of variations in defence model training so that they can be selected to be applied according to the needs and characteristics desired by the coach in the game of football. c) The series of motion has a varied defence exercise pattern. d) Arrangement of a series of motion are ranging from easy to difficult levels e) The movement combines physical condition training, techniques and tactics, including speed, strength, accuracy, coordination, power, agility, flexibility and durability. f) Players are enthusiastic and get to know new ways of thinking in defensive exercise. g) Additional instruction from the trainer is an important key in completing the defensive task. h) DO defensive exercise model products in football games for 13 years players are effective and efficient in terms of equipment, time and cost. i) The coach is assisted by simple instructions in improving his mastery of football defensive tactics. j) This product is a special scientific contribution to football coaching.

While disadvantages have found in this product are a) In limited field trials, the number of samples who became players in research implementation was still small. b) Product perfection has not been reached 100%, because the diversity of exercise models designed has not fully met the needs of every football school in Indonesia. c) Facilities and infrastructure which are also training facilities used are limited considering the circumstances of each football school are different. d) Model drawings or photos in books still need improvement to make them more interesting. e) The characteristics that appear in the survival group exercise model are limited to the physiology and psychology of the 13-year-old players.

Conclusions

The development of a DO defensive exercise model in football games for 13 years of age can be used as a form of exercise that has an effective and efficient effect for football coaches and football extracurricular teachers in maximizing the potential of defender players in Indonesia. Football is a sport that needs an archetype of play so that it can improve the quality of the game. In the end, football achievements in the future can be achieved. Besides, it can be used as an exercise model by the coach through paying attention to the rules of the picture and instructions, wherein its use, it is necessary to consider the condition of the players. This is taken into consideration in changing the pattern that initially the defensive task was only the defender, making all players have a role in defence. DO defensive exercise model is appropriate for all extracurricular teachers specifically for the sport of football. This product provides training offerings that can train defensive tactics following the cognitive and motor skills of the players.

From the advantages and disadvantages found, researchers who want to develop the same concept can also focus on the involvement of research subjects as a medium for product implementation to have a greater number. Research

activities can also involve informal schools or football clubs who want to develop defensive exercise skills for young players because the age of 13 can be a foundation from an early age in mastering or developing the ability to play football. Besides, research can also consider physical conditions in terms of body weight, height, food intake patterns, and the home environment in developing defence exercise patterns so that movement variations can have the right concept, it is not only in general from the psychological or physiological aspects of 13 years of age.

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Conflict of interest

There is no conflicts of interest to declare.

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ПРАКТИЧНА МОДЕЛЬ ВПРАВИ З ВЕДЕННЯ ГРУПОВОГО ЗАХИСТУ ПІД ЧАС ГРИ У ФУТБОЛ ДЛЯ 13-РІЧНИХ УЧНІВ

Нурул Іхсан^{1BD}, Ардо Окіланда^{1ABC}, Доні^{1CD},
Деде Дваансях Путра^{2AD}, Сугар Ванто^{2CD}, Арісман^{3BDE}

¹Державний університет Паданг

²Університет Палембанг Асоціації вчителів Індонезії

³Університет Мітра Каря Бекасі

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

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

Мета дослідження. Футбол має популярність у суспільстві в усьому світі. Кожен завжди дивиться футбольні змагання. Сьогодні існує багато футбольних шкіл для дітей або юних спортсменів. Отже, потрібна модель вправи, яка підходить для юних спортсменів. Це дослідження мало на меті створення моделі вправи з ведення групового захисту

під час гри у футбол. Вона передбачала участь 13-річних учнів футбольної школи. Модель була побудована з урахуванням психологічних і фізіологічних характеристик, при-
таманних 13-річним.

Матеріали та методи. До складу учасників увійшли 120 футболістів віком 12–13 років. У дослідженні вико-

ристували науково-дослідницький метод на базі моделі Борґа та Галла. Дані одержували зі спостережень, співбесід та анкет. Методи аналізу даних включали оцінки експертів і три кроки з підходу до аналізу даних Майлза та Губермана, а саме: скорочення обсягу даних, відображення даних та побудова висновків.

Результати. Результати показують, що модель вправи з ведення захисту у футболі для 13-річного гравця футбол-

ної школи має 13 варіантів цієї вправи. Вона створена з урахуванням психологічних і фізіологічних характеристик юного гравця.

Висновки. Результатом дослідження є рекомендація вчителям або тренерам оптимізувати вправу з ведення захисту у футболі відповідно до потреб гравця.

Ключові слова: захист, вправа, футбол, групова гра, 13-річні.

Information about the authors:

Nurul Ihsan: nurul_ikhsan@ymail.com; <https://orcid.org/0000-0002-2072-0086>; Sport Education, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Ardo Okilanda: ardo.oku@gmail.com; <https://orcid.org/0000-0001-6052-703X>; Sport Education, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Donie: donie.fik.unp@gmail.com; <https://orcid.org/0000-0002-2827-4156>; Sport Education, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Dede Dwiansyah Putra: dededwiansyahputra@gmail.com; <https://orcid.org/0000-0003-2528-3302>; Sport Education, Universitas PGRI Palembang, Jl. Lorong Gotong, 11 Ulu, Kec. Seberang Ulu II, Kota Palembang, Sumatera Selatan 30116, Indonesia.

Sugar Wanto: sugarwanto88@gmail.com; <https://orcid.org/0000-0002-7395-1646>; Sport Education, Universitas PGRI Palembang, Jl. Lorong Gotong, 11 Ulu, Kec. Seberang Ulu II, Kota Palembang, Sumatera Selatan 30116, Indonesia.

Arisman: Arisman@gmail.com; <https://orcid.org/0000-0002-8741-6150>; Sport Education, Universitas Mitra Karya Bekasi, Jl. Mayor Madmuin Hasibuan No.5, RT.006/RW.008, Margahayu, Kec. Bekasi Tim., Kota Bks, Jawa Barat 17113, Indonesia.

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ORIGINAL SCIENTIFIC ARTICLE

NEGATIVE CORRELATION BETWEEN OUTDOOR CYCLING PHYSICAL ACTIVITY AND DEPRESSION LEVELS DURING THE COVID-19 PANDEMIC AMONG MEMBERS OF MALANG CYCLING COMMUNITY

Slamet Raharjo^{1ABD}, Ari Wibowo Kurniawan^{1BD}, Heni Yuli Handayani^{2BD}, Widiastuti^{3AB}, Muhammad Syamsul Taufik^{4BCD}, Avryan Sandryawan^{1BC} and Olivia Andiana^{1CD}

¹State University of Malang

²STKIP PGRI Bangkalan

³State University of Jakarta

⁴University of Suryakencana

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

Corresponding Author: Slamet Raharjo, E-Mail: slamet.raharjo.fik@um.ac.id

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Abstract

The purpose of the study is to analyze the relationship between the habit of outdoor cycling activities and the level of depression during the COVID-19 pandemic among the members of the bicycle community in Malang City.

Materials and methods. This research is correlational, with a cross-sectional study approach. A total of 125 subjects from the bicycle community in Malang City voluntarily participated to become respondents in this study. The measurement of cycling physical activity habits was carried out using the International Physical Activity Questionnaire (IPAQ), while the measurement of the level of depression used the Hamilton Depression Rating Scale (HDRS). Measurements of physical activity habits and depression levels were performed at the same time. The data analysis used the Pearson product-moment model using statistical software package for social science (SPSS) version 17.0 with a set significance level ($p \leq 0.05$).

Results. The results showed that there was a negative correlation between the habit of outdoor cycling activities and the level of depression ($r = -0.604$; $p \leq 0.001$) and showed a strong correlation between the two variables.

Conclusions. Based on the results of the study, there is a negative correlation between the habit of outdoor cycling activities and the level of depression during the COVID-19 pandemic among the members of the bicycle community in Malang City.

Keywords: physical activity, cycling, depression, COVID-19, pandemic.

Introduction

Globally, there were 336,790,193 confirmed cases of Coronavirus Disease (COVID-19), including 5,560,718 deaths, which were reported to the World Health Organization (WHO) (WHO, 2022). Meanwhile, the first confirmed case in Indonesia appeared in March 2020 and the prevalence continues to increase by 455,000 confirmed cases with a mortality rate of more than 14,000 people (Kemenkes, 2020). COVID-19 is caused by infection of the SARS-CoV-2 virus. This virus can be transmitted through the air or ob-

jects contaminated with droplets from people infected with COVID-19 (WHO, 2020). Transmission of this virus is quite easy and fast. The speed of transmission and uncontrolled spread causes fear and interfere with the human ability to meet needs in all fields of life (Dominski & Brandt, 2020). In response to this, the government made rules for people to carry out activities at home during the pandemic. However, this will have an impact on changing people's lifestyles into inactivity (Balanzá-Martínez et al., 2020). Increased sedentary behavior is marked by a 35% increase in internet streaming online users, 39% distance learning or online during the COVID-19 pandemic (Kominfo, 2020). During the pandemic, the physical activity of the population in Indonesia also decreased by more than 50 and it is estimated that 28% of the world population (1.4 billion people) remain physically inactive (Guthold et al., 2018).

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A prolonged COVID-19 pandemic can have an impact on increasing the prevalence of depression (33.7%), stress (29.6%), and anxiety (31.9%) compared to before the pandemic (Twenge & Joiner, 2020). Ettman et al. (2020) also stated that social isolation increased symptoms of depression 3 times, which reached 27.8% during the pandemic compared to before the pandemic which reached 8.5%. Depression is an emotional response caused by a loss of identity for individuals and is not easy to recover (eg lost a job, failed exams, lack of social interaction), because it harms the individual's cognitive system (Sanderson et al., 2020). Physiological depression will increase the secretion of the hormone cortisol which harms all body systems. Depression causes a decrease in the monoamine neurotransmitter system (serotonin, norepinephrine, dopamine) in the brain that occurs slowly accompanied by a reduced functional response to antidepressant therapy and increases chronic and psychological stress (Park et al., 2019). Depression due to lack of physical activity, excessive anxiety, boredom, and chronic and psychological stress will cause mental disorders to death. Excessive depression during a pandemic has a negative and independent impact on people's mental health (Bauerle et al., 2020).

Increased physical activity and exercise are very useful in relieving stress both in physically and psychologically that affect mental health (Maugeri et al., 2020). WHO (2020), recommends physical activity outdoors during the COVID-19 pandemic while maintaining health protocols. Regular outdoor physical activity is beneficial in improving mental health, immune system, and anti-inflammatory system (Althoff et al., 2017). This is also recommended by the issuance of the Decree of the Minister of Health of the Republic of Indonesia Number HK.01.07/MENKES/382/2020, during the COVID-19 pandemic the public is still encouraged to do physical activity, physical exercise, and sports to increase endurance and risk factors for disease (Kemenkes, 2020). Aerobic exercise (cycling) is a physical movement that uses energy derived from burning fat that involves oxygen and takes oxygen without causing fatigue (Palar et al., 2015). Outdoor cycling is a phenomenon of physical activity of choice that is widely practiced by the Indonesian people during the pandemic, as evidenced by the increase in bicycle sales during the COVID-19 pandemic by 1000% (ITDP, 2020). Cycling is a sports activity and alternative mode of transportation of choice for the community because it can be adapted to pandemic social distancing or health protocols by not having direct physical contact and has benefits for psychological health (Teixeira & Lopes, 2020).

Cycling is a low, moderate to high-intensity exercise designed for health benefits, especially during a pandemic (Ryu et al., 2020). The enactment of government regulations regarding outdoor sports while still implementing health protocols has made exercise (cycling) a lifestyle that is often practiced by individuals of all ages (Saatchian et al., 2021). Cycling exercise or outdoor cycling habits have antidepressant effects that are beneficial for reducing depression resulting from the interaction of several neurophysiological mechanisms, such as hormones, neurotrophins, and inflammatory biomarkers (Leyland et al., 2019). Exercise can increase the secretion of Brain-derived neurotrophic factor (BDNF), Insulin-Like Growth Factor-1 (IGF-1), and Vascular endothelial growth factor (VEGF) as a neurotrophic fac-

tor in the hippocampus that is useful for nerve cell growth, increasing stress hormone regulation (Pranoto et al., 2020; Berry et al., 2018; Kraus et al., 2004), namely cortisol by decreasing the activation of the Hypothalamus-Pituitary-Adrenal axis (HPA-axis), and decreasing the release of pro-inflammatory cytokines so that symptoms of depression can be reduced (Andarianto et al., 2022; Arat & Wong, 2017). In addition, regular outdoor cycling exercises will maximize the synthesis of pleasure hormones, namely an increase in endorphins and serotonin (Sharifi et al., 2018). On this basis, *the purpose of this study* was to analyze the relationship between the habit of outdoor cycling physical activity on the level of depression during the COVID-19 pandemic in members of the bicycle community in Malang.

Materials and methods

Study participants

This research is correlational with a cross-sectional study approach. The cross-sectional study approach is applied by connecting the dependent variable with the independent variable simultaneously. The independent variable in this study was the habit of cycling physical activity, while the dependent variable was the level of depression. A total of 125 subjects, male and female aged 18-45 years from the bicycle community in Malang City participated voluntarily as respondents in the study. Prior to participating, all subjects received information both orally and in writing about the study. The informed consent was obtained prior to the conduct of the research.

Study organization

The instrument used to measure the habit of cycling physical activity is the International Physical Activity Questionnaire (IPAQ), while the instrument to measure the level of depression is the Hamilton Depression Rating Scale (HDRS). Measurements of physical activity habits and levels of depression were carried out at the same time. The distribution of IPAQ and HDRS scores is shown in Table 1 and Table 2.

Table 1. International Physical Activity Questionnaire score distribution

HDRS Score	Level of Physical Activity
≤ 600 METS	Low
601-1500 METS	Moderate
1501-3000 METS	High

IPAQ: International Physical Activity Questionnaire

Table 2. Hamilton Depression Rating Scale score distribution

HDRS Score	Severity of Depression
0- 7	Normal
8-17	Low depression
18-24	Moderate depression
25 and above	Severe Depression

HDRS: Hamilton Depression Rating Scale

Statistical analysis

Statistical analysis using Statistical software package for the social sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics including means, standard deviations and percentages were calculated. The Shapiro-Wilk test was applied to the normality test, while to find the relationship between outdoor cycling activity habits and depression levels, the Pearson's product-moment correlation test was used. All statistical analyzes used a significant level ($p \leq 0.05$).

Results

Based on the results of the study obtained data on age, cycling community, cycling habits, depression levels and the relationship between outdoor cycling physical activity habits and depression levels which are presented in Tables 3-6 and Figure 1.

Table 3. Results of the analysis of the percentage of respondents' age

No	Age	Amount	Percentage
1	18-25	75	60.0%
2	26-30	18	14.4%
3	31-35	12	9.6%
4	36-40	9	7.2%
5	41-45	11	8.8%
	Total	125	100%

Table 4. Results of the analysis of the percentage of respondents' bicycle communities

No	Bike Community	Amount	Percentage
1	MTB Malang	25	20%
2	Malang Strattos Community	25	20%
3	Minionminitreng Malang	25	20%
4	Fed Ngalam	25	20%
5	Strolling Bastrad	25	20%
	Total	125	100%

Table 5. Overview of cycling habits

No	Cycling Habits	Amount	Percentage
1	Low	47	37.6%
2	Moderate	50	40.0%
3	High	28	22.4%
	Total	125	100%

Table 6. Description of depression levels categories

No	Depression Levels	Amount	Percentage
1	Normal	27	21.6%
2	Low depression	37	29.6%
3	Moderate depression	35	28.0%
4	Severe Depression	26	20.8%
	Total	125	100%

Based on the results of the Pearson correlation analysis (Figure 1), it shows that there is a negative correlation between the habit of outdoor cycling physical activity and the level of depression ($r = -0.604$; $p \leq 0.001$) and shows a strong correlation between the two variables.

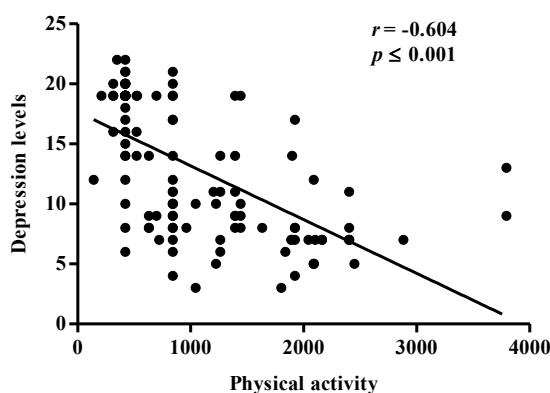


Figure 1. Results of correlation analysis between outdoor cycling physical activity habits and levels of depression. Pearson correlation coefficients (r) and p -values are shown in graph.

Dicussion

This study aims to analyze the correlation between outdoor cycling habits and depression levels during the COVID-19 pandemic among members of the Malang bi-cycle community. The findings reveal that there is a negative correlation between outdoor cycling habits and depression levels during the COVID-19 pandemic among members of the Malang bicycle community. This result was confirmed by Meyer et al. (2019), that cycling exercise at both moderate and preferred intensity can reduce levels of depression and anxiety. Ai et al. (2021) strengthen that physical exercise such as cycling while still implementing health protocols could improve mental health during the COVID-19 pandemic. Outdoor physical activity, (such as walking and cycling) is generally associated with lower depression, tension, anger, and confusion than indoor physical activity (Bowler et al., 2010; Dunton et al., 2015), and has been associated with improved emotional well-being, including in adolescents (Pasanen et al., 2014). Wright et al. (2021), physical activity during the coronavirus pandemic may counter the negative effects of coronavirus fear on adolescent mental health and well-being.

COVID-19 causes increased levels of anxiety and depression in healthy patients and people detected after stay-at-home orders in several countries (Hu et al., 2020; Huang & Zhao, 2020; Li et al., 2020; Ozamiz-Etxebarria et al., 2020). A study in college students showed that daily physical activity conferences have a beneficial effect in reducing stress and anxiety caused by COVID-19 (Hu et al., 2020; Zhang, et al., 2020). Exercise as an intervention for anxiety and depression has been demonstrated in animal studies and clinical trials in humans. The underlying mechanisms, include regulation of BDNF, D-beta-hydroxybutyrate (D-BHB), synaptic transmission, the hypothalamic-pituitary-adrenal axis (HPA-axis), tryptophan hydroxylase, glycogen synthase kinase-3 beta pathway (GSK3 β / β -catenin), neuroinflammation, oxidative stress, peroxisome proliferator-activated receptor-gamma coactivator 1 alpha (PGC-1 α) and peroxisome proliferator-activated receptor gamma (PPARgamma) (Hu et al., 2020; Pranoto et al., 2020).

During the COVID-19 pandemic, adults are more prone to depression because of the increasing economic and social needs and the closure of public spaces which cre-

ates emotional stress. Immature emotional mastery makes individuals in adulthood more susceptible to depression. Psychosocial factors during the COVID-19 pandemic occur very often with many respondents having to be dismissed suddenly by the company which causes respondents to experience a decrease in income. The declining income of respondents made the level of depression increase due to the increasing needs during the COVID-19 pandemic. Increasing age makes the work system and control in the body decrease, making it difficult for individuals to control when there is pressure (Schaakxs et al., 2017). This is following the study with the most respondents aged 18-25 totaling 55 people consisting of 5 women and 50 men with a percentage (59.7%) with the most respondents' occupations being female students (16.6%) followed by employees, private sector (16.3%) and self-employed (15.4%).

During the COVID-19 pandemic, women experienced the most severe depression, which amounted to 7 respondents. Gender differences also cause differences in depression levels. generally, women experience twice as much depression as men, because women have more difficulty controlling emotional states when stress occurs than men (Salk et al., 2017). In addition, women are more prone to depression because in women their emotional control and mood often change, plus women who experience menstruation every month make their emotional control more unstable.

During the COVID-19 pandemic, the closure of public spaces and the application of social restrictions made individuals reduce their physical activity outdoors. The pressures arising from COVID-19 and the social restrictions imposed have a detrimental impact on mental health by increasing fear and will lead to depressive disorders (Chi et al., 2020). This makes people in Malang switch to physical activities outside the room, namely by cycling, increasing bicycle users in Malang because many individuals experience boredom just sitting at home. Many community members think cycling is very fun because they can exercise by enjoying nature, as evidenced by many members of the cycling community with destinations such as tourist attractions, namely Batu City and nature tourism.

The road bike community represents a low percentage of depression because high cycling habits and long distances make their bodies better prepared to deal with COVID-19. Cycling communities that only cycled short distances have a fairly high percentage of major depression rates. Road bikes will maximize muscle work when pedaling because of a straight position when riding. Road racing bicycles will be beneficial for health if done regularly. Road racing bicycles will produce vibrations that the body will respond to for health benefits. Vibration during road cycling will be responded to by the muscles which then activate the neuromuscular system and will stimulate an increase in the respiratory system (Viellehner & Potthast, 2020). An increase in the respiratory system will increase the maximum oxygen consumption (VO_{2max}) of the rider. The increase in VO_{2max} causes the rider's aerobic capacity to increase which is beneficial for cardiovascular endurance so that the rider will last longer when cycling long distances or cycling marathons. Limitations in this study, the research method used is descriptive-analytic cross-sectional, this method is only used by researchers only to find a correlation or relationship between two variables, namely outdoor cycling habits

with depression levels during the pandemic, and for physical activities other than outdoor cycling researchers cannot control. The sample in this study was only 125 people, at least the sample population was taken due to the COVID-19 pandemic and social restrictions, and questionnaires were also distributed online of avoiding the spread of COVID-19.

Conclusions

The current study concluded that there is a negative correlation between the habit of outdoor cycling physical activity and the level of depression during the COVID-19 pandemic in members of the bicycle community in Malang City. Low cycling habits will increase the risk of depression, whereas high cycling habits will decrease the risk of depression. Outdoor cycling physical activity that is carried out regularly, measurably and continuously will maximize the work of the heart, lungs, metabolism, and brain which is very beneficial for individual mental health.

Conflicts of interest

All authors declare that there is no conflict of interest.

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НЕГАТИВНА КОРЕЛЯЦІЯ МІЖ ФІЗИЧНОЮ АКТИВНІСТЮ У ФОРМІ ЇЗДИ НА ВЕЛОСИПЕДІ НА ВІДКРИТОМУ ПОВІТРІ ТА РІВНЕМ ДЕПРЕСІЇ ПІД ЧАС ПАНДЕМІЇ COVID-19 СЕРЕД ЧЛЕНІВ СПІЛЬНОТИ ВЕЛОСИПЕДИСТІВ МІСТА МАЛАНГ (ІНДОНЕЗІЯ)

Сламет Рахарджо^{1ABD}, Арі Вібово Курніаван^{1BD}, Хені Юлі Хандаяні^{2BD}, Відіастуті^{3AB}, Мухаммад Сямсул Тауфік^{4BCD}, Аврян Сандрјаван^{1BC}, Олівія Андіана^{1CD}

¹Державний університет Маланг

²Педагогічний коледж Бангкалан Асоціації вчителів Індонезії

³Державний університет Джакарти

⁴Університет Сур'яканчани

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

Реферат. Стаття: 7 с., 6 табл., 1 рис., 42 джерела.

Мета дослідження полягає в аналізі взаємозв'язку між звичкою до різних форм їзди на велосипеді на відкритому повітрі та рівнем депресії під час пандемії COVID-19 серед членів спільноти велосипедистів міста Маланг (Індонезія).

Матеріали та методи. Це дослідження є кореляційним, у ньому використовується перехресний підхід до дослідження. У цьому дослідженні добровільно брали участь загалом 125 осіб із числа представників спільноти вело-

сипедистів міста Маланг (Індонезія). Вимірювання показників звичок до фізичної активності у формі їзди на велосипеді проводили з використанням Міжнародної анкети з фізичної активності (IPAQ), а для вимірювання рівня депресії використовували шкалу Гамільтона для оцінки депресії (HDRS). Вимірювання показників звичок до фізичної активності та рівнів депресії проводили одночасно. Для аналізу даних використовували коефіцієнт кореляції

Пірсона із застосуванням статистичного програмного забезпечення для суспільних наук (SPSS) версії 17.0 із заданим рівнем значущості ($p \leq 0,05$).

Результати. Результати показали наявність негативної кореляції між звичкою до різних форм їзди на велосипеді на відкритому повітрі та рівнем депресії ($r = -0,604$; $p \leq 0,001$), а також показали сильну кореляцію між обома змінними.

Висновки. На підставі одержаних результатів дослідження зроблено висновок про наявність негативної кореляції між звичкою до різних форм їзди на велосипеді на відкритому повітрі та рівнем депресії під час пандемії COVID-19 серед членів спільноти велосипедистів міста Маланг (Індонезія).

Ключові слова: фізична активність, їзда на велосипеді, депресія, COVID-19, пандемія.

Information about the authors:

Slamet Raharjo: slamet.raharjo.fik@um.ac.id; <https://orcid.org/0000-0002-0708-867X>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Semarang No. 5 Street, Malang, East Java 65145, Indonesia.

Ari Wibowo Kurniawan: ari.wibowo.fik@um.ac.id; <https://orcid.org/0000-0003-2697-8560>; Department of Physical Education, Health and Recreation, Faculty of Sports Sciences, State University of Malang, Semarang No. 5 Street, Malang, East Java 65145, Indonesia.

Heni Yuli Handayani: heni@stkipgri-bkl.ac.id; <https://orcid.org/0000-0002-2612-8067>; Study Program of Sports Education, STKIP PGRI Bangkalan, Soekarno Hatta No. 52 Street, Bangkalan, East Java 69116, Indonesia.

Widiastuti: widiastuti@unj.ac.id; <https://orcid.org/0000-0003-4047-1969>; Faculty of Sport Science, State University of Jakarta, Pemuda, No. 10 Street, East Jakarta, Special Capital Region of Jakarta 13220, Indonesia.

Muhamad Syamsul Taufik: syamsul@unsur.ac.id; <https://orcid.org/0000-0001-5936-515X>; Department of Physical Education, Health and Recreation, Faculty of Teacher and Education, University of Suryakencana, Pasir Gede Raya Street, Cianjur, West Java 43216, Indonesia.

Avryan Sandryawan: avryansandryawan12@gmail.com; <https://orcid.org/0000-0002-4504-1100>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Semarang No. 5 Street, Malang, East Java 65145, Indonesia.

Olivia Andiana: olivia.andiana.fik@um.ac.id; <https://orcid.org/0000-0002-1880-925X>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Semarang No. 5 Street, Malang, East Java 65145, Indonesia.

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EFFECT OF CONTINUOUS-EXERCISE AND MODIFICATION INTERVAL-EXERCISE ON DECREASING MALONDIALDEHYDE AND BLOOD LACTATE LEVELS IN NON-PROFESSIONAL SHORINJI KEMPO ATHLETES

Tri Wahyu Aga, Seputra^{1ABD}, Andri, Suyoko^{2BD}, Purwo Sri, Rejeki^{1ABD},
Adi, Pranoto^{1CD}, Lilik, Herawati^{1AD}, Andre, Andarianto^{1BD}, Ghana Firsta, Yosika^{3BD},
Nabilah, Izzatunnisa^{1BD} and Mohamad Khairuddin Abdul, Wahab^{4AD}

¹University of Airlangga

²State University of Surabaya

³Tanjungpura University

⁴Management and Science University

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 analyze the effect of continuous exercise and modification interval exercise on decreasing malondialdehyde (MDA) and blood lactate levels in non-professional Shorinji Kempo athletes.

Materials and methods. This study used a quasi-experimental method with a randomized pretest posttest-only group design. Subjects were 16 male adolescents aged 18-20, body mass index (BMI) 20-24 kg/m², who had normal blood pressure, normal resting heart rate, and no history of chronic disease. The subjects were randomly divided into two groups: CEG (n = 8, continuous exercise group) and MIEG (n = 8, modification interval exercise group). Continuous and modification interval exercises were carried out in 30 minutes/exercise sessions, with an intensity of 75% HRmax and 75% RM, as often as 3 times/week, for one week. Measurements of resting heart rate, blood lactate and MDA levels were performed 30 minutes pre-exercise and 10 minutes post-exercise. The data analysis technique used the Paired Sample T-Test and the independent T-test with SPSS software version 21.

Results. The results showed significant differences in resting heart rate, blood lactate and MDA levels pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). A difference was also observed in Delta (Δ) heart rate pre-exercise vs. post-exercise on CEG (-3.88 ± 3.36 bpm) and MIEG (-15.25 ± 3.45 bpm) ($p \leq 0.001$), but no differences were observed in the Delta (Δ) blood lactate and MDA levels in both groups.

Conclusion. Based on the study results, it was shown that continuous exercise and modification interval exercise increase blood lactate and MDA levels shortly after intervention but both exercises could reduce acute stress, which was indicated by a decrease in resting heart rate.

Keywords: continuous exercise, modification interval exercise, Shorinji Kempo, healthy life style.

Introduction

Shorinji kempo was founded by Doshin in 1947 in Japan to be a training and self-development system based on Shaolin kung fu. Shorinji kempo is a martial arts sport with

competition numbers consisting of embu and randori. The embu competition consists of combined movements such as punches, kicks, blocks, and slams performed by two Kenshi (Kempo athletes) in pairs or four to eight Kenshi in a team. To support achievement in a match, of course, requires a healthy and fit physical condition to maintain performance when competing and increase the fatigue threshold (Edwards et al., 2018). During the match, there will be repeated muscle contractions, and physiologically, this will trigger a response to oxidative stress (Steinbacher & Eckl, 2015). In addition, blood lactate levels and heart rate will also in-

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crease as a sign that athletes use submaximal to maximum intensity when competing (Stojanović et al., 2018). The high intensity of movement demands and physiological stress on athletes during competition can accumulate during the match, presenting as signs of fatigue that lead to decreased performance and even the risk of injury (Kristie-Lee Taylor, 2012). Of course, this should not happen, so action is needed to maintain physical condition and fatigue levels and prevent oxidative stress (Edwards et al., 2018).

Oxidative stress conditions characterized by increased production of reactive oxygen species (ROS) have implications for various acute and chronic pathological processes such as cardiovascular disease (CVDs), neurodegenerative diseases (NDs), acute and chronic kidney disease (CKD), macular degeneration (MD), biliary diseases and cancer (Liguori et al., 2018). This is due to the high level of inflammation characterized by ROS-mediated increases in IL-1 α , IL-6, and IL-8, and this condition usually occurs in individuals with obesity, diabetes, hypertension, and atherosclerosis (Liguori et al., 2018; Andarianto et al., 2022). In addition, the inflammatory process has a role in the pathogenesis of breast cancer (Rejeki et al., 2021). Then the high level of lactate is also a sign of hypoxia in body tissues (Uyar et al., 2020), an increase in blood lactate caused by the high intensity of muscle work characterized by an increase in heart rate. Hypoxia is one of the factors that can cause an increase in ROS, leading to oxidative stress conditions through reperfusion injury mechanisms (Ferrari & Andrade, 2015). Oxidative stress levels can be determined by looking at changes in malondialdehyde (MDA) levels (Yosika et al., 2020). The reaction between ROS and polyunsaturated fatty acids (on the cell wall) will result in the formation of aldehydes, such as MDA, through the lipid peroxidation process (Su et al., 2019). An important new strategy is to reduce oxidative stress, characterized by an increase in MDA levels. It is known that the body has a natural antioxidant system that helps reduce oxidative stress and this system can be improved with exercise (Park & Kwak, 2016).

Bouزيد et al. (2015) found that MDA levels increased by 5 minutes after ergocycle exercise to experience fatigue. However, a study conducted by Yosika et al. (2020) revealed that moderate continuous exercise in testing in humans could lower MDA levels. Bishop et al. (2008) has revealed that exercise for 5 weeks can reduce blood lactate levels. In his research, Zhao et al. (2021) stated that exercises performed for 4 weeks did not affect the concentration of basal blood lactate. Rahayu et al. (2019) in his study reported that there was a significant difference in heart rate recovery between 60 and 90 minutes after exercise. Therefore, how the fundamental impact of exercise on blood MDA and lactate levels remains controversial. On this basis, the *purpose of this study* was to analyze the influence of continuous exercise and modification interval exercise on the reduction of blood MDA and lactate levels in non-professional athletes with ages 18-20 years and body mass index (BMI) 20-24 kg/m².

Material and Methods

Study participants

This study was a quasi-experiment with a randomized pretest posttest-only group design. The subjects were

16 teenage boys aged 18-20 years, body mass index (BMI) 20-24 kg/m², had normal blood pressure, normal resting heart rate, and no history of chronic disease. All subjects obtained information both orally and in writing about the study and agreed to sign informed consent. These research procedures have been approved by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Airlangga Surabaya Number: 125/EC/KEPK/FKUA/2015.

Study organization

The training program was conducted and supervised by professionals from the Faculty of Sport Science, State University of Surabaya. Subjects were randomly divided into two groups, namely CEG (n = 8, continuous exercise group), MIEG (n = 8, modification interval exercise group). Continuous exercise was done by jogging for 30 minutes with an intensity of 75% HRmax for 30 minutes followed by warming up and cooling for 5 minutes each, while modification interval exercise was done with three stages, including warming up (jogging for 5 minutes), core exercises (Knee up, Knee up twist out, Knee up twist in, Hip twist, Hooping, Jumping Jack, Front Jumping Jack) which was done continuously, 3 sets of 15 reps each type of movement, and followed by active rest between intervals (jogging, side step and backward jogging for 30 seconds), and cooling (jogging and PNF stretching for 5 minutes). Intervention of continuous exercise and modification interval exercise were carried out for one week with a frequency of 3x/week and continued with embu (pattern of movement shorinji kempo (punch, kick, tank, slam, lockdown, catch and throw)) paired for 2 minutes, subaxial intensity, at the end of each exercise intervention. Heart rate during exercise monitored using polar heart rate monitor (Polar H10 Heart Rate Sensor, Inc., USA).

Height measurement using a stadiometer (accuracy of 0.5 cm) (SECA, Chino, CA). Weight measurement using an electronic scale (Tech 05^o, China). BMI is measured by calculating weight (kg) divided by height in square meters (m²). Blood pressure tests are performed using OMRON digital meter tension (OMRON Model HEM-7130L, Omron Co., Osaka, Japan) on the non-dominant arm 3 times in a row at 1-2 minutes between two measurements, then the average value of the measurement is taken. Resting heart rate is measured using a Pulse Oximeter (PO 30 Pulse Oximeter, Beurer North America LP, 900 N Federal Highway, Suite 300, Hallandale Beach, FL 33009).

Blood collection was done 30 minutes pre-exercise and 10 minutes post-exercise (Rejeki et al., 2021). Blood was checked for 15 minutes at a speed of 3000 rpm. Plasma was separated and stored at a temperature of -80°C for analysis of MDA levels the next day. MDA level was measured using the thiobarbituric acid reactive substance (TBARs) (Esgalhado et al., 2015) with a concentration unit of ng/mL. Measurement of lactic acid levels using Accutrend Plus Meter (Accutrend[®] lactate meter, Roche Diagnostics, Mannheim, Germany) (Perez et al., 2008) with mmol/L concentration units.

Statistical analysis

Statistical analysis using Statistic Package for Social Science (SPSS) version 21 (SPSS Inc., Chicago, IL, USA). The

normality test uses the Shapiro-Wilk test, while the other test uses the Paired Sample T-Test and the Independent Samples T-Test. All data is displayed with Mean $\pm$ Standard Deviation (SD). All statistical analyses use significant levels ($p \leq 0.05$).

Results

The results of descriptive analysis of the characteristic data of the research subjects in each group can be seen in Table 1.

Table 1. Results of analysis of characteristics of research subjects

Parameter	Group		Independent Samples T-Test p-value
	CEG (n=8)	MIEG (n=8)	
Age (years)	19.88 $\pm$ 0.83	19.50 $\pm$ 1.20	0.480
Height (m)	60.50 $\pm$ 6.91	59.38 $\pm$ 3.96	0.697
Weight (kg)	1.68 $\pm$ 0.05	1.67 $\pm$ 0.05	0.801
BMI (kg/m ²)	21.44 $\pm$ 1.52	21.25 $\pm$ 0.97	0.778
SBP (mmHg)	116.38 $\pm$ 3.38	114.75 $\pm$ 3.88	0.387
DBP (mmHg)	79.25 $\pm$ 5.47	75.13 $\pm$ 3.80	0.104

Description: BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Independent Samples T-Test. All data is displayed with the mean $\pm$ standard deviation (SD).

Based on Table 1, the Independent Samples T-Test results showed no significant difference in average data on the characteristics of the study subjects in each group ($p \geq 0.05$). The results of the analysis of pre-exercise vs. post-exercise MDA levels in each group can be seen in Figure 1.

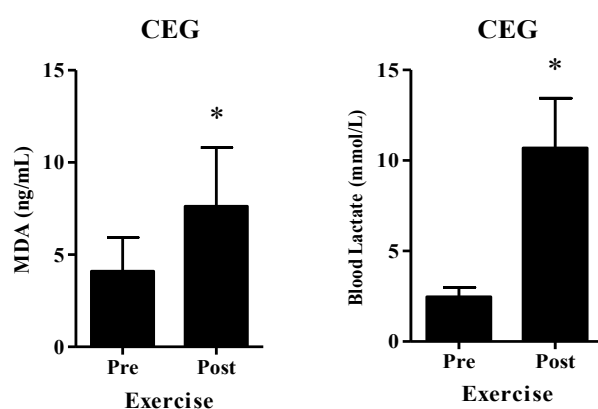


Figure 1. Average MDA pre-exercise vs. post-exercise on each group. Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Paired Sample T-Test. All data is displayed mean $\pm$ SD. (*) Significant vs. Pre-exercise ($p \leq 0.05$).

Based on Figure 1, there was an increase in post-exercise MDA levels in each group. The Paired Sample T-Test showed a significant difference in average increase in MDA levels between pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). The results of the average analysis of blood lactate

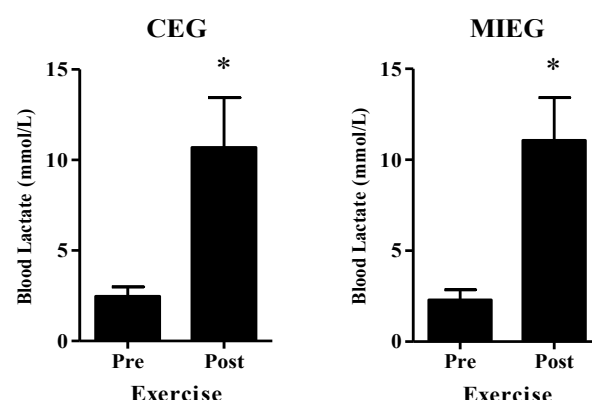


Figure 2. Average blood lactate pre-exercise vs. post-exercise on each group. Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Paired Sample T-Test. All data is displayed mean $\pm$ SD. (*) Significant vs. Pre-exercise ($p \leq 0.05$).

between pre-exercise vs. post-exercise on CEG and MIEG are presented in Figure 2.

Based on Figure 2, there was an increase in post-exercise blood lactate in each group. Paired Sample T-Test results showed a significant difference in average increase in blood lactate between pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). The average resting heart rate analysis results between pre-exercise vs. post-exercise on CEG and MIEG are presented in Figure 3.

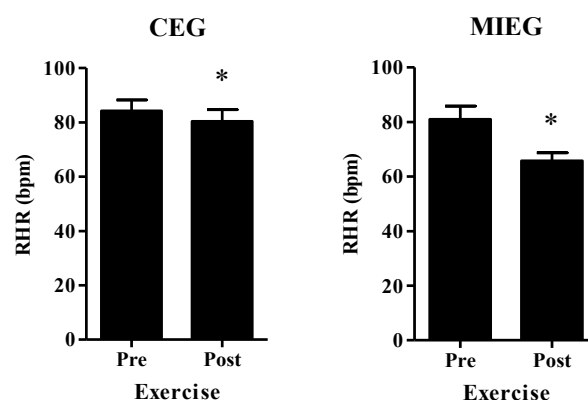


Figure 3. Average resting heart rate pre-exercise vs. post-exercise on each group. Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Paired Sample T-Test. All data is displayed mean $\pm$ SD. (*) Significant vs. Pre-exercise ($p \leq 0.05$).

Based on Figure 3, there was a decrease in resting heart rate post-exercise in each group. Paired Sample T-Test results showed a significant difference in average resting heart rate reduction between pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). The results of the analysis of the average levels of MDA, blood lactate, and resting heart rate based on the examination time are presented in Table 2.

Based on Table 2, the independent samples T-Test showed no significant difference in average resting heart rate pre-exercise between CEG and MIEG ($p \geq 0.05$). In

Table 2. Results of RHR, blood lactate, and MDA analysis based on examination time

Time	Group		Independent Samples T-Test p-value
	CEG (n=8)	MIEG (n=8)	
<i>Resting Heart Rate (bpm)</i>			
Pre-exercise	84.25±4.03	81.00±4.87	0.168
Post-exercise	80.38±4.27	65.75±2.96*	0.000
Delta (Δ)	-3.88±3.36	-15.25±3.45*	0.000
<i>Laktat Darah (mmol/L)</i>			
Pre-exercise	2.48±0.52	2.30±0.55	0.524
Post-exercise	10.70±2.74	11.08±2.33	0.773
Delta (Δ)	8.23±2.82	8.78±2.46	0.684
<i>Malondialdehyde (ng/mL)</i>			
Pre-exercise	4.10±1.83	6.84±1.87	0.070
Post-exercise	7.62±3.18	10.15±2.27	0.091
Delta (Δ)	3.53±3.48	3.31±2.55	0.891

Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Independent Samples T-Test. All data is displayed mean±SD. (*) Significant vs. CEG ($p \leq 0.05$).

contrast, the average resting heart rate post-exercise and delta (Δ) showed significant differences ($p \leq 0.05$). Likewise, the results of the Independent Samples T-Test showed that there was no significant difference in average blood lactate pre-exercise, post-exercise, and delta (Δ) between CEG and MIEG ($p \geq 0.05$). Independent Samples T-Test results also showed that there was no significant difference in average levels of MDA pre-exercise, post-exercise, and delta (Δ) between CEG and MIEG ($p \geq 0.05$).

Discussion

Based on the results of the Independent Samples T-Test test showed a significant difference in average resting heart rate (RHR) between pretest vs. posttest in continuous exercise group and modification of exercise group interval ($p \leq 0.05$). The findings in this study were a decrease in RHR after doing CEG and MIEG and an increase after continuing with embu. This proves that both exercises have the same effect on RHR decline. Bahrainy et al. (2016) showed that increased and decreased parasympathetic tone of resting responses to beta-adrenergic stimulation contributed to a decrease in RHR after regular exercise or physical activity in humans. Silva et al. (2018) explained that increased cardiorespiratory during exercise is associated with an increase in diameter/thickness in the left ventricle and an increase in the final systolic volume, leading to an increase in the stroke volume. An increase in the volume of stroke volume resulted in a decrease in the number of heartbeats, a reduction in the heart's metabolic load, and contributed to the decline of RHR (Silva et al., 2018). In the case of a decrease in RHR after CEG and MIEG it may also result from an increase in output from parasympathetic. In comparison, the rise in RHR after paired embu may be due to decreased parasympathetic activity and an increase in sympathizer output (Tyagi

& Cohen, 2016). The results of this study are similar to systematic reviews and meta-analyses conducted by Reimers et al. (2018), reporting that endurance training and yoga decrease RHR. After endurance exercise, the average RHR of exercise participants decreased compared to those who did not exercise (4.5% to 9.0% and 2.7 to 5.8 bpm).

The main findings in the study related to the degree of oxidative stress measured through parameters of blood lactate levels and the MDA showed a 5-minute increase in post CEG dab MIEG followed by paired embu. Based on the Independent Samples T-Test, the average blood lactate level and MDA showed a significant difference ($p \leq 0.05$) between pre-exercise vs. post-exercise. This is possible because, at the time of doing embu paired, there is a hypoxia moment due to high intensity (sub-maxim), so the predominant energy metabolism used is anaerobic. High blood lactate levels after CEG and MIEG are also considered to be associated with hypoxic conditions, and this is because hypoxia increases the expression of hypoxia-inducible factor 1 α (HIF1 α) which then stimulates the glycolysis process and increases lactic acid dehydrogenase (LDH) activity so that lactate is produced higher (Ivashkiv, 2020). These results are similar to the study conducted by Lesmana et al. (2016) showed that treadmill exercise 5 times/week increased blood lactate levels 25 minutes post-exercise. Kato et al. (2013) have also proven that 5 minutes after moderate-intensity treadmill exercise and swimming for 10 minutes showed that blood lactate levels increased.

When the body undergoes hypoxia, it will also cause electron leakage in the mitochondria during oxygen reperfusion. During oxidative phosphorylation in mitochondria, oxygen is reduced by the mitochondrial electron transport system to form adenosine triphosphate (ATP) and water (H₂O) (Mrakic-Spota et al., 2015). This explanation is supported by the explanation (Arsana et al., 2013) that when oxidative phosphorylation (electron transport) as much as 2-5% of the total oxygen demand can be converted into free radicals, resulting in ROS. The high ROS will result in a reaction with polyunsaturated fatty acids (on the cell wall), resulting in the formation of aldehydes, such as MDA, through the lipid peroxidation process (Su et al., 2019). Therefore, the level of MDA after CEG dab MIEG followed by paired embu increased. The study's findings are similar to the research results conducted by Ilyas et al. (2017), which stated that moderate-intensity exercise training in mice increased MDA levels. Moflehi et al. (2012), in their study, also proved that treadmill exercise, low, moderate, and high intensity was shown to increase MDA levels compared to subjects who did not do exercise. It is also supported by Huang et al. (2015) that acute exercise can cause oxidative stress, in contrast to chronic exercise, which can provide a stimulus for beneficial oxidative adaptation and improve physiological performance and physical health.

Limitations of this study include (1) Lack of inflammatory parameters as a marker of generality due to oxidative stress, (2) Absence of control groups, (3) Absence of measurement of the body's internal antioxidant parameters, (4) This study only conducted acute exercises. First, in this study, we only measured blood lactate levels and MDA as oxidative stress markers. Therefore, future studies should include more in-depth parameters as a sign of the discharge from oxidative stress, such as inflammatory parameters

(IL-6). Second, the absence of a control group that did not intervene was exercised. Therefore, further research needs to be added to control groups as a comparison with groups given exercise interventions. Third, measurement of MDA levels is only a marker of high levels of oxidative stress, but the balance between antioxidants and oxidative stress is not yet known. Therefore, further research is recommended to take measurements of antioxidant activity (SOD, GPX). Fourth, the study only conducted acute intervention (exercise), so more research is needed to find out the effects of chronic intervention (training) in non-professional athletes. The results are expected to be useful for leteration in creating a pre-condition training program before the athlete's games.

Conclusion

Based on the results of the study, it was concluded that the provision of continuous exercise and modification interval exercise which was carried out for 30 minutes/exercise session with an intensity of 75% HRmax and 75% RM, a frequency of 3x/week for one week was able to reduce acute stress which was characterized by a decrease in RHR, but not yet able to reduce blood lactate and oxidative stress which is indicated by MDA levels.

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Conflict of interest

The authors declare that they have no competing interests.

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ВПЛИВ БЕЗПЕРЕРВНОЇ ВПРАВИ ТА МОДИФІКОВАНОЇ ІНТЕРВАЛЬНОЇ ВПРАВИ НА ЗНИЖЕННЯ РІВНІВ МАЛОНОВОГО ДІАЛЬДЕГІДУ ТА ЛАКТАТУ В КРОВІ В НЕПРОФЕСІЙНИХ СПОРТСМЕНІВ, ЯКІ ЗАЙМАЮТЬСЯ СЬОРІНДЗІ-КЕМПО

Три Вах'ю Ага Сепутра^{1ABD}, Андрі Суєко^{2BD}, Пурво Шрі Реджекі^{1ABD}, Аді Праното^{1CD}, Лілік Хераваті^{1AD}, Андре Андріанто^{1BD}, Гана Ферста Йосіка^{3BD}, Набила Ізатунніса^{1BD}, Мохамад Хайруддін Абдул Вахаб^{4AD}

¹Університет Айрланга

²Сурабайський державний університет

³Університет Танджунгпура

⁴Університет менеджменту та науки

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів
Реферат. Стаття: 7 с., 3 табл., 3 рис., 31 джерело.

Метою дослідження було проаналізувати вплив безперервної вправи та модифікованої інтервальної вправи на зниження рівнів малонового діальдегіду (МДА) та лактату в крові в непрофесійних спортсменів, які займаються сьоріндзі-кемпо.

Матеріали та методи. У цьому дослідженні використовували квазіекспериментальний метод, при цьому план проведення дослідження включає лише попереднє та заключне дослідження в рамках двох експериментальних груп із випадковою вибіркою учасників. Учасниками були

16 підлітків і юнаків чоловічої статі віком 18–20 років, індекс маси тіла (ІМТ) 20–24 кг/м², з нормальним кров'яним тиском, нормальною частотою серцевих скорочень (ЧСС) у стані спокою та без хронічних захворювань. Учасників випадково розподілили на дві групи: CEG (n = 8, група безперервної вправи) та MIEG (n = 8, група модифікованої інтервальної вправи). Безперервні та модифіковані інтервальні вправи проводили по 30 хвилин/заняття вправами, з інтенсивністю 75% максимальної ЧСС (HRmax) та 75% повторного максимуму (RM), із частотою 3 рази/тиждень, протягом одного тижня. Вимірювання показників ЧСС у стані спокою, рівнів малонового діальдегіду (МДА) та лактату в крові проводили за 30 хвилин до початку тренування та через 10 хвилин після завершення тренування. Як метод аналізу даних використовували t-критерій Ст'юдента для парних вибірок та t-критерій Ст'юдента для незалежних вибірок із застосуванням програмного забезпечення SPSS версії 21.

Результати. Результати показали значні відмінності в показниках ЧСС у стані спокою, рівнів малонового діаль-

дегіду (МДА) та лактату в крові до початку тренування та після завершення тренування в групі безперервної вправи (CEG) та в групі модифікованої інтервальної вправи (MIEG) ($p \leq 0,05$). Також зафіксована відмінність у різниці (Δ) показників ЧСС до початку тренування та після завершення тренування в CEG ($-3,88 \pm 3,36$ уд./хв) та в MIEG ($-15,25 \pm 3,45$ уд./хв) ($p \leq 0,001$), але в обох групах не зафіксовано жодних відмінностей у різниці (Δ) рівнів малонового діальдегіду (МДА) та лактату в крові.

Висновки. На підставі одержаних результатів дослідження було показано, що безперервна вправа та модифікована інтервальна вправа підвищують рівні МДА та лактату в крові незабаром після втручання, але обидва види вправ можуть зменшувати гострий стрес, на що вказувало зниження ЧСС у стані спокою.

Ключові слова: безперервна вправа, модифікована інтервальна вправа, сьорінджі-кемпо, здоровий спосіб життя.

Information about the authors:

Tri Wahyu Aga, Seputra: triwahyuagaseputra@gmail.com; <https://orcid.org/0000-0002-5907-0017>; Sports Health Science, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No. 47 Street, Surabaya, East Java 60132, Indonesia.

Andri, Suyoko: olympus.suyoko@gmail.com; <https://orcid.org/0000-0001-6836-8731>; Faculty of Sport Science, Universitas Negeri Surabaya, Lidah Wetan Street, Surabaya, East Java 60213, Indonesia.

Purwo Sri, Rejeki: 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, Prof. Dr. Moestopo No. 47 Street, Surabaya, East Java 60132, Indonesia.

Adi, Pranoto: adipranoto83@gmail.com; <https://orcid.org/0000-0003-4080-9245>; Doctoral Program of Medical Science, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No. 47 Street, Surabaya, East Java 60132, Indonesia.

Lilik, Herawati: 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, Prof. Dr. Moestopo No. 47 Street, Surabaya, East Java 60132, Indonesia.

Andre, Andarianto: andariantoandre@gmail.com; <https://orcid.org/0000-0001-5387-2767>; Sport Health Science, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No. 47 Street, Surabaya, East Java 60132, Indonesia.

Ghana Firsta, Yosika: gfyosika@gmail.com; <https://orcid.org/0000-0002-9993-7586>; Faculty of Teacher Training and Education, Universitas Tanjungpura, Prof. Dr. H. Hadari Nawawi Street, Pontianak, West Kalimantan 78124, Indonesia.

Nabilah, Izzatunnisa: nabilah.izzatunnisa-2019@fk.unair.ac.id; <https://orcid.org/0000-0003-3103-8434>; Medical Program, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No. 47 Street, Surabaya, East Java 60132, Indonesia.

Mohamad Khairuddin Abdul, Wahab: khairuddin_abdwahab@msu.edu.my; <https://orcid.org/0000-0002-8235-2493>; Orthopaedic & Sport Medicine, International Medical School, Management & Science University, 40100 Shah Alam, Selangor, Malaysia.

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ORIGINAL SCIENTIFIC ARTICLE

INTENSIFICATION OF BACK MUSCLE STRENGTH TESTING IN PHYSICAL EDUCATION OF STUDENTS BY APPLYING INFORMATION AND COMMUNICATION TECHNOLOGIES

Zinoviy Mykytyuk^{1ABE}, Oksana Blavt^{1BCD}, Yaroslav Hnatchuk^{2ADE},
Oleh Stechkevych^{1ADE} and Tetiana Helzhynska^{1BCE}

¹Lviv Polytechnic National University

²Khmelnytskyi National University

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

Corresponding Author: Oksana Blavt, E-mail: oksanablavt@ukr.net

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Abstract

The purpose of this study is the experimental substantiation of the implementation of information and communication technologies to test the control of back muscle strength in the process of physical education of students.

Materials and methods. General scientific methods were used to solve the research problems: analysis, synthesis, generalization, induction and systematization, technical modeling, pedagogical experiment, pedagogical testing, and mathematical methods. The study involved 240 students aged 17 to 18 at the beginning of the study.

Results. An electronic device for determining the strength of the muscles of the back was developed and tested, the readings of which allow the user to get clear current information on the panel of a personal computer. The device was built on a combination of modern electronic technologies and software. For the purposes of the experimental substantiation of the developed back muscle strength control device, a correlation analysis was used to empirically investigate the authenticity degree of the tests used to control back muscle strength. According to the results of the reliability of the tests of back muscle strength control tests, the results of which were recorded using a dynamometer, those are between low and medium. The recording of the back muscle strength test results with the developed device ensured the achievement of a high level of test authenticity.

Conclusions. The result of the research study aimed at solving the problematic aspects of test control was to ensure the appropriate degree of authenticity of the tests used to control back muscle strength. The recording of the back muscle strength test results with the developed device ensured the achievement of a high level of test authenticity.

Keywords: testing, control, physical education, student, back muscle strength, device, information and communication technologies.

Introduction

Problem statement. The current stage of reorganization of the system of physical education in universities as an important part of social policy is characterized by active evolutionary changes. Effective physical education of young people is historically one of the first significant pedagogical problems, and, at the same time, the center of the innovative pedagogical movement (Anikieiev, 2015). The urgency of finding ways to improve the effectiveness of physical educa-

tion for students is growing significantly in connection with the reorganization of higher education in accordance with European standards. The problem is important for the health of the nation, especially young people.

Promising, in connection with the above, is the use of innovative methods based on information and communication technologies (ICT) in the physical education of students (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Siregar, Kasih, & Pardilla, 2022). According to the requirements of the time, the global development of ICT necessitates significant changes in all aspects of the organization of physical education and physical training in universities, which are able to raise the quality of this process to a significantly higher level (Di Tore, Schiavo, & D'isanto, 2016).

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Analysis of recent research and publications. The use of innovative technologies in the practice of physical education is considered in a fairly wide range of scientific papers (Capobianco, Almuklass, & Enoka, 2018; Chow, Chung, Ma, Macfarlane, & Shirley, 2017). It is considered that their active implementation and use is one of the most important priorities for the development of the industry in accordance with today's challenges (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020).

It is believed that an important mechanism of influence and management in the course of physical education is control (Ivashchenko, & Khudolii, 2016; Magill, & Anderson, 2017; Solohubova, Lakhno, Shyyan, & Shyyan, 2020). Improvement of technologies of pedagogical control is considered as a possible direction of increase of quality and efficiency of physical education of students. The target direction of control is to analyze the relationship between the dynamics of pedagogically oriented actions and pedagogically determined changes during physical training (Vanhelst, Beghin, Fardy, Ulmer, & Czapllicki, 2016). Control as a means of improving the system of information support for the management of the process of physical education is considered in a large list of works (Di Tore, Schiavo, & D'isanto, 2016; Ivashchenko, Yermakova, Cieslicka, & Muszkieta, 2015; Kriventsova, Pashkevych, Iermakov, Bartík, Michal, Nosko, & Yermakova, 2017).

The growing importance of comprehensive control in physical education and management of this process is due to many factors characteristic of the current state of the field of physical education (Edwards, 2010; Khudolii, Iermakov, & Ananchenko, 2015). Among the main ones, it is believed, is the lag in the quality of comprehensive control from the requirements for the organization of the training process, as well as increasing the requirements for metrological support for the collection and analysis of information (Chow, Chung, Ma A.W.W, Macfarlane, & Shirley, 2017; Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021).

It is believed (Kok, Komen, van Capelleveen, & J. van der Kamp, 2020; Koryahin, Blavt, Vanivska, & Stadnyk, 2020) that all these issues are most effectively addressed in the case of the introduction of automated techniques that allow you to monitor the status of the main parameters in real-time. A special role is given to information technology of automated control and evaluation of acquired skills (Magill, & Anderson, 2017). The integration of ICT in the educational process provides the establishment of facts, identification of links and patterns, and forecasting of the consequences to improve the effectiveness of this process (Chow, Chung, Ma, Macfarlane, & Shirley, 2017; Siregar, Kasih, & Pardilla, 2022).

The purpose of this study is experimental substantiation to implement ICT in test control of back muscle strength in the process of physical education of students.

Materials and methods

Study participants

The first-year students from Lviv Polytechnic National University were selected for research. The study involved 240 students, their age at the beginning of the study was 17-18 years. It is important that the number of students in the

research groups was sufficient for the demonstrable evaluation of the experiment's results. The requirements for the adequacy of the information volume at the level of $p < 0.05$ were met.

The organization of the study took into account the provisions of the Declaration of Helsinki of the World Medical Association (WMA-2013) on the ethical principles of medical research with human participation; the research protocol was approved by the ethics commission of the Lviv Polytechnic National University.

Study organization

Research methods. In accordance with the goal, the study required implementation at the theoretical and empirical levels, in accordance with modern requirements for research.

At the theoretical level, the following are applied: general scientific methods: analysis (analytical, structural-target, problem-oriented) to obtain theoretical and empirical material; synthesis and generalization of information presented in the scientific literature, documentary, and methodological sources (to clarify the theoretical aspects of the problem, their state, and development; to establish methods, levels of implementation, research approaches to research); induction and systematization (for processing of theoretical data, formulation of the basic provisions of research and their systematization in the context of the considered problems).

The methods used to obtain empirical data were the pedagogical experiment, pedagogical testing, and mathematical methods for processing digital files. Technical modeling was used as a method of the empirical level of research. Technical modeling was used to create an ICT-based device to be studied.

Organization of research. The scientific research was carried out in the process of interrelated stages of theoretical and empirical research.

Pedagogical testing involved determining muscle strength in the traditional way and using a developed device. This determined the strength of the torso flexors, torso and extensor muscles, or the strength of the back extensor muscles.

A back dynamometer (dynamometer from Baseline Products) and a wide belt with a buckle were traditionally used to determine back muscle strength. Measurements were performed using a gymnastic wall.

The strength of the back muscles is a total indicator of the group of muscles that perform flexion and extension of the torso. Determination of torso flexors was performed in a sitting position on the floor with the back to the gymnastic wall (chain - dynamometer - chain to wall system in the belt loop on the chest, Fig. 1.a). To avoid moving to the wall, the student rests his pelvis on a gymnastic bench placed on the edge, which is held by another person. Efforts are directed forward, arms bent at the elbows. The strength of the torso extensors was determined from the starting position sitting on the floor facing the gymnastic wall.

We also measured strength, which is a total measure of the group of muscles that stretch the torso. To determine it, the student becomes the middle of the feet on a metal platform with a hook and holds the dynamometer handle at the level of the knee joints, gripping from above.

The strength was determined as follows: the student stands with his feet on a wooden platform with a dynamometer attached to it, using a hook so that it is at knee level. Bending at the waist, the student takes the handle of the dynamometer with both hands and, without bending the knees, straightens his back and squeezes to failure. The study is conducted twice, the best result is recorded. Measurements are made with an accuracy of 5 kg.

Statistical analysis

Within descriptive statistics, the comparative-statistical method of determining of empirical authenticity of tests is applied. To determine the empirical authenticity of the tests, variance and correlation analysis (between the obtained test results and the correlation criterion) were used. Quantitatively, the degree of authenticity of the tests is expressed using the reliability and validity coefficients, which are calculated using the intra-class correlation coefficient. The methods of mathematical statistics are used, it can be confirmed that the criteria of reliability and validity are adequately met. All statistical analysis was performed using SPSS Version 20.

The statistical data required for the interpretation of the studied parameters were obtained by sampling two samples of 120 people of the same sex aged 18 to 22 years. The sample was considered as an empirical analog of the general population, which made it possible to form an opinion about the numerical values of the studied parameters as a whole.

Results

The effectiveness of all types of physical activity and ensuring a high level of efficiency limits the development of strength abilities, which are also an important component of the physical fitness of students. Compared to other motor abilities, power abilities are the most multi-component in structure and measurement and are the basis of their development (Ivashchenko, Yermakova, Cieslicka, & Muszkiet, 2015; Prieske, Muehlbauer, & Granacher, 2016). That is why specialists pay a lot of attention to the methods of control and improvement of these characteristics of muscular work (Alfrey, & Gard, 2014; Khudolii, et al., 2015).

The issue of control of the indicator of strength abilities is one of the determining factors that regulate the dynamics of physical fitness and allows you to purposefully manage this process. From the standpoint of the theory of abilities, the structure of these abilities is the least prone to adjustment and change (Edwards, 2010).

The muscular strength of the back is distinguished by the structure of strength abilities (Catalá, Schroll, Laube, & Arampatzis, 2018). There is a very strong muscle group in the back, which is the basis of a properly formed musculo-skeletal system and ensures its proper functioning. Research of means and methods of force training is considered one of the most priority directions of modern intelligence (Ivashchenko, Yermakova, Cieslicka, & Muszkiet, 2015).

Quantitatively, the level of development of strength abilities in the practice of physical education of students is assessed using special control exercises - strength tests (Magill, & Anderson, 2017). This process is technically complex, as testing involves maintaining balance by the student, which can lead to errors in the results. It is impossible to

intensify the test process, as it requires constant registration of results.

In order to eliminate the listed factors, objectify the assessment, and to ensure the reliability of the test results, a device was developed and tested, the readings of which allow receiving clear current information on the panel of the personal computer. In the presented electronic device for determining the strength of the back muscles, the system "chain-dynamometer-chain" is replaced by a rubber band with a known coefficient of elasticity (Fig. 1). When performing the test, the bending and unbending force of the torso will be proportional to the coefficient of elasticity and the amount of deformation.

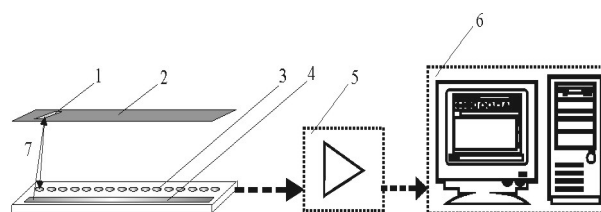


Fig. 1. Block diagram of a device for determining the strength of the back muscles: 1 – light reflector; 2 – rubber tape; 3 – line of photodetectors; 4 – radiation source; 5 – amplification unit based on the operational amplifier; 6 – personal computer; 7 – the course of the rays

The following scheme has been developed to fix the amount of deformation. A light reflector is attached to the rubber band. A wide-spectrum LED that covers the visible range is used as the light source. Opposite the rubber band on the rack is a line of photodiodes, which registers the signal that falls on a particular photodiode (Hotra, Mykytyuk, Diskovskyi, Barylo, & Vezyr, 2018). During the flexion and extension of the torso by the student in the testing process is stretching the elastic band and displacement of the reflector due to its deformation, and hence change the position of the reflected beam, which is fixed by photodiodes. The value of the deformation of the rubber band is equal to the signal from the corresponding photodiode on which the radiation hit. The signal from the photodiodes is amplified by an operational amplifier and fed to the screen of a personal computer. Visual information about the strength of the back muscles is generated on a personal computer using the developed software.

The expediency of using LEDs in our development is that such a sensor has advantages that significantly differentiate it from others, among them: high level of accuracy, speed, and resolution, minimum size, lack of sensitivity to external influences (vibration, etc.), low energy consumption level. In addition, LEDs have a great advantage: the brightness of the LEDs is very well adjustable, the ability to focus the light flux in one direction of its increased energy efficiency, and almost no negative environmental impact. Due to some physical properties, LEDs have a so-called instantaneous start. In its structure, the LED is similar to a conventional semiconductor diode, just like any semiconductor diode, the LED has the property of unilateral conductivity (Vistak, Dmytrah, Mykytyuk, Sushynskyi, Barylo, Prysiazhniuk, & Horbenko, 2017).

Table 1. Authenticity of student control tests of back muscle strength (n - 240)

	T	A	T	A	T	A	T	A	T	A	T	A
H	0,766	0,758	0,734	0,715	0,782	0,692	0,666	0,611	0,911	0,953	0,899	0,872
B	0,121	0,310	0,176	0,293	0,076	0,277	0,113	0,271	0,105	0,315	0,101	0,328

* Note: H – reliability of the test, B – validity of the text T – the traditional way, A – using the developed tool

The back muscle strength tester can use an optocoupler to record signals: an optoelectronic semiconductor device consisting of an emitter and a radiation receiver, between which there is an optical link and electrical insulation. In the electronic “circuit”, the optocoupler performs the function of a communication element, in which the electrical isolation of input and output is performed. At the same time, the unidirectionality of information flow through the channel is ensured, there is no feedback of the receiver to the signal. Optocoupler is characterized by physical and structural-technological compatibility with microelectronic devices (Wojcik, Vistak, Mykytyuk, Politskyi, Diskovskyi, Sushynskyi, Kremer, Prystay, Jaxylykova, Shedreyeva, 2020).

In the case of using an optocoupler in the developed device, the light reflector will be implemented on a rubber band in the form of alternating dark and light stripes. Data transmission in the control device is provided by wireless information transmission devices – Bluetooth.

The combination of the necessary analysis of the obtained control results with the visual form of presentation in the developed device is implemented by the software. The use of software allows simultaneous analysis of test results of a group of students without loss of information. The software includes recording and mathematical programs that quickly process the obtained control results using the methods of multidimensional mathematical analysis. At each current test time, only the required measurement elements are visible on the screen, other graphic objects are hidden. It also allows you to get a dynamic picture of the process, which significantly expands the informativeness of the test control.

Our development provides for automatic receipt of the results of multiple tests in the form of an electronic protocol. Numerous control data are written to files stored on disk, so it is available for further processing. Instant availability of information materials allows you to plan practical actions based on reliable information, therefore, you can significantly influence the improvement of organizational forms of physical education for students.

Thus, the unification and intensification of obtaining and processing control results is ensured. The software implements the accumulation, updating, adjustment and multifaceted use of a large array of information stored in a centralized database and automatic receipt of multiple test results in the form of an electronic protocol. The use of the developed device in the process of testing the strength of the back muscles provides simplification and automation of control procedures, accuracy and efficiency of testing, consisting of information retrieval time (usually up to 60 s), review time and analysis of results. Long-term observation throughout the period of physical education of students involves updating the results of control and storing them in a database in the format of hypertext arrays, which ensures the formation of information space at a qualitatively new level.

For the practical substantiation of the developed device for control of back muscle strength, correlation analysis has empirically investigated the degree of authenticity of tests used to control back muscle strength. To do this, the results of testing students of research groups, which were used as a retest, in three exercises to determine the strength of the back muscles: flexion of the torso, stretching of the torso, and posture. The test results were recorded traditionally and using the developed device (Tab. 1).

According to the results of the reliability of the tests of back muscle strength control tests, the results of which were recorded using a dynamometer is between low and medium, which is considered acceptable. The coefficient of validity in numerical values corresponds to the limits of low and medium. The recording of the back muscle strength test with the developed device ensured the achievement of a high level of test authenticity.

The developed device for testing the strength of the back muscles is characterized by ease of use and compact size of the device, and its use ensures the absence of human influence on the results of control.

Discussion

Ensuring the quality of physical education of university students is due to a number of factors, in the list of which control plays an important role. Control in physical education is positioned as an important component of managing the process of physical training (Khudolii, Iermakov, & Ananchenko, 2015). Management provides analysis of test results, which is the basis of operational corrective decisions. The tool in this case is the possibility of implementing operational control (De Oliveira, Arrebola, De Oliveira, & Liu, 2021). Our research is consistent with the information on the need to ensure the possibility of obtaining objective results as a basis for adjusting physical education plans for students (Ivashchenko, & Khudolii, 2016; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020; Chernenko, Muszkiet, Dolynnyi, Oliynyk, & Honcharenko, 2022).

The study integrates scientific ideas that progress in the field of knowledge of the theory and methods of physical education, increasing the importance of the scientific component, and requires the development of automated control using the potential of ICT (Kok, Komen, van Cappelleveen, & Van der Kamp, 2020; Zanevskyy, & Labartkava, 2020). The implementation of information processes of collecting, accumulating, storing, transmitting, processing and presenting (displaying) information of test control of back muscle strength in physical education of students using ICT ensures the effectiveness of the control process, which is consistent with the ideas presented in existing research (Chow, Chung, Ma, Macfarlane, & Shirley, 2017; Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021).

Informatization of the control of physical education of university students presupposes the transition to a qualita-

tively new level of its efficiency (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Blavt, Vanivska, & Stadnyk, 2020). At the heart of this direction is a technological approach to the implementation of test control, aimed at ensuring its high efficiency, which integrates existing scientific ideas in this direction. This approach makes it possible to systematize the direction of research in this field of knowledge in order to obtain objective and comprehensive information for the effective implementation of management functions in the process of physical training (Alfrey, & Gard, 2014; Estivalet & Springer, 2009).

The obtained scientific results are represented in the software's complex information and communication support. In this way, there is a unification and intensification of obtaining and processing test results, which generally reorganizes the procedure of control of students' strength abilities and increases the level of information support.

We support scientific ideas on the introduction and use of modern ICT in the process of control of physical education to ensure the reliability and efficiency of this process. In turn, it is possible to implement forecasting, design individual components of classes and evaluate the effectiveness of the process of physical education for students while studying at the university (Anikieiev, 2015; Koryahin, Blavt, Vanivska, & Stadnyk, 2020).

Determining the reliability of tests used to control back muscle strength confirms the data (Edwards, 2010; Vanhelst, Beghin, Fardy, Ulmer, & Czaplicki, 2016) that tests measured by mechanical dynamometers are quite unreliable. It is confirmed (Koryahin, & Blavt, 2019; Magill, & Anderson, 2017), that the level of reliability of the test is not an absolute indicator and depends on the method of obtaining test results. Thus, there is a change in the degree of reliability of the tests depending on how the results are recorded.

The obtained results expand and supplement the information on the possibilities of modernization of physical education of students on the basis of integration of the latest ICT to ensure the implementation of this process at the modern scientific level as a factor of its effectiveness in terms of health (Kok, Komen, van Capelleveen, & J. van der Kamp, 2020; Koryahin, Iedynak, Blavt, Galamandjuk, Prozar, Zai-kin, Veselovska, Golub, Kucher, & Gurtova, 2019). The new scientific results presented in the work are aimed at reorganizing the procedures of control of physical education of students and increasing the level of its information support, which meets modern standards. Adaptation of teachers and students to the information society allows for a new type of educational service.

Conclusions

According to the results of the study, a new approach to the implementation of the procedure of testing the strength of the back muscles in physical education of students using the potential of modernization and strengthening the processes of informatization in physical education of students based on ICT. The developed device of registration of test results is scientifically substantiated and represented.

The novelty and practical significance of the ICT-based back muscle strength testing device lies in the ability to ensure the efficiency and high efficiency of the procedure of monitoring the strength abilities of students, the result of

which is the prompt receipt of reliable measurement data. In case of their inconsistency, the necessary decisions are made and adjustments are made to the process of physical training.

The paper presents a new approach to solving the problem of improving the effectiveness of control in physical education of students, which meets modern standards. The use of an ICT-based back muscle strength monitoring device has been experimentally substantiated. In the obtained values of the degree of authenticity of the tests there is a change in the degree depending on the method of recording the results. Based on the results obtained, we can conclude that the reliability of the same test depends on the method of recording the results.

The result of scientific research aimed at solving the problematic aspects of test control was to ensure the appropriate degree of authenticity of tests used to control back muscle strength. Developed software complex automated control and evaluation of back muscle strength parameters, unifies and intensifies the receipt and processing of test results. All this provides modernization of the control process in the physical education of students and is a significant contribution to its implementation at the modern scientific level.

Conflict of interest

The authors state no conflict of interest.

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ІНТЕСТИФІКАЦІЯ ТЕСТОВОГО КОНТРОЛЮ СИЛИ М'ЯЗІВ СПИНИ У ФІЗИЧНОМУ ВИХОВАНІ СТУДЕНТІВ НА ОСНОВІ ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ

Зіновій Микитюк^{1ABE}, Оксана Блавт^{1BCD}, Ярослав Гнатчук^{2ABE},
Олег Стечкевич^{1ADE}, Тетяна Гельжинська^{1BCE}

¹Національний університет "Львівська політехніка"

²Хмельницький національний університет

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

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

Мета дослідження полягала у експериментальному обґрунтуванні та упровадженні інформаційно-комунікаційних технологій у тестовий контроль сили м'язів спини в процесі фізичного виховання студентів.

Матеріали та методи. Для вирішення завдань дослідження використовувалися загальнонаукові методи: аналіз, синтез, узагальнення, індукція та систематизація, технічне моделювання, педагогічний експеримент, педагогічне тестування, математичні методи. У дослідженні взяли участь 240 студентів, їх вік на початок дослідження становив 17-18 років.

Результати. Розроблено та апробовано електронний пристрій для визначення сили м'язів спини, показання якого дозволяють отримати чітку поточну інформацію на панелі персонального комп'ютера. Пристрій побудований на поєднанні сучасних електронних технологій і програмного забезпечення. Для експериментального обґрунтування розробленого пристрою для контролю сили м'язів спини кореляційним аналізом емпірично досліджено ступінь

достовірності тестів, що використовуються для контролю сили м'язів спини. За результатами дослідження автентичність тестів контролю сили м'язів спини, результати яких реєструвалися за допомогою динамометра, знаходиться між низьким та середнім рівнем. Реєстрацією результатів контролю сили м'язів спини за допомогою розробленого пристрою забезпечили досягнення високого рівня достовірності тестів.

Висновки. Результатом наукових досліджень, спрямованих на вирішення проблемних аспектів тестового контролю, стало забезпечення належного ступеня достовірності тестів, що використовуються для контролю сили м'язів спини у фізичному вихованні студентів. Реєстрація результатів тестових вправ з використанням презентованого приладу забезпечує досягнення високого рівня достовірності тесту.

Ключові слова: тестування, контроль, фізичне виховання, студент, сила м'язів спини, пристрій, інформаційно-комунікаційні технології.

Information about the authors:

Oksana Blavt: oksanablavt@ukr.net; <https://orcid.org/0000-0001-5526-9339>; Department of Physical Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine

Zinoviy Mykytyuk: zm.mykytiuk@gmail.com; <https://orcid.org/0000-0002-1944-2015>; Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

Yaroslav Hnatchuk: swim.k.ua@gmail.com; <https://orcid.org/0000-0001-9819-5069>; Department of Theory and Methods of Physical Education and Sports, Khmelnytskyi National University, Instytuts'ka St, 11 Khmelnytskyi, 29016, Ukraine.

Oleh Stechkevych: Oleh.Stechkevych@lpnu.ua; <https://orcid.org/0000-0002-2194-8787>; Department of Pedagogy and Innovative Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

Tetiana Helzhynska: Tetiana.helzhynska@lpnu.ua; <https://orcid.org/0000-0003-3280-5199>; Department of Pedagogy and Innovative Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF WEARABLE RESISTANCE LOADING DURING WARM-UP PROTOCOL ON FRONT KICK BIOMECHANICS IN TAEKWONDO

Tuan Muhammad Shafiq Tuan Ibrahim^{1ABCD}, Kevin Tan^{2ABCD},
Nor Fazila Abd Malek^{1ABCD}, Ahmad Aqil Mohamad Jahizi^{1AB},
Nur Ikhwan Mohamad^{1ACD}, Zulezwan Ab Malik^{1ACD} and Ali Md Nadzalan^{1ABCDE}

¹Sultan Idris Education University

²Management and Science University

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

Corresponding Author: Ali Md Nadzalan, E-mail: ali.nadzalan@fsskj.upsi.edu.my

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Abstract

Research purpose. This study aims to examine and determine the effect of wearable resistance loading during warm-up protocol on front kick movement mechanics and muscle activation.

Materials and methods. Twenty-five ($N = 25$, height = 174.00 ± 4.76 cm, weight = 75.93 ± 13.64 kg, age = 22.57 ± 1.36 years) male university taekwondo athletes were recruited as participants of the study. Wearable resistance with loading of 0%, 5% and 10% of the athletes' body mass were attached to participants' thigh and shank. Kinematics, kinetics and muscle activation during front kick were assessed.

Results. Overall, the results showed that there were no significant differences found between different WR loading in kinematics, kinetics and muscle activation during front kick movement. The results reflected that there were no detrimental effects of wearing wearable resistance during warm-up sessions. The findings are somewhat surprising as it was hypothesized that WR loading would produce effects on the mechanics of kicking and muscle activation. Wearable resistance did not increase kicking performance which was reflected by kicking velocity. This might be due to percentage of loading used which are seen as not reducing the performance, which reflects that the wearable resistance can be used during warm-up in training sessions as an add-on to resistance training.

Conclusions. We suggest that future studies should examine the chronic effects of wearable resistance as specific tools to be used in enhancing the performance of taekwondo kicks.

Keywords: training, kinematic, kinetic, muscle activation, performance.

Introduction

Taekwondo is a martial art that focuses on empty-hand combat, concentrating on striking with the use of hand and leg techniques. Leg techniques such as roundhouse kicks, axe kicks, back kicks, and other advanced kick that involves leap action and rotation while executing kicks are commonly used in competition. Since the 1950s, the techniques have been modified and varied technically and strategically by old masters in the Korean army (Gillis, 2016). As a result, kicking techniques account for 98% of match points (Kazemi et al., 2013).

The athlete's ability to execute an excellent kick is measured by the velocity and kicking force. Meanwhile, the ability to execute powerful and fast kicks will give the opponent less time to counterattack and the need to admit the lost point scored.

Numerous studies had been conducted in Taekwondo such as kicking speed and time of movement (Estevan et al., 2016; Estevan et al., 2011), kinematic and kinetic (Mailapalli et al., 2015; Qian et al., 2010; Yu et al., 2012), tactical and technical (Casolino et al., 2012) and impact forces toward the participants whose has different background expertise (O'Sullivan et al., 2009). Therefore, based on the previous study, kicking capability can influence the match outcome. Thus, it becomes apparent that kicking variables need to be focused on during taekwondo training.

Warm-up is one of the most important routines that should be included in an athlete's training regime to achieve maximum potential during training. Warming up is a pre-

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workout practice that raises body temperature, improves blood circulation, and prepares the body for heavy load training (Erkut et al., 2017). In addition, a warm-up protocol can help athletes or individuals avoid injury and muscular soreness during training sessions (Çilli et al., 2014).

A dynamic warm-up is a warm-up method practiced by various types of sports. Previous findings showed dynamic stretching improves muscle locomotion, increases power generation, and effectively stimulates nerve-muscle communication (Burkett et al., 2005; Faigenbaum et al., 2006; Gelen, 2010; Thacker et al., 2004; Thompson et al., 2007). Besides, the dynamic warm-up also was shown to boost force, strength, response time, and flexibility (McMillian et al., 2006).

The use of wearable resistance devices during the Taekwondo pre-training program is thought to reduce the time needed to warm up for the next high-intensity training session or upcoming match in a specific protocol, as athletes can perform warm-up activities with load affixed to the targeted muscle location. Due to its contribution to the specific movement in sports, the load proportion on the targeted muscle is still within the research range (Bustos et al., 2020; Faigenbaum et al., 2006). Currently, little to no study has been done on determining and comparing the various load effects of wearable resistance intensities during warm-up protocol toward kicking biomechanics in Taekwondo. As a result, this research will add to the body of knowledge and literature about the influence of various wearable resistance intensities on taekwondo kicks during warm-up procedures.

The aims of this study are to examine, determine and compare the acute effect of wearable resistance loading (0% of body mass, 5% of body mass and 10% of body mass) applied during warm-up sessions on kinematics (maximum kick height, peak time, kicking velocity, kicking angle and displacement), kinetic (ground reaction force) and muscle activations (bicep femoris, gluteus maximus, gastrocnemius medial head, rectus abdominis and vastus lateralis) during front kick in Taekwondo. We hypothesized that there will be changes and significant differences of front kick movement mechanics and muscle activation as a result of different WR loading worn during warm-up protocols.

Materials and methods

Study participants

Twenty-five ($n = 25$) male taekwondo elite athletes voluntarily participated in this study. All of them hold a black belt in taekwondo and were currently competing in a national-level competition in taekwondo. All participants were screened to ensure that they are injury-free. Despite these requirements, it was discovered that the participants had no prior experience with WR thus familiarisation session is compulsory. All the participants were required to fill in the Physical Activity Readiness Questionnaire and informed consent. All the participants were told that they could withdraw from the study at any time. This study has been approved by the UPSI Human Research Ethics Committee [Code: UPSI/PPPI/PYK/ETIKA(M)/014(163)].

Study organization

Participants need to attend four sessions. Briefing and familiarisation were done during the first session. There was

a 72-hour gap between sessions. Taking into account the participants' preparation and the actual testing of the protocols, each session lasted around 30 minutes to an hour.

Participants were brief about the study, personal rights to withdraw and a pre-exercise questionnaire screening was also given. The session followed with an introduction of all testing apparatus that would be used. Participants are then asked to sign the consent letter. The equipment familiarisation session was crucial because none of the participants had previously used WR in their training.

During the second, third and fourth sessions, participants wore the WR with 0, 5 and 10% of their body mass during the warm-up session in a randomized order to avoid order effects. After performing kicking drills while wearing WR as a warm-up routine, the WR was removed from their body and their movements were recorded. The kicking drills included 10 minutes of various kicking movements. The loading was attached to the participants' lower limb at the targeted muscles which is the thigh and shank.

Data analysis

The kinematic data were recorded using multiple high-speed cameras (Vicon T10s). Reflective markers were placed on the participant's second metatarsals, lateral malleolus, calcaneus, lateral shank, lateral femoral epicondyle, lateral thigh, and anterior superior iliac spine on the right and left lateral side of the body using the plugin-gate marker set model. Vicon Nexus software then was used to analyse the kinematics data acquired. The kicking kinematic model includes the hip, thigh, shank, and ankle. Kicking height, peak time, kicking angle, displacement and kicking velocity were analyzed.

The electromyography (EMG) signals were converted from analog to digital, which was set at 1000Hz. The EMG data were analysed using EMG workstation software.

Raw data from the force platform was filtered using six channels of signal commercial conditioner (Gen5, AMTI, Watertown, USA) and the final data were processed by using netforce software (Netforce, AMTI, Watertown, USA) in Microsoft Excel file format (Microsoft Excel, Microsoft, Washington, USA) for further analysis.

Statistical analysis

Mean and standard deviations were used to represent the centrality and spread of the data for all biomechanical data measured. One-way repeated measure analysis of variances (ANOVA) was used to determine if significant differences existed across different load percentages. An alpha level of 0.05 was set to assess statistical significance for all tests.

Results

Table 1 showed the demographic background of participants involved in this study.

Table 1. Characteristics of subjects

Variables	Mean $\pm$ Age
Age (years old)	22.57 $\pm$ 1.36
Height (m)	1.72 $\pm$ 0.14
Body mass (kg)	75.93 $\pm$ 13.64

Table 2. Kinematics, kinetics and Muscle activation data for 0, 5 and 10 % WR

	Parameters	WR0	WR5	WR10	F value	Sig.
Kinematics	Maximum kicking height (m)	1.71 ± 0.15	1.69 ± 0.12	1.70 ± 0.13	0.25	0.78
	Kicking velocity (m/s)	5.13 ± 0.95	4.88 ± 1.03	5.18 ± 0.96	1.14	0.33
	Kicking angle (°)	112.84 ± 13.63	115.16 ± 13.41	114.16 ± 11.74	0.64	0.53
	Displacement (m)	2.17 ± 0.11	2.16 ± 0.09	2.17 ± 0.10	0.55	0.54
Kinetic	Ground reaction force (N)	955.10 ± 169.77	955.24 ± 169.68	950.91 ± 173.57	0.25	0.78
Muscle activations	Bicep femoris (% MVC)	13.48 ± 5.26	13.63 ± 6.85	13.74 ± 5.98	3.28	0.06
	Gluteus maximus (% MVC)	14.66 ± 8.50	13.55 ± 7.68	13.96 ± 7.84	2.19	0.15
	Gastrocnemius (% MVC)	17.74 ± 10.75	17.92 ± 9.13	18.55 ± 9.63	0.20	0.82
	Rectus abdominis (% MVC)	19.41 ± 6.49	19.84 ± 7.25	18.67 ± 7.67	0.69	0.47
	Vastus lateralis (% MVC)	21.05 ± 11.84	22.15 ± 11.70	20.68 ± 10.84	2.52	0.09

* Significant difference ($p < 0.05$)

The mean and standard deviation of kinematics, kinetics, and muscle activations data were shown in Table 2. No significant interaction was found for all the variables tested.

Discussion

The purpose of this study was to compare the acute effects of wearable resistance loading used during a warm-up session in taekwondo front kick where data of kinematic, kinetic, and muscle activities were compared between selected loads of WR (0%, 5%, and 10% of body mass) attached on the lower extremities. The analysis of kicking height, kicking velocity, kicking angle, displacement, ground reaction force (GRF), and muscle activities of BF, GM, G, RA, and VL were acquired from the data.

Looking at the kinematic data, no significant differences were found comparing all the loading conditions used during warm-up. Thus our hypothesis was rejected. We assume that there will be changes to the kinematic data, especially in the kicking velocity and maximum kicking height due to the warm-up protocols using loads. However, both these performance indicators were found not to be changed. Besides, kicking angle and displacement also were found not to be changed, thus demonstrating the wearable resistance can be used during warm-up as it did not change the movement mechanics related to performance. In terms of specific data during the kicks, we found that the kick velocity of the participants is less than what has been found by (Wąsik et al., 2018). The differences might be contributed by the factors of participants recruited. Wąsik et al. (2018) recruited elite level athletes while we in this study only recruit university level athletes.

Although there is no significant difference detected between all the WR tested, kinematics analysis demonstrated that kicking height is 1.16% lower when the front kick is executed with 5% load, and 0.58% lower with 10% load WR when compared to no WR implementation. Kicking velocity also showed that it is faster by 4.87% when executed with 0% load WR and 5.79% faster when executed with 10% load WR when compared to 5% load used. The kicking angle showed

that the angle is larger by 2.01% and 1.15% when executed with 5% load WR and 10% load WR respectively compared to 0% load WR. Displacement of kicking on the other hand showed an increase of 0.46% when executed with 0% load WR and 10% load WR when compared to 5% load WR.

WR application during the warm-up session will alter segment inertial properties and as such can be considered an organismic constraint (Field et al., 2019; Martin & Cavanagh, 1990). A prolonged adaptation toward the application of WR in training especially during the warm-up session would ultimately be a useful stimulus to develop and train an adapted movement behavior among athletes in preparation for changing real-life situations during match games which could be an advantage in terms of performance deliverance later on.

As found in the kinematic data, the ground reaction force that is the indicator of kinetic in this study was also found not to be changed. The ground reaction force in this study refers to the supporting legs that step on the force plate. The results, it shows that the supporting leg did not have any effects with the use of wearable resistance during warm-up. The supporting leg really does play role in determining kicking performance as what was found by (Chinnasee et al., 2018) who found the greater kick was produced by more force production by the supporting leg. Thus, the analysis of the supporting leg is also important in a study like this (Prajongjai et al., 2019).

Muscle activation data were collected to look at the muscle contraction during the kicks as the result of warming up with wearable resistance. The finding is somewhat surprising, that there were no significant changes occurred to the muscle activation even though they wore wearable resistance during warm-up. This showed that the muscles were able to overcome the loading used during the warm-up and not become tired to reduce muscle activation.

Muscle activation is a piece of vital information in determining which muscle contributes the most during kicking in taekwondo (Ervilha et al., 2020). The findings revealed a substantial difference between loads for the front kick. Although there is no significant difference to the muscle ac-

tivities when different WR load is applied during the warm-up session, there is a slight difference in terms of muscle activities when different WR load is applied. It can be seen that gluteus maximus activate the most when no WR load is applied compared to when there is WR load applied during warm-up session. This showed that when there is no load, there is less fatigue and typically the velocity of kicking would be faster and gluteus maximus is the muscle that are responsible to stabilize the whole movement of kicking which originated from the movement of quadriceps. Since the movement is light and faster, the gluteus maximus need to work more in order to stabilize the kicking movement.

Based on this finding, it can be noted that different WR load actually affect different type of leg muscles. The percentage involvement of muscle seems to be different when the WR load is getting heavier. As such, this could be a good indicator for coaches to determine which type of load effect different type of leg muscles independently.

The objective for development of WR technology has been to allow a relevant load to be applied directly to the body that will then directly stress specific movements under the specific demands of an actual sport and competitive environment, with little compromise to the speed of motion, range of motion and specific skill (Dolcetti et al., 2019). Nowhere is this more important than in the realm of speed and agility training where even slight modifications in these parameters greatly reduce improvement in actual competition. The application of WR in the movement of kicking like in this study is significantly important to deliver an optimum training mechanism which could then transfer to competition.

Coaches and athletes could benefit from a good warm-up session with the implementation of WR to optimize their warm-up session. This is generally important because warm-up is an important session before a workout session. This is to avoid injury during training sessions, especially in a burst activity like taekwondo. Further research could be done on the different percentages of WR implementation to add to the library of knowledge upon an optimum WR loading to be used in warm-up sessions. The physiological effect such as the heart rate, lactate level, and also any biomarkers that could indicate importance before starting an activity could be measured to see the effect of WR effectively as stimulation during warm-up.

Conclusions

The wearable resistance with 5% and 10% loads appear to be the suitable weight used during warm-up protocols without disrupting the whole movement of kicking and causing a significant decrease in all the kinematic and kinetic variables that is important during a kicking movement execution.

Future research should focus on long-term or chronic effects, as this will allow researchers to see how long the wearable resistance effect lasts on athletes. Furthermore, the study should take into account the 3D design because each WR placement will create a different outcome and more loading will be able to attach to the body segment as well to cover the important joint while exploring the biomechanical characteristics of the specific skills. Wearable resistance could be used by coaches and athletes as one of the choices

since it allows athletes to lift weights while performing movements that are unique to the tournament's skills without jeopardizing the mechanics of movement.

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Conflict of interest

The authors state no conflict of interest.

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ВПЛИВ НАВАНТАЖЕННЯ НАТІЛЬНИМИ ОБВАЖНЮВАЧАМИ ПІД ЧАС ВИКОНАННЯ ПРОТОКОЛУ РОЗМИНКИ НА БІОМЕХАНІКУ ПРЯМОГО УДАРУ НОГОЮ В ТХЕКВОНДО

Туан Мухаммад Шафік Туан Ібрагім^{1ABCD}, Кевін Тан^{2ABCD}, Нор Фазіла Абд Малек^{1ABCD}, Ахмад Акіль Мохаммад Джахізі^{1AB}, Нур Іхван Мохаммад^{1ACD}, Зулезван Аб Малік^{1ACD}, Алі Надзалан^{1ABCDE}

¹Університет освіти Султана Ідріса

²Університет менеджменту та науки

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Реферат. Стаття: 7 с., 2 табл., 1 рис., 25 джерел.

Мета дослідження. Це дослідження має на меті вивчення та визначення впливу навантаження натільними обважнювачами під час виконання протоколу розминки на механіку руху прямого удару ногою та активацію м'язів.

Матеріали та методи. У дослідженні брали участь двадцять п'ять університетських спортсменів чоловічої

статі (N = 25, зріст = $174,00 \pm 4,76$ см, маса = $75,93 \pm 13,64$ кг, вік = $22,57 \pm 1,36$ року), які займаються тхеквондо. До стегон і гомілок учасників були прикріплені натільні обважнювачі з навантаженням 0%, 5% та 10% маси тіла спортсменів. Оцінювали кінематику, кінетику та активацію м'язів під час виконання прямого удару ногою.

Результати. Загалом результати показали відсутність значних відмінностей між різними навантаженнями натільними обважнювачами в показниках кінематики, кінетики та активації м'язів під час виконання руху прямого удару ногою. Результати також показали відсутність шкідливого впливу внаслідок носіння натільних обважнювачів під час занять розминкою. Результати є дещо несподіваними, оскільки було висунуто гіпотезу, що застосування обважнювачів впливатиме на механіку удару ногою та активацію м'язів. Натільні обважнювачі не підвищили показник виконання удару ногою, якому відповідає швидкість удару ногою. Це, можливо, зумовлено використовуваними

відсотковими частками навантаження, які вважаються такими, що не знижують показник виконання, що показує, що ці натільні обважнювачі можна використовувати під час розминки на тренувальних заняттях як доповнення до тренувань з обтяженнями.

Висновки. Ми рекомендуємо в майбутніх дослідженнях вивчити хронічні ефекти натільних обважнювачів як спеціальних засобів, які використовуватимуть для покращення показників виконання ударів ногою в тхеквондо.

Ключові слова: тренування, кінематика, кінетика, активація м'язів, показники виконання.

Information about the authors:

Tuan Muhammad Shafiq Tuan, Ibrahim: kingzaaron@gmail.com; <https://orcid.org/0000-0001-5235-6824>; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, 35900, Tg Malim, Perak, Malaysia.

Kevin, Tan: kevin13@live.com.my; <https://orcid.org/0000-0003-3676-5614>; Faculty of Health and Life Sciences; Management & Science University, University Drive, Off Persiaran Olahraga, 40100 Shah Alam, Selangor, Malaysia.

Nor Fazila Abd, Malek: fazipanthera@gmail.com; <https://orcid.org/0000-0001-8998-228X>; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, 35900, Tg Malim, Perak, Malaysia.

Ahmad Aqil Mohamad, Jahizi: aqilmohamadjahizi@gmail.com; <https://orcid.org/0000-0001-6135-9904>; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, 35900, Tg Malim, Perak, Malaysia.

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

Zulezwan, Ab Malik: zulezwan@fsskj.upsi.edu.my; <https://orcid.org/0000-0002-7817-0574>; Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, 35900, Tg Malim, Perak, Malaysia.

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

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ORIGINAL SCIENTIFIC ARTICLE

EFFECTIVENESS OF TELEREHABILITATION ON HAMSTRING FLEXIBILITY IN HEALTHY ADULTS

Hazal Genç^{1,2ACD}, Tuğçe Poyraz İşleyen^{2BC}, Tuğçe Tahmaz^{2BD},
Yeldağ Aydoğan^{2AB} and Esra Atilgan^{1BD}

¹Istanbul Medipol University

²Bahçeşehir University

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

Corresponding Author: Hazal, Genç, E-mail: hazaloksuz@gmail.com

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Abstract

Background. Telerehabilitation used as an exercise method has become increasingly common in recent years. Various methods have been used to increase hamstring flexibility, but more research is required on the optimal program.

The study purpose was to investigate the effect of hamstring stretching exercises given as telerehabilitation and home exercise program on hamstring flexibility.

Materials and methods. Sixty-eight healthy adults were randomly assigned to two groups, namely telerehabilitation and home exercise. Exercises were performed for 8 weeks (4 sessions/week) in both groups. Active and passive range of motion (ROM), sit and reach test (SRT), and International Physical Activity Questionnaire Short Form (IPAQ-SF) were conducted in the pre- and post-intervention and after a 6-month period.

Results. At the end of 8 weeks, a significant improvement was observed in the SRT scores in both the telerehabilitation group ($p = 0.001$) and the home exercise group ($p = 0.001$). In addition, significant improvements were observed in the passive ROM measurements of both the telerehabilitation group ($p = 0.005$) and the home exercise group ($p = 0.001$). At the end of 8 weeks, the telerehabilitation group was found to be significantly superior to the home exercise group in the SRT results ($p = 0.034$). As for the long-term results, significant improvement was maintained in both SRT ($p = 0.001$) and passive ROM ($p = 0.014$) in the telerehabilitation group.

Conclusions. Eight-week telerehabilitation and home exercise program was observed to have positive effects on passive and active ROM. The telerehabilitation method may prove to be more effective than the home exercise method in the long term.

Keywords: exercise, hamstring muscle, telerehabilitation, muscle stretching, flexibility.

Introduction

Adequate extensibility of the hamstring muscle is known to be an important factor in the efficiency and quality of basic activities such as walking and running. Physical inactivity leads to a decrease in muscle-tendon flexibility, especially in the hamstring muscles (De Oliveira et al., 2018).

It has been shown that decreased hamstring flexibility can cause muscle imbalances, muscle injuries, musculoskeletal disorders such as patellar tendinopathy and patellofemoral pain (Medeiros et al., 2016).

Stretching exercises consist of three interventions, namely, static, dynamic, and ballistic stretching, and both static and dynamic stretching help to increase range of motion (ROM) and flexibility (Lempke et al., 2018). Static stretching usually involves moving a limb to the end of its ROM (Matsuo et al., 2019). Dynamic stretching is a movement-based method of stretching (Opplertid et al., 2020; Demoulin et al., 2016).

Stretching exercises have acute effects through viscoelastic change and chronic effects through the myogenic response of sarcomeres (Shamsi et al., 2020). Hamstring stretching exercises improve hip joint ROM, increase dynamic balance ability, and reduce the risk of injury by enabling the development of functional skills for sports (O'Sullivan et al., 2009; Martin et al., 2022).

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Lockdown imposed to prevent the spread of the disease during the COVID-19 pandemic has increased the need for telerehabilitation methods (Hamadi et al., 2022). It has been observed that the use of telerehabilitation can promote standardization, improve patient compliance with exercise programs and reduce costs (Syamsul Taufik et. al., 2021; Middleton et al., 2020).

To our knowledge, there is no study examining the long-term results of hamstring flexibility exercises applied through telerehabilitation. Our aim is to use two different exercise approaches to increase hamstring flexibility and to examine the short- and long-term effectiveness of these approaches. Our hypothesis is that the telerehabilitation method is more effective than the home exercise method in increasing hamstring flexibility, and that the short-term effects of the exercise programs may be maintained in the long-term. For this purpose, both groups performed static and dynamic stretching exercises for 8 weeks, but the first group did so through telerehabilitation, and the second group through home exercise program. Whether they achieved superiority over one another was assessed at the end of the 8th week and 6th month.

Materials and methods

Study participants

University students with 18-25 years of age and hamstring shortness were included in our study. The criteria for inclusion in the study were: having active hip flexion ROM between 0-80 degrees and being able to speak and understand Turkish language. The criteria for exclusion from the study were: being a professional athlete, having orthopedic or neurological problems, and having undergone lower extremity musculoskeletal surgery. All participants read and signed the informed consent form before participating in the study.

Having met the criteria for inclusion, 68 participants were randomly divided into 2 groups of 34 individuals. Exercises were applied with telerehabilitation in the first group ($n = 34$), and home exercise program in the second group ($n = 34$) (Figure 1).

Study organization

This study was conducted between August 2021 and February 2022 in accordance with the Declaration of Helsinki, which provides ethical principles for medical research involving humans. Ethical approval was obtained from Istanbul Medipol University Non-Invasive Clinical Research Ethics Committee (E-10840098-772.02-2899). Clinical trials registration number: NCT05083533.

The study lasted for 8 weeks. The participants were evaluated before the start of the study. Then, the participants were randomly divided into two groups by means of a computer program. Assessment was repeated at the end of 8 weeks. Finally, the participants were re-evaluated at the end of 6 months.

Following the initial evaluations, the individuals were divided into 2 groups using a computer-assisted randomization table. This study was planned as a single-blind randomized controlled trial. The researchers who carried out the assessment measurements were blinded to all participants.

The sample size was calculated using the raosoft sample size calculator. The universe of our study consists of students

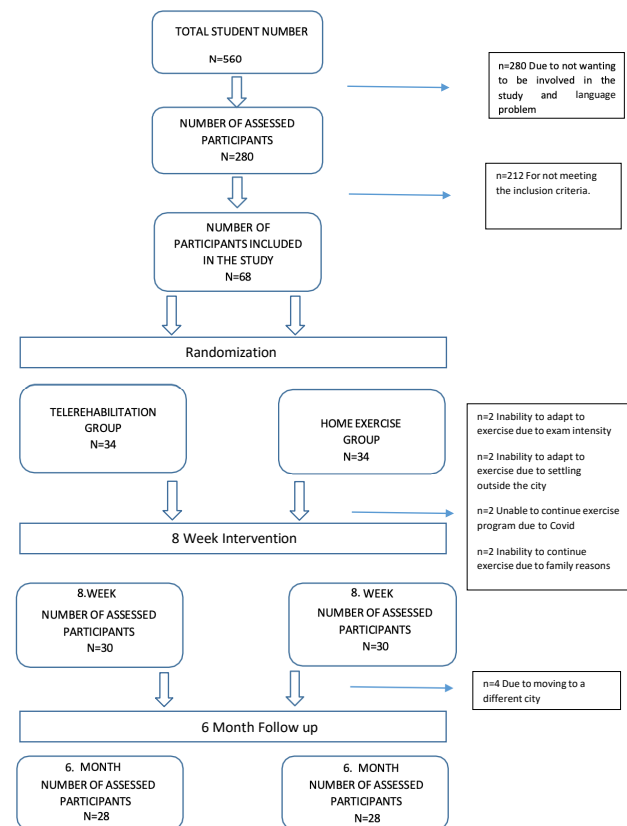


Figure 1. Flowchart of Participant Selection throughout the Study

of Bahçeşehir University Physiotherapy and Rehabilitation Department ($n = 280$). The sample size was calculated to be 55 with %10 error in the %90 confidence interval. After calculating the dropout rate as 20%, 68 individuals were included in the study.

Hamstring flexibility exercises were applied to the telerehabilitation group via an online communication program (Microsoft Teams program 1.5.00.8070). The participants completed the exercises in front of the camera and under the supervision of a physiotherapist. The exercise program continued 4 days a week for 8 weeks. In the first four weeks, 3 different dynamic and static hamstring stretching exercises were performed for 10 seconds and in 5 repetitions. These exercises were hamstring stretching exercises performed in the position of standing with the help of a chair, sitting and supine. In the last 4 weeks, 4 different dynamic and static stretching exercises were performed for 20 seconds and in 10 repetitions. These exercises were forward folding in straddle and with straight legs, and hamstring stretching exercises performed in the sitting and half-knee positions.

The participants in the second group were given a home exercise program that included the same protocol as the first group. The exercises were explained in a brochure containing written and visual information. The participants were interviewed by phone once a week. The home exercise program continued for 8 weeks.

Three different tests were implemented to assess hamstring shortness. The sit and reach test (SRT) was performed with a SRT box. The participants were asked to sit on a flat surface, place their hands on top of each other with their palms facing the ground, and move the indicator on the box

Table 1. Baseline characteristic data

Characteristics	All (n = 60) (Mean±SD)	Group 1-Telerehabilitation group (n = 30) (Mean±SD)	Group 2-Home exercise group (n = 30) (Mean±SD)	p
Age (yrs)	20.80 ± 1.59	20.60 ± 1.26	21.00 ± 1.85	0.33
BMI (kg/m ²)	23.18 ± 3.76	24.07 ± 3.16	22.29 ± 4.14	0.06
Gender (female)	33(55%)	10 (33.3%)	23 (76.7%)	0.44
Dominant side (right)	55 (91.6%)	27 (90.0%)	28 (93.3%)	1.0

The values are shown as mean ± SD. p < 0.05 was considered statistically significant. Age: years, BMI: body mass index (kg/m²)

to the furthest point they could without bending their knees. Measurements were repeated three times. The three measurement results were averaged and the result was recorded in centimeters (Ayala et al., 2012).

In the active straight leg raise test, while the participant was in the supine position, they actively raised the dominant-side lower extremity with their knee extended. In the meantime, care was taken not to flex the hip and knee on the non-dominant side. The degree of hip flexion on the dominant side was measured by the physiotherapist with the help of a goniometer. Goniometric measurement was repeated 3 times. The averages were taken and recorded in the participants' files.

In the passive straight leg raise test, while the participant was in the supine position, the physiotherapist passively lifted the dominant-side lower extremity with the knee extended. In the meantime, care was taken not to flex the non-dominant hip and knee.

The degree of hip flexion on the dominant side was measured with the help of a goniometer. Goniometric measurement was repeated 3 times. The averages were taken and recorded in the participants' files. All hamstring shortness measurements were performed at the beginning, and repeated at the 8th week and 6th month.

The level of physical activity was evaluated using the International Physical Activity Questionnaire Short Form (IPAQ-SF). The short form consists of 7 questions in to-

tal. The questionnaire provides information about the time spent walking, performing moderate and vigorous activities, and sitting. The measurement of all activities performed is based on the fact that each activity is carried out for at least 10 minutes at a time. According to the total physical activity score, the physical activity levels of the participants are defined as "low, moderate and high" (Saglam et al., 2010).

Statistical analysis

Descriptive statistics were presented as mean ± standard deviation (SD). Independent samples t-test, Paired t-test, Wilcoxon test and Mann Whitney U test were used for analysis. Pearson correlation coefficient was used to measure the correlation. All statistical analyzes were performed using SPSS for Windows, version 26.0 (SPSS Inc., Chicago, IL, USA). p value lower than 0.05 was considered statistically significant.

Results

A total of 280 participants were initially evaluated, and 68 participants meeting the inclusion criteria were included in the study. The 8th-week results of 60 participants and the long-term results of 56 participants were analyzed.

The dropout rate was the same in both groups (13%). The reasons for dropping out were the COVID-19 pandemic,

Table 2. Analysis of intra-group differences

	Group 1-Telerehabilitation group (n = 30)					Group 2-Home exercise group (n = 30)				
	Baseline (Mean ± SD)	8 th week (Mean ± SD)	P	6 th month (Mean ± SD)	P	Baseline (Mean ± SD)	8 th week (Mean ± SD)	P	6 th month (Mean ± SD)	P
Sit and reach test	16.29 ± 3.89	23.45 ± 7.25	0.001	24.25 ± 7.97	0.001	16.75 ± 5.02	20.87 ± 6.01	0.001	20.68 ± 6.21	0.001
Dominant side AROM	52.21 ± 1.52	66.35 ± 2.26	0.001	70.44 ± 2.72	0.162	53.96 ± 1.72	64.56 ± 2.48	0.001	68.89 ± 1.84	0.454
Dominant side PROM	57.45 ± 1.56	71.551724 ± 2.18	0.005	74.36 ± 2.99	0.014	57.20 ± 2.18	68.63 ± 2.86	0.001	72.95 ± 2.17	0.762
IPAQ-SF Total	4678.60 ± 317.76	4230.85 ± 360.55	0.657	3512.394 ± 368.56	0.02	497.15 ± 475.56	4596.06 ± 558.58	0.66	3788.74 ± 569.61	0.238
IPAQ-SF Low	290.02 ± 81.61	1065.45 ± 186.88	0.001	1040.33 ± 144.76	0.001	480.88 ± 130.13	1383.40 ± 329.93	0.319	1395.89 ± 258.2	0.388
IPAQ-SF Moderate	286.20 ± 104.95	380.01 ± 108.62	0.275	331.684729 ± 71.35	0.234	432.00 ± 193.71	561.71 ± 158.01	0.320	836.22 ± 312.48	0.538
IPAQ-SF High	806.53 ± 158.43	1163.14 ± 194.88	0.015	994.01 ± 200.79	0.27	912.73 ± 181.84	114.86 ± 235.53	0.170	874.67 ± 245.95	0.116

The values are shown as mean ± SD, p < 0.05 was considered statistically significant. Dominant side AROM: Dominant side active range of motion, Dominant side PROM: Dominant side passive range of motion, IPAQ: International Physical Activity Questionnaire

Table 3. Analysis of Intergroup Differences

	Group 1 - Difference between baseline-8 th week (Mean ± SD)	Group 2 - Difference between baseline-8 th week (Mean ± SD)	P	Group 1 - Difference between baseline-6 th month (Mean ± SD)	Group 2 - Difference between baseline-6 th month (Mean ± SD)	P
Sit and Reach Test	6.60 ± 4.71	4.03 ± 4.42	0.033	7.26 ± 8.33	3.83 ± 5.86	0.070
Dominant Side AROM	17.53 ± 14.96	14.90 ± 12.81	0.467	14.60 ± 9.72	11.86 ± 10.43	0.298
Dominant Side PROM	11.43 ± 9.55	15.70 ± 12.66	0.146	8.10 ± 17.26	12.44 ± 8.10	0.370
				12.44 ± 8.10	8.10 ± 17.26	
IPAQ SF Total	25.20 ± 257.23	43.93 ± 276.49	0.763	39.16 ± 206.28	-34.93 ± 149.08	0.295
IPAQ SF Low	153.36 ± 336.59	94.50 ± 280.94	0.368	134.83 ± 323.85	230.86 ± 334.38	0.426
IPAQ SF Moderate	366.75 ± 875.37	-114.36 ± 1191.41	0.088	109.60 ± 290.71	100.20 ± 317.08	0.905
IPAQ SF High	258.23 ± 1120.44	-38.13 ± 1460.63	0.169	786.86 ± 1228.50	442.66 ± 1050.0	0.116

The values are shown as mean ± SD, $p < 0.05$ was considered statistically significant. Dominant side AROM: Dominant side active range of motion, Dominant side PROM: Dominant side passive range of motion, IPAQ SF: International Physical Activity Questionnaire Short Form

moving to a different city, busy exam schedule and family-related ones. The long-term results of 76% of the participants in both groups could be analyzed.

There were 30 participants in the telerehabilitation group (mean age: 20.60 ± 1.26) and the home exercise group (mean age: 21.00 ± 1.85) each. There was no significant difference between the baseline values for mean age ($p = 0.33$), BMI ($p = 0.06$), female-to-male ratio ($p = 0.44$) and dominant side ($p = 1.0$). The characteristics of the participants are presented in Table 1.

The effects of the 8-week intervention on hamstring flexibility are given in Table 2. At the end of 8 weeks, significant improvement was observed in the SRT scores of both the telerehabilitation group ($p = 0.001$) and the home exercise group ($p = 0.001$). In addition, significant improvements were observed in active ROM ($p = 0.001$) and passive ROM ($p = 0.005$) in the telerehabilitation group, and those ($p = 0.001$) in the home exercise group.

The long-term results revealed that the improvements in both the SRT ($p = 0.00$) and passive ROM ($p = 0.014$) were maintained in the telerehabilitation group, while the improvement was maintained only in the SRT ($p = 0.001$) in the home exercise group. When the difference between the groups was analyzed, only the telerehabilitation group was found to be significantly superior in the 8th week results of the SRT ($p = 0.034$). No significant difference was observed between the groups in the other parameters.

No significant change was observed in the level of physical activity in the home exercise group. In the telerehabilitation group, a significant increase was observed in IPAQ-SF total score in the 6th month ($p = 0.028$), IPAQ-SF low score in both the 8th week ($p = 0.001$) and the 6th month ($p = 0.001$), and IPAQ-SF high score in the 8th week ($p = 0.015$). There was no significant difference in IPAQ-SF total score and its categories between the groups.

When all participants were evaluated, a high level of correlation was found between IPAQ-SF total score and active ROM of dominant hip ($r = 0.942$).

Discussion

In this randomized controlled trial, significant improvements were found in passive ROM of hip flexion after hamstring stretching in both the telerehabilitation group

($\Delta = 11.43$) and the home exercise group ($\Delta = 15.70$). There was a significant difference between the groups in favor of the telerehabilitation group only in the SRT. In addition, at the end of the 6-month period, significant improvement was observed in passive ROM of hip flexion only in the telerehabilitation group.

Studies have reported that adults with a sedentary lifestyle have less hamstring flexibility (De Oliveira et al., 2018). Cho et al. (2017) observed a significant relationship between physical activity level and hamstring flexibility. This finding agrees with previous report, our initial evaluation results showed that hamstring flexibility was low in individuals with low physical activity levels.

Different measurement methods are used to measure hamstring flexibility. The SRT is one of these methods. The literature suggests that the SRT should not be used as a cut-off value in the measurement of hamstring flexibility (Ayala et al., 2012). We used passive ROM of the dominant extremity as the cut-off value in the measurement of hamstring flexibility in the individuals included in our study. We included both tests to evaluate the efficacy of the treatment.

The duration of the hamstring stretching exercises varies. Ayala et al. (2010) examined the effect of 15-, 30- and 45-second active stretching exercises on the degree of hip flexion. An increase in hip flexion angle was observed after the treatment in our study. There was no statistically significant difference between the effectiveness of the exercises performed at different lengths. Takeuchi et al. (2020) investigated the effectiveness of 20-second static stretching exercise applied to the hamstring muscle in healthy individuals. The study showed that the hip joint ROM increased as a result of the 20-second stretching program, which is in line with our study.

In a review study examining the effects of stretching exercises, the immediate and chronic effects of stretching were found to be different from each other (Knudson, 2006). Similar to our study, the immediate effect of hamstring flexibility exercises was examined in the study, in which 46 physiotherapy students participated, and significant improvements were observed in the degree of passive hip flexion (Cini et al., 2017).

In some of the studies, four-week exercises were found to be sufficient for significant improvement, while in others they were not. Davis et al. (2005) did not observe any

increase in hamstring flexibility after 4 weeks of hamstring flexibility exercises. They stated that an exercise program lasting longer than 4 weeks might be required to increase the passive ROM of the hip. In the study LaRoche & Connolly (2006) conducted, an improvement was observed in functional capacity and muscle performance at the end of the 4-week hamstring flexibility exercise program, while no improvement was observed in muscle stiffness. We are of the opinion that although a 4-week period is effective in establishing regular exercise habits, it is not enough for an effective rehabilitation program.

According to studies on the stretching of different muscle groups, remarkable improvements were found thanks to 3 to 6 weeks of training in the ROM of the joint, and it was reported that the muscle was lengthened by 5-31% or 6 to 12 degrees (Knudson, 2006). There are hamstring flexibility exercise programs performed with different durations with healthy adults in the literature. However, there is no consensus on the optimal duration (Sainz de Baranda & Ayala, 2010). Chan et al. (2001) applied two stretching exercise programs lasting 4 and 8 weeks in their study on healthy adults. The study reported that the 8-week program was more effective on hip joint ROM and hamstring flexibility than the 4-week program. Ayala et al. (2013) reported an increase in passive hip flexion angle in individuals with and without hamstring shortness after a 12-week exercise program. We observed a significant improvement in hamstring flexibility with an 8-week exercise program in our study. To the best of our knowledge, there is no study in the literature examining the long-term effects in this population. Our study found that the effects of hamstring flexibility exercises in healthy individuals were maintained in the long term.

The effect of exercise position on flexibility response is also discussed in the literature. Investigating the effects of hamstring stretching positions on flexibility, Borman et al. (2011) reported that there was no difference between exercises performed while sitting and standing. Stretching exercises performed in both positions were included in the flexibility program in our study. We believe that exercises performed in different positions affect patient participation in the exercise positively.

Different types of stretching exercises can be used to increase hamstring flexibility (De Oliveira et al., 2018). In their study comparing the effectiveness of active and passive hamstring stretching exercises, Meroni et al. (2010) reported that active stretching is more efficient in terms of time use and requires less compliance in terms of performing the exercises. We speculate that the high effectiveness of the exercise program in our study may be because the exercises were planned to be performed actively.

Fasen et al. (2009) compared four different types of stretching, including static and dynamic stretching exercises, in their study in healthy adults. Following the 8-week exercise training, they reported that there was no difference between the effectiveness of different stretching types on flexibility. In our study, we implemented a combination of active static and active dynamic hamstring stretching exercises to increase the effectiveness of the exercise program.

Telerehabilitation applications are generally applied in neurological and orthopedic patient groups, for whom it is difficult to access the hospital (de Menezes et al., 2021; Lawford et al., 2018). The pandemic process has adversely

affected not only certain patient groups but also all populations in accessing health services. This has revealed that we need innovations in rehabilitation and exercise practices. Studies on young individuals, who can use new technology really well, are extremely insufficient (Hasani et al., 2021).

Exercise practices have been performed using different telerehabilitation methods in the literature. The use of mobile technology-based health interventions is encouraged, and the use of programs is supported to reach large populations economically (Mönninghoff et al., 2021; Stork et al., 2021). Videoconference-based exercise training can be considered a safe and effective way to maintain functional capacity (Kuldavletova et al., 2021). We observed a significant effect on flexibility by using the video conference method in our study.

The advantage of telerehabilitation and home exercise programs over one another is still debated. In their study, Özer et al. (2021) divided the patients diagnosed with non-specific neck pain into two groups as telerehabilitation and home exercise. After the four-week exercise program, significant improvements were observed in both groups. However, the groups did not have superiority over each other. In our study, in which we also applied telerehabilitation and home exercise, the only difference between the short- and long-term results was the evaluation of hamstring flexibility performed at the end of the 8th week. Dias et al. (2021) concluded in their review study that telerehabilitation and exercise practices could lead to clinical results similar to other interventions in improving pain, physical function and quality of life in the short and long term. Similarly, the clinical results of the home exercise group and of the telerehabilitation group were similar in our study.

Various studies also indicate that hamstring flexibility is related to physical activity level, muscle injuries and performance (Martin et al., 2022; Barbosa et al., 2020). However, due to individual characteristics such as age and muscle-tendon structure, there is no consensus on the optimal exercise program to increase hamstring flexibility in healthy adults (Medeiros et al., 2016).

Conclusions

The pre- and post-treatment measurements of the telerehabilitation and home exercise groups showed that the improvement in the results of hamstring flexibility was more significant in the former. The main reason for this difference could be the inability to perform a supervised exercise program in the home exercise group. Based on the data we obtained, we believe that hamstring stretching exercises performed through telerehabilitation can be used to increase flexibility, just like other methods. Our study has several limitations. The limitation of our study is that we conducted it with a healthy young population aged 18-25. The heterogeneity of physical activity levels is another limitation.

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Clinical trials registration number: NCT05083533.

Conflict of interest

The authors declare no conflict of interest.

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ВПЛИВ ТЕЛЕРЕАБІЛІТАЦІЇ НА ГНУЧКІСТЬ ПІДКОЛІННИХ М'ЯЗІВ СТЕГНА У ЗДОРОВИХ ДОРОСЛИХ

Хазал Генч^{1,2ACD}, Тугче Пойраз Ішлейєн^{2BC}, Тугче Тахмаз^{2BD},
Єлдаг Айдоган^{2AB}, Есра Атілган^{1BD}

¹Стамбульський університет Медіпол

²Університет Бахчешехір

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

Реферат. Стаття: 7 с., 3 табл., 1 рис., 37 джерел.

Базова проблематика. Телереабілітація, яку використовують як метод виконання вправ, набуває дедалі більшого поширення за останні роки. Для підвищення гнучкості підколінних м'язів стегна використовують різні методи, але пошук оптимальної програми потребує більших обсягів досліджень.

Метою дослідження було вивчення впливу на гнучкість підколінних м'язів стегна вправ на розтягування підколінних м'язів стегна, рекомендованих у рамках телереабілітації, і програми домашніх вправ.

Матеріали та методи. Шістдесят вісім здорових дорослих випадково розподілили на дві групи, а саме: група теле-

реабілітації та група домашніх вправ. В обох групах вправи виконували протягом 8 тижнів (4 заняття/тиждень). У період безпосередньо до та після втручання, а також через 6 місяців після втручання проводили вимірювання активної та пасивної амплітуди руху (ROM), вимірювання гнучкості під час тесту на згинання тулуба вперед сидячи на підлозі з випрямленими вперед руками (Sit and Reach Test, SRT), а також вимірювання рівнів фізичної активності учасників на підставі заповнених ними коротких форм Міжнародної анкети з фізичної активності (IPAQ-SF).

Результати. Наприкінці 8 тижнів спостерігалось значне покращення показників гнучкості за результатами тесту на згинання тулуба вперед сидячи на підлозі з випрямленими вперед руками (SRT) як у групі телереабілітації ($p = 0,001$), так і в групі домашніх вправ ($p = 0,001$). Крім того, суттєве покращення спостерігалось в показниках вимірювань пасивної амплітуди руху (ROM) як у групі телереабілітації ($p = 0,005$), так і в групі домашніх вправ

($p = 0,001$). Наприкінці 8 тижнів було визначено, що група телереабілітації значно перевершує групу домашніх вправ за результатами тесту на згинання тулуба вперед сидячи на підлозі з випрямленими вперед руками (SRT) ($p = 0,034$). Що стосується довгострокових результатів, у групі телереабілітації зберігалось суттєве покращення в показниках тесту на згинання тулуба вперед сидячи на підлозі з випрямленими вперед руками (SRT) ($p = 0,001$) та вимірювань пасивної амплітуди руху (ROM) ($p = 0,014$).

Висновки. За результатами спостереження восьми-тижневої програми телереабілітації та домашніх вправ було встановлено її позитивний вплив на показники пасивної та активної амплітуди руху (ROM). У довгостроковій перспективі метод телереабілітації, можливо, виявиться ефективнішим за метод домашніх вправ.

Ключові слова: вправа, підколінні м'язи стегна, телереабілітація, розтягування м'язів, гнучкість.

Information about the authors:

Hazal GENÇ: hazaloksuz@gmail.com; <https://orcid.org/0000-0001-9999-1040>; Physical Therapy and Rehabilitation PhD Program, Graduate School of Health Sciences, Istanbul Medipol University, Turkey, Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Bahçeşehir University, Turkey.

Tuğçe POYRAZ İŞLEYEN: fzt.tugcepoyraz@gmail.com; <https://orcid.org/0000-0001-9512-7650>; Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Bahçeşehir University, Turkey.

Tuğçe TAHMAZ: tugcetahmaz@msn.com; <https://orcid.org/0000-0001-6953-7138>; Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Bahçeşehir University, Turkey.

Yeldağ AYDOĞAN: yeldag.aydogan@bahcesehir.edu.tr; <https://orcid.org/0000-0003-3289-5227>; Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Bahçeşehir University, Turkey.

Esra ATILGAN: eatilgan@medipol.edu.tr; <https://orcid.org/0000-0002-6381-5982>; Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul Medipol University, Turkey.

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PROFILE AND DIFFERENCES IN ANTHROPOMETRIC DATA AND JUMPING ABILITY PERFORMANCE BETWEEN ELITE AND AMATEUR U16 VOLLEYBALL PLAYERS

Gaetano Altavilla^{1ABCE}, Giovanni Esposito^{1ABCE}, Rosario Ceruso^{1ABCD},
Felice Di Domenico^{1ABCD} and Tiziana D'Isanto^{1ABCD}

¹University of Salerno

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

Corresponding Author: Rosario, Ceruso, E-mail: r.ceruso2@studenti.unisa.it

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Abstract

Research purpose. The purpose of this study is to verify if there are significant differences between different anthropometric and jumping ability variables by testing two groups of elite and amateur volleyball players (under 16) after having submitted the two groups to the same training protocol performed 4 times a week for 4 months.

Materials and methods. The study was carried out on 24 volleyball players divided into two groups. The following anthropometric and jumping ability parameters were assessed in all subjects: height, weight, body mass index, height with a stretched arm and height with two extended arms. The jumping ability measurement was carried out with the Vertec jump test.

Results. The results of the anthropometric parameters showed significant differences between the two groups on all the variables considered: in height ($p = 0.00$), in weight ($p = 0.00$), in Vertec attack with a stretched arm, AH1 ($p = 0.00$) and in Vertec wall with two outstretched arms, AH2 ($p = 0.01$). The results of the jumping ability parameters showed significant differences between the two groups (elite and amateur): in Vertec Wall, VW ($p = 0.00$) and Vertec Attack with run-up, VA ($p = 0.00$); and a high correlation was shown for both the groups.

Conclusions. Above all, in high-level youth volleyball, the anthropometric and jumping ability profile is directly linked to the evaluation; training and continuous monitoring of physical qualities and jumping ability become an important aspect for the control of performance and the possibility of selecting talented players.

Keywords: anthropometric and conditional skills, training, testing, talent selection.

Introduction

Volleyball is a team sport involving short explosive activity bursts, such as serves, receptions, passes, spikes, short sprints, jumps and high-speed movement (Lidor & Ziv, 2010; Hank et al., 2015). Volleyball is classified as an activity with alternating aerobic and anaerobic engagement (Forte et al., 2019a) with a high percentage of body muscle mass and district demands for high strength (D'Isanto et al., 2018). The limited dimensions of the field determine a performance characterized by technical gestures (jumps, attack shots, etc.) at high intensities (Ferrara et al., 2019). The volleyball is a sport considered of attack (Raiola et al., 2016) with technical and physical characteristics where precision and power are a very important aspect to obtain a winning action (D'Isanto et al., 2017) and is a game-sport that includes some aspects

of human sciences and science experimental for descriptively analyzing the movement (Parisi & Raiola, 2014).

In modern volleyball the use of the jump and the speed of play is a clear sign of a greater demand for physical strength and the speed of the technical gesture; the aim is to express the power necessary to gain an advantage over the opponent (steal time or acquire a space, a position), overcome or contain it (Alminni et al., 2019). In fact, the explosive dynamic strength, the elevation, and the speed of displacement are selective and determining (Forte & Altavilla, 2018); while physical demands during a training or the match differ from each playing position (Altavilla et al., 2017). In volleyball, a vertical jump is adopted (Forte et al., 2019b), preceded or not by a movement (run-up), generally aimed at increasing its effectiveness; the aim is to express the necessary power in order to gain an advantage over the opponent (steal time or acquire a space, a position), overcome or contain it. Several research has shown that anthropometric and physical variables are able to discriminate players as starters vs. non-starters or elite vs. amateur (Gabbett et al., 2007; Smith et al., 1992).

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The main objective of athletic training and sports participation has always been to improve the performance of players; therefore, the ability to jump together at the anthropometric parameters represent fundamentals quality (Aquino et al., 2019) in this type of sport. The relationship between the potential strength, power, and anthropometric contributors to vertical jump performances is unknown for young jumping athletes. Therefore, the purpose of this investigation was to examine if there were significant differences between anthropometric variables and jumping ability, by testing two groups of Italian Under 16 volleyball players (elite and amateur).

The purpose of this study is to verify if there are significant differences between different variables anthropometric and jumping ability, by testing two groups: elite and amateur volleyball players (under 16), after having submitted, for 4 months, the two groups to the same training protocol, for 4 times a week.

Materials and methods

Study participants

The sample of subjects included young male volleyball players ($n=24$), were divided in two groups of 12 with an age (years) elite = 16.4 ± 0.6 and amateur = 16.5 ± 0.8 ; height (cm) elite = 181.3 ± 6.6 and amateur = 173.2 ± 8.1 ; weight (kg) elite = 77.2 ± 3.6 and amateur = 71.6 ± 6.7 and BMI (kg/m^2) elite = 23.4 ± 0.5 and amateur = 23.9 ± 0.5 . The players had at least four years of training experience and participated at the Italian volleyball Under-16 Championship. The inclusion criteria considered, for young volleyball players, was four years of training experience and participate on average 4 months training sessions; whereas the exclusion criteria was no history of injuries in the last year (i.e. muscles, tendons, bones).

Study organization

The variables investigated were: height (cm); weight (kg); BMI (kg/m^2); height with a stretched arm (AH1, cm); height with two extended arms (AH2, cm); Vertec Wall (VW, cm) and Vertec Attack with run-up (VA, cm). The method of detection and analysis of data required the use of following tests and devices: altimeter, electronic scale and vertec jump test. The tests were carried out after having subjected the two groups to the same training protocol 4 times a week for 4 months (Table 1). Vertec jump test was used to measure the elevation in a specific way (Isaacs, 1998), using the technical action of the attack to net (VA) and the technical action of the wall (VW). Each player simulated the attack action with a run-up step (VA) and the wall action (VW). For each test three trials were performed: from the jumps performed only the best result was considered for the statistical analysis. It was possible to calculate the different elevations (with and without the run-up) obtained by the various players, for each group, by jumping with and without run-up (Table 2). Other data has been obtained by evaluating the results obtained by the difference between the measurement of the attack action with a run-up step (VA) and the maximum measure reached by extending the dominant arm (AH1), between the technical action of the wall from a standstill (VW) and the maximum measure reached by completely extending the upper limbs (AH2). The differences calculated between VA-AH1 and VW-AH2 were obtained two values

that represents an evident index to evaluate the elasticity and of power of the extensor muscles (Komi & Bosco, 1978) of the lower limbs between two groups. In table 1 is shown the workload (physical, technical and tactical) provided during the four months of intensive training, specifying the distribution of work in hours.

Statistical analysis

All data are presented as mean and standard deviation (Mean $\pm$ SD). Prior to the parametric analysis, the normality of data distribution was verified by the using Shapiro-Wilk test. The independent-samples t-test was used to examine significance differences for each anthropometrics and jumping ability variables between two groups (elite and amateur); while homogeneity of variances was checked with Levene's test. The correlations between all the variables considered were calculated using the Pearson correlation coefficient. Type I error was set at $\alpha=5\%$ and all statistical analyses were performed with the software IBM SPSS Statistics 23.

Results

Table 1. Weekly training hours report for both two groups

Type of training	Duration, hours
Physical training	2h 00'
Technique	2h 00'
Phases of game	2h 00'
Total	6h 00'

Table 2. Anthropometric and jumping ability values of all players

Variables Mean $\pm$ SD (n = 24)	Group A (Elite) (N = 12)	Group B (Amateur) (N = 12)	Differences (Gr.A - Gr.B)
Age (years)	16.4 ± 0.6	16.5 ± 0.8	+ 0.2
Height (cm)	181.3 ± 6.6	173.2 ± 8.1	+ 8.1
Weight (kg)	77.2 ± 3.6	71.6 ± 6.7	+ 5.6
BMI (kg/m^2)	23.4 ± 0.5	23.9 ± 0.5	+ 0.5
AH1 (cm)	239.6 ± 7.6	221.7 ± 17.4	+ 17.9
AH2 (cm)	234.7 ± 6.3	219.0 ± 17.3	+ 15.7
VW (cm)	270.0 ± 17.8	237.3 ± 16.2	+ 32.7
VA with run-up (cm)	292.6 ± 16.9	254.3 ± 16.5	+ 38.3
Differences VA - AH1	+ 53.0	+ 32.6	+ 20.4
Differences VW - AH2	+ 35.3	+ 18.3	+ 17.0

Table 3. Comparison of anthropometric and jumping ability values between groups

Variables	Group A (N = 12)	Group B (N = 12)	t	p
Height	181.3	173.2	2.847	0.00
Weight	77.2	71.6	4.475	0.00
AH1	239.6	221.7	3.117	0.00
AH2	234.7	219.0	2.825	0.01
VW	270.0	237.3	4.479	0.00
VA with run-up	292.6	254.3	5.366	0.00

Table 4. Correlation matrix (anthropometric and jumping ability values)

Group A (Elitè)	Height	Weight	AH1	AH2	VW	VA with run-up
Height	-					
Weight	0.948	-				
AH1	0.917	0.974	-			
AH2	0.963	0.922	0.938	-		
VW	0.822	0.891	0.932	0.939	-	
VA with run-up	0.844	0.924	0.921	0.908	0.971	-

Table 5. Correlation matrix (anthropometric and jumping ability values)

Group B (Amateur)	Height	Weight	AH1	AH2	VW	VA with run-up
Height	-					
Weight	0.978	-				
AH1	0.989	0.985	-			
AH2	0.982	0.984	0.999	-		
VW	0.976	0.991	0.975	0.972	-	
VA with run-up	0.957	0.977	0.979	0.982	0.954	-

Discussion

Table 2 show the mean and the standard deviation of the anthropometric values and of the jumping ability of all the volleyball players considered, as well as the differences between two groups. The results of the comparison of the anthropometric parameters and of the jumping ability between the two groups (elitè and amateur) are shown in table 3. To detect these differences between the different variables considered between two groups (elitè and amateur) t-test for independent groups was used. Regarding the anthropometric data, we obtained significant results for the Height ($t = 2.847$; $p = 0.00$), Weight ($t = 4.475$; $p = 0.00$), AH1 measured with a stretched arm ($t = 3.117$; $p = 0.00$) and AH2 measured with two outstretched arms ($t = 2.825$; $p = 0.01$). The results of the comparison on the Vertec jump test between the two groups showed significant differences for the VW ($t = 4.479$; $p = 0.00$) and for the VA with run-up ($t = 5.336$; $p = 0.00$).

The results of the correlation matrix of the different variables considered between the two groups are shown in the tables 4 and 5. A high correlation was found between the results of the anthropometric parameters and those of the Vertec Test for both groups. From the statistical analysis of the tests, we can say that group A (elitè), compared to group B (amateur), recorded better values, in fact, both for the anthropometric parameters and jumping ability there was a significant difference on all the variables considered. These analyzes show that different elements such as the arm length, the push of the arms in the attack and block jumps, the strength developed by the lower limbs, the use of an effective run-up in the jump phase and the coordination between the movements of the arms and legs, can be decisive for assessing a talented player. The strong correlation between VA and VW could be an indicator of an athlete's

ability to transform the accumulated kinetic energy during the run-up phase into potential energy.

The results of the anthropometric parameters, linked to particular morphological characteristics, are already present in the junior phase and can be used among the selection criteria in the identification of talents. The attackers must decrease the flight time to intercept the attacking actions faster and faster, with the ball hit at higher elevated; a greater extension of the arms decreases the flight time needed to intercept the ball. The correct identification of the morphological characteristics and the close connection of these with the technical role becomes at this point decisive for obtaining excellent results. These results confirm, mostly for regarding the elite group is concerned, the link between the morphological characteristics, the orientation towards specialization and the training of muscular qualities (Sands et al., 2005). These qualities result to be fundamental in the choice of the player of talent (elitè). Finally, the analysis of the correlation matrix (for both the groups) shows that all the anthropometric and jumping ability variables are correlated with each other. In agreement with the findings in the literature, we found that power and jump height increase with age (Taylor et al., 2010). Similar study of Sheppard et al., (2008) examined the potential strength, power, and anthropometric contributors to vertical jump performances that are considered specific to volleyball success. The results of this study clearly demonstrate that in an elite population of volleyball players, stretch-shortening cycle performance and the ability to tolerate high stretch loads, as in the depth jump, is critical to performance in the jumps associated with volleyball performance. Another study of Aouadi et al. (2012) showed that age, weight, standing height and fat-free mass were the predictors of jumping performance.

Thus, the measurement of anthropometric characteristics, such as stature and lower limb length may assist coaches in the early phases of talent identification in volleyball. The results may help in verifying the effectiveness of a specific training program and detecting highly talented athletes. This study present a limited sample, instead with a much more wide sample it is could come to stronger conclusions. Finally a possible future research might be to repeat the study on a female sample and then to compare the data obtained with the male sample to detect performance and abilities differences, in quantitative and qualitative terms.

Conclusions

There are significant differences between the two groups (elitè and amateur) both in the characteristics anthropometric that in the jumping ability. In particular, the group A (elitè) confirms that high-level volleyball players have an anthropometric and conditional profile directly linked to specific variables such as height, neuromotor coordination and jumping ability. Modern volleyball, due to the reduced duration of play and increasing intensity of rhythm; therefore, we increasingly need tall, fast and powerful athletes. In addition, due to the reduced duration of the game actions and the increasing intensity of the pace, we are increasingly in need of tall, fast and powerful athletes. The evaluation, training and continuous monitoring of physical qualities and jumping ability become an important aspect for the control of performance and the possibility of selecting talented players.

Conflict of interest

The authors declare that there is no conflict of interest.

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ПРОФІЛЬ ТА ВІДМІННОСТІ В АНТРОПОМЕТРИЧНИХ ДАНИХ І ПОКАЗНИКАХ СТИБУЧОСТІ МІЖ ВОЛЕЙБОЛІСТАМИ ВИСОКОГО КЛАСУ ТА АМАТОРСЬКОГО РІВНЯ ВІКОМ ДО 16 РОКІВ

Гаetano Альтавілла^{ABCE}, Джованні Еспозіто^{ABCE}, Розаріо Серузо^{ABCD},
Феліче Ді Доменіко^{ABCD}, Тиціана Д'Ісанта^{ABCD}

Університет Салерно

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

Реферат. Стаття: 5 с., 5 табл., 21 джерело.

Мета дослідження. Метою цього дослідження є перевірка наявності суттєвих відмінностей між різними змінними антропометричних даних і показників стрибучості шляхом тестування двох груп волейболістів віком до 16 років: високого класу та аматорського рівня – після виконання обома групами того самого протоколу тренувань по 4 рази на тиждень протягом 4 місяців.

Матеріали та методи. Дослідження проводили на 24 волейболістах, розподілених на дві групи. В усіх учасників оцінювали наступні параметри антропометричних даних і показників стрибучості: зріст, вага, індекс маси тіла, зріст із витягнутою вгору рукою та зріст із витягнутими вгору обома руками. Вимірювання показників стрибучості здійснювали за допомогою тесту на висоту стрибка вгору з використанням пристрою «Vertec».

Результати. Результати вимірювання параметрів антропометричних даних показали суттєві відмінності між обома групами за всіма взятими до уваги змінними: у

зрості ($p = 0,00$), у вазі ($p = 0,00$), у тесті Vertec «Стрибок з атакою» з однією витягнутою рукою, AH1 ($p = 0,00$) і в тесті Vertec «Стрибок із блоком» з двома витягнутими руками, AH2 ($p = 0,01$). Результати вимірювання параметрів показників стрибучості показали суттєві відмінності між обома групами (високого класу та аматорського рівня): у тесті Vertec «Стрибок із блоком», VW ($p = 0,00$) і в тесті Vertec «Стрибок з атакою» з розбігу, VA ($p = 0,00$); також результати показали високу кореляцію для обох груп.

Висновки. Перш за все, у юнацькому волейболі високого рівня профіль антропометричних даних і показників стрибучості безпосередньо пов'язаний з оцінкою; тренування та безперервний контроль фізичних якостей і показників стрибучості стають важливим аспектом контролю результативності та можливості відбору талановитих гравців.

Ключові слова: антропометричні та обумовлені навички, навчання, тестування, відбір талантів.

Information about the authors:

Altavilla, Gaetano: gaetano.altavilla_@libero.it; <https://orcid.org/0000-0001-8436-7819>; Department of Human, Philosophical and Education Sciences, University of Salerno, Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.

Esposito, Giovanni: g.esposito198@studenti.unisa.it; <https://orcid.org/0000-0002-3659-8943>; Department of Political and Social Studies, University of Salerno, Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.

Ceruso, Rosario: r.ceruso2@studenti.unisa.it; <https://orcid.org/0000-0002-5656-7490>; Department of Human, Philosophical and Education Sciences, University of Salerno, Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.

Di Domenico, Felice: fdidomenico@unisa.it; <https://orcid.org/0000-0002-5897-9704>; Department of Political and Social Studies, University of Salerno, Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.

D'Isanto, Tiziana: tizidisanto@libero.it; <https://orcid.org/0000-0001-7151-7486>; Department of Human, Philosophical and Education Sciences, University of Salerno, Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.

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ORIGINAL SCIENTIFIC ARTICLE

COMPARATIVE PERFORMANCE OF SOCCER TEAMS OF DIFFERENT AGE GROUPS

Andriy Kolosov^{1ABD}, Serhii Voitenko^{2ABC}, Viktor Kostiukevych^{2BCD}, Tetiana Vozniuk^{2BCD}, Maksym Perepelytsia^{2BCD}, Nataliia Svirshchuk^{2BCD} and Tamara Chernyshenko^{2BCD}

¹Vinnitsa Social and Economic Institute of the University of Ukraine

²Vinnitsia Mykhailo Kotsiubynskyi State Pedagogical University

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

Corresponding Author: Tetiana Vozniuk, E-mail: tv_vinnitsa@ukr.net

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Abstract

The study purpose is to establish differences in the joint activities of soccer teams of different age.

Materials and methods. Psychological methods for indicators of joint activity of sports teams were used. Statistical analysis was performed using non-parametric analysis of variance (Kruskal-Wallis H-test). The study involved 105 soccer players, including 37 boys aged 15-18, 45 juniors aged 19-21 and 23 adult athletes aged 22 and over.

Results. In the young soccer players, group interaction, intellectual communication, psychological compatibility, as well as indicators of real and reflective group subjectivity are higher than in the adult and junior teams. The levels of group organization, diligence and success in performing sports tasks are dominant in the adult teams. At the same time, the integrative characteristic of joint sports activities is group efficiency, which is presumably the most pronounced in adults, thus characterizing the processes within the mental organization of joint activities of soccer players. It is the result of their cooperation, a transformed form of external teamwork.

Conclusions. The organization of joint mental activity differs in different age groups. This affects the formation and development of intra-group position of the athletes, influencing their optimal involvement in the team in the performance of designed or creative functions.

Keywords: soccer players, efficiency, interaction, subjectivity, organization.

Introduction

The study of the joint activities of soccer teams in the context of professional performance remains relevant in the scientific and practical activities of sports pedagogy and psychology. The importance of studying this problem lies in the possibility of increasing the group efficiency of the sports team through the organization of their mental activity. The formation and development of the athlete's active and collaborative personality requires his optimum inclusion in the team for performing the designed or creative functions (Voronova, Petrovska, Kovalchuk, Smoliar, 2020). At the same time, the athlete's internal mental processes are transformed forms of external team action, the result of their cooperation.

The relevance of our research is due the requirements of psychological and pedagogical practice in assessing differences in the joint activities of groups, in particular

interaction, organization and subjectivity, to determine the group efficiency and to identify the factors of its regulation in soccer players of different age groups.

Joint activity is considered one of the most important scientific categories in social psychology, which is studied at the level of general methodology, specific socio-psychological theory, as well as in applied activities (Petrovska, Voronova, Hryn, et al., 2021).

The team, as is known, represents the highest level of development of the group, in which joint activity is built on the basis of individual peculiarities, achievement of a personal maxim and orientation for common success (Durdubas, & Koruc, 2022). Individual achievements depend on the effective interaction of team members while preserving their individuality. Team members are characterised by the compatibility of personal and professional goals, which provides the basis for high cohesion, which makes them feel responsible for the success of the overall performance (Jowett, Shanmugan, Caccoulis, 2012; Kurdybakha, 2019; Vysochina, 2021).

The problems of increasing the effectiveness of joint activities and optimizing the selection of individuals for

groups to perform certain tasks are one of the priorities of sports breeding today. An analysis of the literature on the study revealed the existence of different views and conceptual approaches to the development of cooperative activities among athletes. The phenomena of psychological compatibility (Kurdybakha, 2020), homogeneity and heterogeneity of team members, organizational leadership (Duguay, Loughead, Hoffmann, & Caron, 2022), motivation of group activity (Vozniuk, Dibert, & Bazhan, 2020), collaboration, communication and interaction in "athlete-athlete" systems were studied in depth by domestic and foreign scientists, "athlete-trainer" (Vojtenko, 2017; Demerouti et al., 2021), conflicts in the sports team, team cohesion (McLaren, & Spink, 2020; Tolkunova et al., 2021), psychological and socio-psychological climate of the sports team (Petrovska, Voronova, & Hryn, 2021), collective subjectivity of the joint sports activity (Heilmann et al., 2022; Durdubas, & Koruc, 2022), reliability of the group activity (Hryn, 2009; Yongtawee et al., 2022), individualizing the training of the sports team (Khurtenko et al., 2021; Fortes et al., 2022).

At the same time, despite the considerable scientific achievements in this field, the methodological aspects of diagnosis, development and control of the effectiveness of joint competitive (training) actions remain underdeveloped.

The study of the joint activities of soccer teams of different age groups involves, first of all, the identification of such components as a source, means or additional mechanism for influencing the formation process, Management and enhancement of individual parties of joint activity, group efficiency, interaction, organization and subjectivity, the systematization of which determines the scientific interest of our research and determines its purpose.

The aim of the study is to establish differences in the joint activities of soccer teams of different age groups.

The objectives of the work: to assess the effectiveness of joint activities of soccer teams in different age groups.

Material and methods

Study participants

A total of 105 soccer athletes participated in the study, including 37 boys aged 15-18, 45 boys aged 19-21 and 23 adults aged 22 and over from educational, sports and educational institutions: The Faculty of Physical Education and Sport of the Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia National Agrarian University, Vinnytsia Oblast Children and Youth Sports School of soccer "Nyva Vinnytsia". Informed consent was obtained from all participants and written consent was obtained from the parents of the boys for participation in the experiment.

Study organization

In order to achieve these goals, a number of methods were used: analysis and generalization of scientific and methodical literature; questionnaires; and psycho-diagnostic tests using methods. For the evaluation of the group efficacy of the sports team, we adapted the questionnaire "Group efficiency of the sports team" Feltz and Lirg (1998). For the measurement of the athletes' perception of the abilities of their team to organize and perform joint actions, necessary

to achieve a team result (Kolosoov, & Vojtenko, 2014; Lirg, Feltz, & Chase, 1994; Martinez, Roman, Guillen, & Feltz, 2011). The questionnaire contained 20 different questions concerning the imaginary competitive situation described in the instruction. Five indicators were evaluated: capacity, unity, sustainability, preparedness and effort. The questions contained options of answers, each of which is asked to score on a 10-point Likert's scale (1-10). Scale determined higher or lower scores from "not at all certain" to "absolutely certain". For the evaluation of the group organization of the sports team the test "Visually analogous scale of organization of the group" (Hryn, 2013) was used. The players noted on the form line how well-functioning, psychologically compatible and successfully carrying out the assigned tasks their team. The one on the far left will mean very low performance, the one on the far right will mean very high performance. The evaluation of each indicator was measured with a ruler (0 to 10 cm) and the resulting data were given points. As a study of group interaction in a sports team the methodology "Map-scheme of the psychological-pedagogical characteristics of the group" (Voronova, 2017). She is consisting of questionnaires, forms a five-point scale, built into the set of specific qualities (activity orientation, organization, intellectual communication, psychological climate) characterizing the integrative properties of the group. Since the quality of the group is presented in the diagram map in most cases in the opposite way, it is necessary to consider them simultaneously. To assess any quality, you have to read the positive grade on the left, and the negative one on the right, and then cross-reference the grade against the corresponding score. The quantification is based on a comparison of the total for all integrative properties of the development level of the team. In order to determine the level of development of the group subjectivity, the test questionnaire "Types of group subjectivity" was used, the basis of which is the concept of the collective subject A.L. Zhuravlev, developed by K.M. Gaidar (Hryn, 2013). The study evaluated the team using a number of characteristics. To do so, first select the pole of characteristic that the athlete believes correctly describes his team. Then assessed the weighting of that quality using the corresponding half of the response scale (right or left). One of three variants of the answer is selected: "the quality is absolutely expressed", "the quality is significantly expressed", "the quality is expressed". The answer is denoted by the sign "+", placing it in the answer graph located between the two poles of the characteristic.

Statistical analysis

The digital material has been processed using traditional methods of mathematical statistics. The arithmetic mean of X, the square mean of S (standard deviation) was determined for each indicator. A non-parametric dispersion analysis (Kruskal-Wallis ANOVA ranks by H-test) was also performed to determine the degree of variation between several groups. Factor and cluster analysis of testing rates. The data obtained are processed using STATISTICA.

Results

The study found differences in the quality of joint performance of soccer teams of different age groups (Tab. 1).

According to the evaluation of the results of the group interaction we have found reliable differences in the indicator “intellectual communicativeness” ($H = 7.15$; $p < 0.05$; $v = 3$). The highest data (44.11 ± 2.9) are found among young athletes, the lowest (41.96 ± 4.4) among junior athletes. This shows that young soccers, unlike other age groups, quickly and easily find a common language in the team, come to a common opinion, find a common judgment.

According to the results of the analysis of the dynamics of changes in the group organization of soccer teams of different age groups, reliable significance has been established on the basis of “performance” ($H = 15.96$; $p < 0.001$; $v = 3$), “psychological compatibility” ($H = 14.31$; $p < 0.005$; $v = 3$), “success in achieving the set sports goals” ($H = 11.45$; $p < 0.01$; $v = 3$).

The performance of the indicator “performance” was the highest among soccer players of the adult group (72.48 ± 21.1). This demonstrates the quality of interaction of athletes, their joint productivity, their emotional and energy costs, their satisfaction with themselves, their partners and the content of their work, because the ability to interact with team members leads to the greatest possible group result.

According to the indicator “psychological compatibility” high value is fixed in youth soccer teams (72.24 ± 11.9), which indicates formation of interpersonal interaction and cooperation of partners, combination of personal characteristics, which have a positive influence on the results of joint sports activities.

A statistical difference in the indicator of “success in achieving the set sport tasks” was found high value recorded in adult soccer teams (74.35 ± 19.8). This is reflected in the increased satisfaction of the partners with joint actions, achievement of common tasks, as well as positive emotional release after successfully overcoming difficulties during competitions.

The analysis of the dynamics of the indicators of group subjectivity found a statistically reliable difference in the indicators of the “real subjectivity” ($H = 7.03$; $p < 0.05$; $v = 3$) and the “reflective subjectivity” ($H = 11.14$; $p < 0.01$; $v = 3$).

High values (48.59 ± 5.8) of “real subjectivity” have been recorded in teams of young men, which may indicate the manifestation of general activity of athletes realized in various types and forms of communication and interaction, as well as group relations. Adult soccer teams also recorded

Table 1. Comparative performance of joint soccer teams different age groups

Indicator		Age groups of athletes			H	p
		Boys 15-18 years n = 37	Juniors 19-21 years n = 45	Adults 22 years and over n = 23		
		X ± S	X ± S	X ± S		
Group interaction	Activity orientation	43.19 ± 3.8	42.33 ± 5.3	45.13 ± 5.7	3.54	0.17
	Organization	42.27 ± 4.7	43.47 ± 4.6	43.26 ± 4.7	1.55	0.46
	Intellectual communication	44.11 ± 2.9	41.96 ± 4.4	43.83 ± 4.2	7.15	0.05*
	Psychological climate	41.97 ± 3.7	41.98 ± 3.1	42.35 ± 4.8	1.96	0.375
	The average	42.89 ± 2.7	42.43 ± 3.5	43.64 ± 4.1	0.64	0.72
	Assessment of development	170.16 ± 14.1	169.31 ± 14.5	174.57 ± 16.3	3.37	0.185
Group organization	Teamwork	68.03 ± 13.5	63.11 ± 8.9	72.48 ± 21.1	15.96	0.001*
	Psychological compatibility	72.24 ± 11.9	61.04 ± 15.6	72.04 ± 20.2	14.31	0.005*
	Success in meeting sporting objectives	71.92 ± 10.3	64.93 ± 12.4	74.35 ± 19.8	11.45	0.01*
	The average	70.73 ± 9.3	63.03 ± 10.9	72.96 ± 18.9	3.86	0.145
Group subjectivity	Potential subjectivity	48.95 ± 9.2	46.60 ± 4.04	46.87 ± 3.2	2.58	0.275
	Real subjectivity	48.59 ± 5.8	45.71 ± 5.7	48.43 ± 8.8	7.03	0.05*
	Reflexive subjectivity	48.95 ± 9.3	46.00 ± 4.8	43.13 ± 4.2	11.14	0.01*
	The average	48.83 ± 4.9	46.10 ± 4.1	46.14 ± 3.7	3.46	0.177
Group efficiency	Ability	32.68 ± 4.0	28.36 ± 6.3	33.57 ± 4.8	17.81	0.001*
	Unity	30.46 ± 3.8	26.73 ± 6.4	32.87 ± 6.5	16.96	0.001*
	Sustainability	31.89 ± 31.22	28.71 ± 5.3	33.74 ± 5.4	14.91	0.005*
	Preparedness	31.22 ± 4.4	28.69 ± 5.3	34.39 ± 5.2	16.67	0.001*
	Efforts	32.19 ± 3.4	28.20 ± 5.0	33.91 ± 5.5	20.61	0.001*
	The average	31.69 ± 3.0	28.14 ± 4.9	33.70 ± 5.3	0.52	0.771

Notes: * – Indicators that differ reliably from the H-criterion ($n = 105$, $v=3$, $H_{cr(p \leq 0.05)} = 7.81$; $H_{cr(p \leq 0.01)} = 11.34$; $H_{cr(p \leq 0.005)} = 12.84$; $H_{cr(p \leq 0.001)} = 16.27$)

high numbers (48.43 ± 8.8). This may indicate a coherent formulation of common goals, mutual communication, joint decision-making and implementation, and adherence to group norms and values. According to the indicator of "reflective subjectivity" high value was recorded in soccer teams of youth age (48.95 ± 9.3). This characterizes their group self-reflection. The team realizes its psychological unity, the feeling of "We", the ability to carry out self-assessment of its own potentials, to relate them to group claims, to conduct self-analysis of its strengths and weaknesses. Players are able to formulate agreed opinions and judgements, have a common understanding of their own qualities and characteristics, discuss team goals and objectives together, and analyze group successes and failures.

An analysis of differences in the performance of group soccer teams of different age groups statistically reliable significance was established in the values "capacity" ($H = 17.81$; $p < 0.001$; $v = 3$), "unity" ($H = 16.96$; $p < 0.001$; $v = 3$), "stability" ($H = 14.91$; $p < 0.005$; $v = 3$), "preparedness" ($H = 16.67$; $p < 0.001$; $v = 3$), "effort" ($H = 20.61$; $p < 0.001$; $v = 3$).

High values have been recorded for adult soccer teams in all indicators: "ability" (33.57 ± 4.8), indicates their individual psychological characteristics, expressing readiness to master certain types of activities and to successfully implement them, this peculiarity depends not only on the quality of training, but also on the level of intellectual activity. Indicator "unity" (32.87 ± 6.5) indicates the community of thoughts, a stimulating process of group decision-making and a positive motivational factor both for the effective sporting activity of each athlete and for the team as a whole. "Stability" (33.74 ± 5.4) indicates efficiency in achieving results of training and competitive activity, where the effect depends on the stability of each team member. Indicator "preparedness" (34.39 ± 5.2) evaluation of the psychological attitudes of athletes to specific competitions. "Effort" (33.91 ± 5.5) evaluation of readiness to show better possibilities. Indicator "average value" (33.70 ± 5.3) generalized characteristic of the group of effectiveness of the athlete.

The results of the group effectiveness evaluation are an integral characteristic of the joint activity of soccer teams of different age groups. They express the shared belief of players in their ability to organize and execute the joint actions necessary to achieve a certain result.

Discussion

In modern scientific and methodical literature, a wide variety of material is widely presented, devoted to the regulation of the cooperative activities of teams and the integration of sports teams in order to achieve a better sporting result (Meyer, & Fletcher, 2007; Martinez, Roman, Guillen, & Feltz, 2011; McCarthy, 2011). At the same time, the specific conditions of joint sports activities, in particular the means of team development, the reduction of factors limiting them, the identification of indicators of psychological and pedagogical dynamics, and the assessment of the current status of the team, leading dominant intra-command processes, preparedness for joint action, etc. is rarely included in the group of reference factors for training and preparatory activities.

Most studies of joint activities tend to focus on results, for example, by showing a high level of group efficiency, bet-

ter results can be achieved (Lirgg et al., 1994; Pineau et al., 2019; Kostiukevych et al., 2021), but studies of its mechanisms, the sources of regulation in the literature are much smaller.

In our study, we traced changes in the characteristics of joint group activity in terms of age. Given the results, the knowledge and understanding of group efficiency regulators can have important practical implications for sports educators and coaches who seek to develop their athletes to become a successful team. Activities in a constantly changing environment require the ability to deal with new and unconventional situations and raise the requirements for communication and cooperation among people in the process of solving joint tasks (Brown et al., 2018; Van Slingerland et al., 2020; Kinoshita et al., 2022). The ability to act in a team is one of the most important qualities of the athlete, along with other sporting skills, while the team becomes the leading form of organizing joint sporting activities (Heilmann et al., 2022). A careful study of the differences in the quality of the performance of soccer teams showed that soccer players' perception of organizing joint mental activity differs in different age groups, which affects the formation and development of the intra-group position of the individual, influencing their optimal inclusion in the actions of the team in performing the designed or creative functions (Beavan et al., 2022).

The results of our experiment are being studied for the first time and are well consistent with other group performance studies in sport (Jowett et al., 2012; Kolosov et al., 2014; Josefsson et al., 2020). Our data is a continuation of the scientific problem of previous studies which have shown that group efficiency is closely related to the interpersonal relations of the coach and the athlete where group efficiency is a key variable of the group, as well as the coach's motivational climate, coach's leadership, team cohesion (especially the cohesiveness of athletes' tasks) which are predicted by direct commitment, and others (Vojtenko, 2017; McLaren et al., 2020; Pineau et al., 2019).

The data suggest a positive outcome in combining the effects of joint activities more pronounced in different age groups. On that basis, in providing guidance on how to maintain the most effective configuration of joint activities soccer teams.

Conclusions

The organization of joint mental activity differs in different age groups. It has an impact on the formation and development of the personality of the athletes within the group, influencing their optimal inclusion in the actions of the team in performing the designed or creative functions. Young soccer players have greater group interaction, intellectual communication, psychological compatibility, and real and reflective group subjectivity than adult and junior teams. In adult teams, the dominant levels are levels of group organization, teamwork, and success in performing assigned sports tasks. However, the integral characteristic of joint sports activity - group efficiency is predictably most expressed in adults, thus characterizing the processes within the mental organization of joint activities of soccer players, through the result of their cooperation, Transformed forms of external command interaction.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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ПОРІВНЯЛЬНА ХАРАКТЕРИСТИКА СПІЛЬНОЇ ДІЯЛЬНОСТІ ФУТБОЛЬНИХ КОМАНД РІЗНИХ ВІКОВИХ ГРУП

Андрій Колосов^{1ABD}, Сергій Войтенко^{2ABC}, Віктор Костюкевич^{2BCD}, Тетяна Вознюк^{2BCD}, Максим Перепелиця^{2BCD}, Наталія Свірщук^{2BCD}, Тамара Чернишенко^{2BCD}

¹Вінницький соціально-економічний інститут Університету «Україна»

²Вінницький державний педагогічний університет імені Михайла Коцюбинського

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів
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Мета дослідження – встановити відмінності спільної діяльності футбольних команд різних вікових груп.

Матеріали і методи. Використовувалися психологічні методики показників спільної діяльності спортивних команд. Статистичний аналіз проводився з використанням непараметричного дисперсійного аналізу (Н-критерію) Крускала-Уолліса. У дослідженні брали участь 105 футболістів, з них 37 юнаків 15-18 років, 45 юніорів 19-21 року та 23 дорослі спортсмени 22 років і старші.

Результати. У футболістів юнаків групова взаємодія, інтелектуальна комунікативність, психологічна сумісність, а також показники реальної та рефлексуючої групової суб'єктності вищі, ніж у командах дорослих та юніорів. У дорослих командах домінуючими є рівні групової організованості, спрацьованості та успішності у виконанні поставлених спортивних завдань. Разом з тим, інтегративна характеристика спільної спортивної діяльності – група-ва ефективність, що передбачувано найбільш виражена у

дорослих, характеризуючи таким чином процеси всередині психічної організації спільної діяльності футболістів. Вона є результатом їхньої співпраці, перетвореною формою зовнішньої командної взаємодії.

Висновки. Організація спільної психічної активності відрізняється у різних вікових групах. Це відбивається

на формуванні та розвитку внутрішньогрупової позиції особи спортсменів, впливаючи на їх оптимальну включеність у дії команди у виконанні спроектованих або творчих функцій.

Ключові слова: футболісти, ефективність, взаємодія, суб'єктність, організованість.

Information about the authors:

Kolosov A.B.: andriy_kolosov@i.ua; <http://orcid.org/0000-0001-6834-940X>; Department of Psychology, Vinnitsa Social and Economic Institute of the University of Ukraine, Khmelnytske Shosse, 23a, Vinnytsia, 21000, Ukraine.

Voitenko S.M.: voytenkos@ukr.net; <http://orcid.org/0000-0003-0025-1064>; Department of Theory and Methodology of Sport, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Kostiukevych V.M.: kostykevich.vik@gmail.com; <http://orcid.org/0000-0002-9716-134X>; Department of Theory and Methodology of Sport, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Vozniuk T.V.: tv_vinnitsa@ukr.net; <http://orcid.org/0000-0002-5951-7333>; Department of Theory and Methodology of Sport, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Perepelytsia M.O.: maks83star@gmail.com; <http://orcid.org/0000-0003-4283-2596>; Department of Theory and Methodology of Sport, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Svirshchuk N.S.: svirshchuk83@gmail.com; <http://orcid.org/0000-0001-6997-1778>; Department of Theory and Methodology of Sport, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Chernyshenko T.M.: tamarra2803@gmail.com; <http://orcid.org/0000-0001-9689-5758>; Department of Theory and Methodology of Sport, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

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ORIGINAL SCIENTIFIC ARTICLE

ELECTROMYOGRAPHICAL ANALYSIS OF TABLE TENNIS FOREHAND STROKE USING DIFFERENT BALL MATERIALS

Anubha Maheshwari^{1ABCD}, Gayatri Pandey^{1ABCD}, Manish Shukla^{2ABCD},
Vijay Singh Rawat^{3ABCD} and Tanushree Yadav^{1ABCD}

¹Lakshmibai National Institute of Physical Education

²Government Law College Morena

³STP Government Science College Dewas

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

Corresponding Author: Anubha Maheshwari, E-mail: anubhamaheshwari95@gmail.com

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Abstract

Research purpose. This study aimed to determine the EMG analysis of forehand topspin using different ball materials.

Materials and methods. For the purposes of this study, seven male university-level table tennis players who were right-hand dominant players (age 21.1 ± 2.4 years, height 162.6 ± 6.8 cm, mass 61.8 ± 3.2 kg) with at least 6 years of playing experience were selected. The selected participants were physically active and had no physical injuries. The study was approved by the research committee. Pectoralis Major (PM), Deltoid Anterior (DA), Latissimus Dorsi (LD), Biceps Brachii (BB), Extensor Carpi Radialis (ECR), Flexor Carpi Radialis (FCR) muscles were selected for the electromyographical study. One of the EMG signals variable Root Mean Square was measured in all muscles, through which the maximum muscle involvement was evaluated. For each assessed muscle and both ball materials, the mean value of Root Mean Square EMG signals was computed. For descriptive statistics, minimum, maximum, mean, and standard deviation were used, and a t-test was used as a statistical technique.

Results. The level of significance was set at 0.05. Results of the study showed no significant difference in EMG variable Root Mean Square between celluloid and poly plastic ball material on selected muscles.

Conclusions. We conclude that the biceps brachii and extensor carpi radialis are important muscles for the forehand topspin because they are responsible for flexion of the arm and work strongly in the action of gripping in the performance of quick forehand spin strokes.

Keywords: electromyography, table tennis, forehand topspin, root mean square, celluloid balls, poly plastic balls.

Introduction

Today's sports training program, which includes table tennis, physical conditioning, and strength training, as well as advanced fitness training diagnostic methods, have now become significantly important (McCann & Bigliani, 1994). Table tennis is a vigorous activity that needs tactical awareness, as well as cognitive and motor preparation (Bańkosz & Winiarski, 2017). It is quick and requires a fast response. Spinning the ball changes its path and minimizes the possible alternatives to a competitor, providing the player a major benefit (Zagatto et al., 2018).

The International Table Tennis Federation changed the ball material from celluloid to polyplastic in 2014 (Kuneth, 2014). "Balls that do not include celluloid" were identified as polyplastic balls (Kuneth, 2020). Celluloid balls were considered to be costly and fragile, causing a fire issue while transporting, that's why this new material (polyplastic) was introduced (Huges, 2014).

The ITTF equipment committee conducted a study on polyplastic and celluloid balls material comparison (Huges, 2014; Kuneth, 2014; Paul, 2015). The polyplastic balls were found to have a greater vertical speed but a slower horizontal speed than celluloid balls (Lee, 2020). The fundamental issue for the modification in ball material, according to ITTF President Adam Sharara, is to decrease the game's speed to make it more viewer-friendly (Kuneth, 2014). Due to the slowing down of the match, various regulations and ball

materials have been changed in present table tennis. A lot of elite players focused on the offensive or attacking style of play (Wang et al., 2018). In table tennis, the forehand topspin is the most dominant offensive shot (Seemiller & Holowchak, 1997). To win a game, attacking players must be successful in generating racket force on the forehand side because a faster forehand racket movement results in a quicker post-impact ball velocity, greater post-impact ball spin, or maybe both, that would be the fact (Iino & Kojima, 2011).

Nowadays, sports are becoming more professional, because we use a lot of technology to uncover flaws to stay on top in the modern world.

Electromyography (EMG) is also used for providing the first functional classification of certain muscles based on the table tennis technique (Petrofsky, 1979). Few studies have been conducted on EMG techniques to evaluate the kinematics of table tennis strokes (Tsai et al., 2010) as well as muscle EMG activity patterns of table tennis forehand shots (38mm and 40mm). They compare muscle patterns while playing with various ball sizes (Kondrič, Miran, Furjan-Mandic, Gordana, Medved, 2006). However, no scientific research has been conducted on muscular involvement using differences in table tennis ball material (celluloid and polyplastic). As a result of this knowledge gap, the authors decided to conduct this research study.



Figure 1. Surface electromyography (Bioengineering, 2011)

When we look at the muscular involvement of the forearm muscle with different ball materials (celluloid and polyplastic), we can identify which muscle is more involved during the forehand topspin and which muscle is more advantageous for performance improvement.

The goal of this research is to see how the forearm muscles Pectoralis Major, Deltoid Anterior, Latissimus Dorsi, Biceps Brachii, Extensor Carpi Radialis, and Flexor Carpi Radialis interact during forehand topspin skill using different ball materials.

Material and methods

Study participants

This study included seven male national-level table tennis players who were right-handed dominant (Age 21.1 ± 2.4 years, Height 162.6 ± 6.8 cm, Bodyweight 61.8 ± 3.2 kg). All the participants had at least 6 years of playing experience at the time of data collection. The participants were physically

active, and there were no reports of the recent upper limb, neurological or ligament damage. All the participants were briefed about the purpose and process of data collection and they provided their written informed consent for participation. The study was approved by the Departmental Research Committee of Lakshmibai National Institute of Physical Education, Gwalior.

Test Administration

During the warm-up, participants performed ten minutes of dynamic stretching. Pectoralis Major (PM), Deltoid Anterior (DA), Latissimus Dorsi (LD), Biceps Brachii (BB), Extensor Carpi Radialis (ECR), Flexor Carpi Radialis (FCR) were selected for assessment. The SENIAM (Surface Electromyography for Non-Invasive Assessment of Muscle) group's recommendations were followed for the procedure of electrode placement on the muscles. Wireless surface electromyography with eight channels (Bioengineering, 2011a) was used for the acquisition of EMG signals from the selected upper extremity muscles.

During a 40s forehand topspin with balls composed of two different materials, the measurements were taken (20 seconds for celluloid balls and 20 seconds for poly-plastic balls). To ensure that all of the performers would be in the same setting, a table tennis Robo machine was used (Newgy's Pro Digital Robo-Pong Table Tennis Robot). Electrodes were placed on the right side of the participants' bodies due to their right-handedness. The contraction intensity and duration of activation were measured.

The EMG signal size method is a standardized approach for detecting, amplifying, and registering bioelectrical activity differences in skeletal muscle (Halaki & Gi, 2012a). Two electrodes are placed beside the muscular fibers at the midpoint of the studied muscle at a standardized distance of 3 cm, using a different method of detection (center to center located). Differential detection eliminates noise (Latasa et al., 2019). For signal recording and interpretation, the bio-mechanical device (Bioengineering, 2011b) was used.

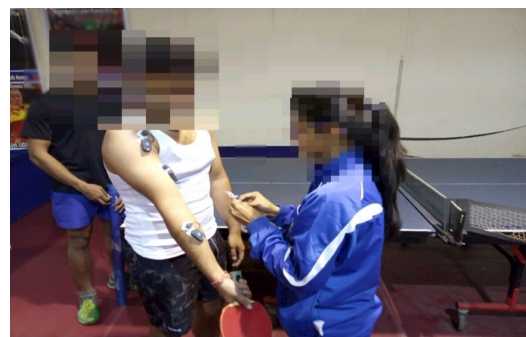


Figure 2. Placement of Electrode on Specific Points

Data analysis

Analysis of the EMG signals was carried out in BTS EMG Analyzer software (version 2.9.40.0). The RMS EMG signals were band-pass filtered using the Butterworth smoothing technique with a lower cut-off frequency of 20 Hz and a higher cut-off frequency of 400 Hz (Halaki & Gi, 2012b) and include: electrode configuration (distance between electrodes as well as area and shape of the electrodes).

Based on Root Mean Square EMG signals measured in all muscles, the maximum muscle involvement was evaluated. For each assessed muscle and both ball materials, the mean value of Root Mean Square EMG signals was computed. Range, mean and standard deviation were reported as descriptive statistics. The data were compared using the t-test. The SPSS software was used to perform all statistical procedures. Significance was accepted at $p < 0.05$.

Results

In Table 1 During forehand topspin using celluloid ball Extensor Carpi Radialis muscles showed maximum involvement (469.31) and Lattismus Dorsi showed minimum involvement (169.04). For polyplastic ball Biceps Brachii, muscles showed maximum involvement (433.81), and Lattissimus Dorsi involved minimum (60.08). The maximum deviation is found in Flexor Carpi Radialis (celluloid ball) and deltoid anterior (polyplastic ball).

Table 2 shows the significant values of equality of variances on both ball materials root mean square data. All values were greater than the .05 level which shows the equality of variances for both celluloid and poly-plastic balls. The obtained results from Table 2 showed no significant difference in selected muscles Root Mean Square using celluloid and polyplastic ball material as p-values of these is $> .05$.

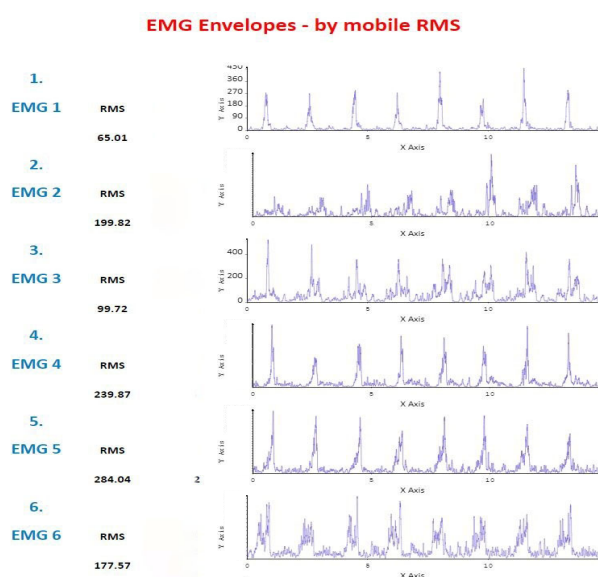


Figure 3. Raw EMG Signal of Muscles Contraction

Figure 3 showed the EMG signals, Root Mean Square (RMS) of muscles while forehand topspin, figure 4 showed the descriptive values of muscles RMS with celluloid and polyplastic ball.

Table 1. Descriptive statistics of Celluloid and Polyplastic balls on Root Mean Square

Muscle	N*	Range (EMG Signal)				Mean		SD [^]	
		Max.		Min.		Celluloid	Polyplastic	Celluloid	Polyplastic
		Celluloid	Polyplastic	Celluloid	Polyplastic				
Pectoralis Major	7	179.56	194.43	70.49	68.31	137.38	135.13	42.10	40.51
Deltoid Anterior	7	414.11	391.61	78.68	89.08	235.35	232.25	114.83	110.60
Latissimus Dorsi	7	169.04	151.49	69.51	60.08	104.34	92.49	40.54	35.14
Biceps Brachii	7	456.53	433.81	169.76	172.95	334.64	315.14	105.31	95.01
Extensor Carpi Radialis	7	469.31	339.66	173.76	176.79	297.87	271.06	95.18	56.39
Flexor Carpi Radialis	7	461.90	387.60	103.60	116.36	216.32	201.02	116.86	93.06

N* Number of Participants; Max. Maximum Range; Min. Minimum Range; SD[^] Standard Deviation

Table 2. Results of t-test on selected muscles Root Mean Square using Celluloid and Polyplastic Balls

Variables		Levene's Test		T-test for equality of means			
		Sig.	t	df	Sig. (2-Tailed)	Mean Difference	
RMS	Equal Variances Assumed	0.881	0.14	12	0.88	3.35	
Pectoralis Major	Equal Variances Assumed	0.945	0.51	12	0.96	3.10	
RMS	Equal Variances Assumed	0.672	0.58	12	0.57	11.85	
Deltoid Anterior	Equal Variances Assumed	0.818	0.36	12	0.72	19.31	
RMS	Equal Variances Assumed	0.385	0.64	12	0.53	26.81	
Latissimus Dorsi	Equal Variances Assumed	0.882	0.27	12	0.79	15.30	
RMS	Equal Variances Assumed						
Biceps Brachii	Equal Variances Assumed						
RMS	Equal Variances Assumed						
Extensor Carpi Radialis	Equal Variances Assumed						
RMS	Equal Variances Assumed						
Flexor Carpi Radialis	Equal Variances Assumed						

RMS – Root Mean Square; t – Obtained Value of t; df – Degrees of Freedom; Sig. (2-Tailed) – Significance Level

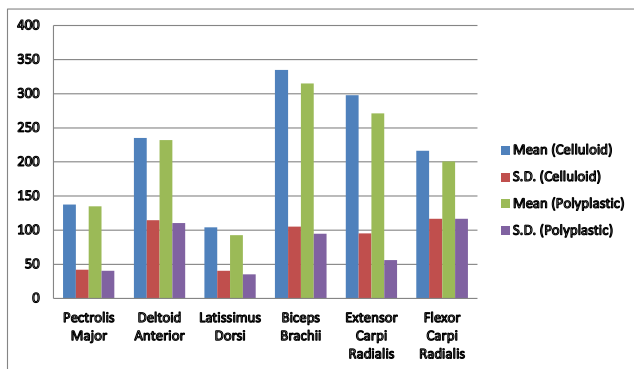


Figure 4. Mean and Standard Deviation (S.D.) values of Root Mean Square on Celluloid ball and Polyplastic ball on selected muscles

Discussion

Earlier gathered information on table tennis ball behavior mostly concerned celluloid balls, which are being widely used since their introduction around 1900 (<http://www.ittf.com/media/History/TimelineHistory.pdf>). The International Table Tennis Federation (ITTF) modified the ball material from celluloid to “polyplastic” for most international tournaments conducted from July 2014. “Balls that do not include celluloid” were defined as polyplastic balls (Huges, 2014; Kuneth, 2014; Paul, 2015).

With varied ball materials (celluloid and polyplastic), we looked at muscle activity during the forehand topspin shot. This study compared the Root Mean Square EMG signal value, which measures physiological activity during contraction.

The findings of the study showed that there was no significant difference found in selected muscles i.e. Pectoralis Major, Deltoid Anterior, Latissimus Dorsi, Biceps Brachii, Extensor Carpi Radialis, Flexor Carpi Radialis muscles' Root Mean Square value using different ball material (Celluloid and Polyplastic ball). ITTF changed the ball material from celluloid to polyplastic balls, (Paul, 2015) Because table tennis balls are light and have a low density, any differences in material, size, or sphericity are likely to influence the ball's trajectory as well as the interactions between the ball, table, racket, and players' responses (Kei et al., 2019). The minimal changes in kinematics reaction to topspin might be explained by the same changes in speed and spin of both types of balls (celluloid and polyplastic) at ball-table contact (Lee, 2020).

Polyplastic balls had a higher speed increase (0.69 %) and a lower spin decrement (0.19 %) after impact with the table tennis surface than celluloid balls (Chen & Huang, 2020). Differences in kinematic reactions to different ball materials were identified when players rebounded backspin shots. Players supinated their rackets 2.23 % ever more produced 3.37 % reduced ball to Polyplastic spin while returning Polyplastic balls than when returning celluloid balls, showing a quick response to the lower spin rate of Polyplastic balls. The absence of variations in kinematic reaction to topspin might be explained by the similar changes in speed and spin of both types of balls upon ball table impact (Iino et al., 2018; Kondrić et al., 2013; David Paar, 2019).

The descriptive statistics of the study showed, maximum RMS (Root Mean Square) for Extensor Carpi Radialis muscle

(469.31) and minimum for Lattissimus Dorsi muscle (169.04) during forehand topspin using a celluloid ball. For the polyplastic ball, the Biceps Brachii muscles showed maximum RMS (Root Mean Square) (433.81) and Latissimus Dorsi showed minimum (60.08). The maximum RMS (Root Mean Square) deviation is found in Flexor Carpi Radialis (celluloid ball) and Deltoid Anterior (polyplastic) muscles.

The analysis of results supports the variations in maximum and minimum voluntary muscular contraction; for slower balls with backspin, as in the case of a service, polyplastic balls are predicted to endure more deceleration upon impact with the table than celluloid balls. Polyplastic balls, on the other hand, are predicted to experience higher acceleration upon impact with the table tennis surface than celluloid balls for quicker balls with more topspin (Iino & Kojima, 2016).

When plastic balls strike the table, they are expected to accelerate more than celluloid balls since they are faster and have more topspin. Because the initial conditions have a large effect on the ball's behavior, testing under various initial factors is necessary to know the properties of each type of ball (Ozaki, 2017).

As the findings of this study showed no significant difference in RMS (Root Mean Square) EMG signals using forehand topspin against backspin balls. Many more studies should be done to understand the effects of ball spin more comprehensively. One limitation of this study is that the participants of this study may not be enough to find possible significant effects of forehand topspin using different ball materials. The participants were recruited from national-level table tennis players.

Different types of styles of play of forehand topspin from the players may be the reason for insignificant results. To establish more definitive results on the examination of EMG during table tennis forehand topspin using different ball materials, more research with a greater number of participants recruited from bigger populations would be required.

Conclusion

The observed results and graphical displays from the research showed that there is no significant difference in activity of the analyzed muscles while using different ball materials for forehand topspin. We conclude that the biceps brachii and extensor carpi radialis is an important muscle for the forehand topspin because it is responsible for flexion of the arm and works strongly in the action of gripping in the performance of quick forehand spin strokes (Buckley & Kerwin, 1988). From this point of view, greater interest is to be paid to the improvement of this muscle in the physical training of the table tennis players. Qualified table tennis players should therefore increase the muscles training that is wanted for their particular style of play after they have set up a large basis of physical fitness.

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Conflicts of interest

The authors declare no conflict of interest.

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ЕЛЕКТРОМІОГРАФІЧНИЙ АНАЛІЗ УДАРУ ВІДКРИТОЮ РАКЕТКОЮ В НАСТІЛЬНОМУ ТЕНІСІ З ВИКОРИСТАННЯМ РІЗНИХ МАТЕРІАЛІВ М'ЯЧА

Анубха Махешварі^{1ABCD}, Гаятрі Пандей^{1ABCD}, Маніш Шукла^{2ABCD},
Віджай Сінгх Рават^{3ABCD}, Танушрі Ядав^{1ABCD}

¹Національний інститут фізичного виховання імені Лакшмі Бай

²Державний юридичний коледж Морена

³Державний науковий коледж Девас

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

Реферат. Стаття: 6 с., 2 табл., 4 рис., 25 джерел.

Мета дослідження. Дослідження мало на меті встановлення показників ЕМГ-аналізу удару відкритою ракеткою з верхнім обертанням з використанням різних матеріалів м'яча.

Матеріали та методи. Для складання цього дослідження були відібрані сім гравців у настільний теніс рівня університетської спортивної команди чоловічої статі, які володіли правою рукою краще, ніж лівою, (вік $21,1 \pm 2,4$ року, зріст $162,6 \pm 6,8$ см, вага $61,8 \pm 3,2$ кг) та мали принаймні 6 років досвіду гри. Відібрані учасники були фізично активними та не мали фізичних травм. Дослідження було затверджене комітетом із наукових досліджень. Для електроміографічного дослідження були вибрані такі м'язи: великий грудний м'яз (Pectoralis Major, PM), передній пучок дельтоподібного м'яза (Deltoid Anterior, DA), найширший м'яз спини (Latissimus Dorsi, LD), двоголовий м'яз плеча (Biceps Brachii, BB), променевий м'яз-розгинач зап'ястка (Extensor Carpi Radialis, ECR), променевий м'яз-згинач зап'ястка (Flexor Carpi Radialis, FCR). Середньоквадратичне значення змінної одного з ЕМГ-сигналів вимірювали на всіх м'язах, завдяки чому оцінювали максимальну задіяність м'язів. Для кожного оцінюваного м'яза та обох матеріалів

м'яча обчислювали середнє значення середньоквадратичних значень ЕМГ-сигналів. Для описової статистики використовували мінімальні, максимальні, середні значення та величину стандартного відхилення, а як статистичний метод використовували t-критерій Стьюдента.

Результати. Рівень значущості був заданий значенням 0.05. Результати дослідження показали відсутність суттєвої відмінності в середньоквадратичному значенні змінної ЕМГ на вибраних м'язах між такими матеріалами м'яча, як целулоїд і полімерна пластмаса.

Висновки. Ми дійшли висновку про те, що двоголовий м'яз плеча та променевий м'яз-розгинач зап'ястка є важливими м'язами для виконання удару відкритою ракеткою з верхнім обертанням, тому що вони відповідають за згинання руки та інтенсивно працюють у процесі дії з міцного утримування під час виконання швидких ударів відкритою ракеткою з обертанням.

Ключові слова: електроміографія, настільний теніс, удар відкритою ракеткою з верхнім обертанням, середньоквадратичне значення, целулоїдні м'ячі, м'ячі з полімерної пластмаси.

Information about the authors:

Maheshwari, Anubha: anubhamaheshwari95@gmail.com; <https://orcid.org/0000-0002-7530-5410>; Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Mela Road, Gwalior, 474002, India.

Pandey, Gayatri: pandeygayatri24@gmail.com; <https://orcid.org/0000-0003-0840-060X>; Department of Physical Education, Lakshmibai National Institute of Physical Education, Mela Road, Gwalior, 474002, India.

Shukla, Manish: manish.shukla1992@gmail.com; <https://orcid.org/0000-0002-3568-8496>; Department of Sports, Near Morena Railway Station, Ramnagar, Morena, Madhya Pradesh 476001, India.

Rawat, Vijay Singh: vijay.tt74@gmail.com; <https://orcid.org/0000-0002-6689-9018>; Department of Sports, STP Government Science College Dewas, Adarsh Nagar, Itawa, Dewas, Madhya Pradesh 455001, India.

Yadav, Tanushree: tanushree.yadav0405@gmail.com; <https://orcid.org/0000-0002-9280-3112>; Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

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EFFECT OF RECREATIONAL FUTSAL ON BODY COMPOSITION IN PASSIVE FOOTBALL PLAYERS

Arben Maliqi^{1ABCD}, Blerim Sylejmani^{1ABCD} and Nazim Myrtaj^{1ABCD}

¹AAB College

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

Corresponding Author: Blerim Sylejmani, E-mail: blerim.sylejmani@aab-edu.net

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Abstract

The purpose of this study was to evaluate the impact of recreational futsal on passive middle-aged footballers in body composition.

Materials and methods. The research was conducted on a sample of 58 men aged from 30 to 40, average age 35.88 ± 2.39 . The sample was divided into two groups. The first group included 29 passive football players (average age 35.58 ± 2.36) who were engaged in recreational futsal 2-3 times a week, and the second group included 29 passive football players (average age 36.17 ± 2.42) who weren't engaged in recreational physical activity. The body composition was assessed by TANITA BC-601, the method of bioelectrical impedance, which became a reference method in research studies in the body composition analysis. The variables obtained were: body height (cm), body weight (kg), fat mass (%), muscle mass (kg), bone mass (kg), body mass index (kg/m^2), calorie consumption – daily calorie intake (kcal), vitality of the body, quantity of water in the body (%), visceral fat (%).

Results. Groups are not distinguished in the variables body height (HBH), calorie consumption – daily calorie intake (DCI), vitality of the body (BMR), and quantity of water in the body (TBV) because $p > 0.05$. In the variables where body mass, body fat tissue and muscle mass were assessed, namely body weight (BWT), fat mass (BFP), muscle mass (TBM), bone mass (BMD), body mass index (BMI) and visceral fat (AVF), a statistically significant difference was gained $p < 0.05$ in favor of the group of passive football players who were involved in recreational futsal.

Conclusions. It can be said that the recreational futsal as physical activity is an effective tool to improve body composition not only in passive football players but in all persons of all ages regardless of gender. Intensity and duration in recreational futsal is an effective way to reduce body fat in the population of passive middle-aged football players.

Keywords: recreational futsal, body composition, passive football players, variables.

Introduction

Lifestyle changes, the transition from an active state in sports to a passive state bring many psychophysical changes that endanger the health of passive athletes. Physical inactivity on the one hand, as well as increased calorie intake, on the other hand, lead to a reduction in (excess) calorie burning, which can have major negative effects on the human body, activation of pathophysiological mechanisms and the development of disease (Hollmann & Hettinger, 2000) as a result of increased subcutaneous fat and blood fat (Booth & Chakravarthy, 2002). Several other studies speak about this issue (Troost et al., 2003; Hajmer, 2010) which stress that

engagement in recreational sports is in significant correlation with various social factors (Sallis et al., 2000). In these studies, the finding for the negative impact of hypokinesia is confirmed, and is stressed its impact on the increasingly pronounced occurrence of non-communicable diseases which can be prevented (and treated) directly with regular and adequate physical activity (Warburton et al., 2001; World Health Assembly, 2004; Schneider & Becker, 2005). Many studies have shown that middle-aged people who are engaged in sports and organized recreational activities enjoy better psychophysical health, normal body mass index 18.5-24.9, are more vigilant and resilient to the stresses of modern living (Xu et al., 2017; Altavilla et al., 2018). Recently research has been done on the impact of recreational futsal on the health of athletes and passive football players (Krustrup et al., 2010; Raiola, 2013) and the effects on the fundamental health vari-

ables that influence the risk of lifestyle-related illnesses of young and middle-aged men (Severino et al., 2019). In addition to the health benefits, the improvements resulting from practicing recreational futsal were compared to other types of recreational physical activity that were practiced more widely. And the results show recreational futsal is complete in the various districts examined (Severino et al., 2019) always at the same level as other sports and more effective in other fields where others are scarce (Krustrup et al., 2010). Recreational futsal less structured than traditional fitness classes, but for many people it is more enjoyable and thus it has a greater potential to develop and sustain the intrinsic motivation of participants (Helge et al., 2010). Factors such as pitch size, the number of players, and training time and format can substantially modify exercise characteristics (Randers et al., 2014). Compared to research in other fields of anthropology conducted so far research with passive athletes is less. This research is therefore an attempt to clarify the effect of continuity from active competitive football to recreational football.

The purpose of this study is to evaluate the impact of recreational futsal on body composition at passive middle-aged football players. In particular, we focus on reducing of some parameters of body composition, especially body mass index (BMI) and subcutaneous adipose tissue (as risk factors for many diseases) in passive football players engaged in recreational futsal compared to passive football players of this age who have not been engaged in recreational physical activities.

Materials and Methods

Participants

The research was conducted on a sample of 58 men from 30 to 40 years of age, average age 35.88 ± 2.39 . The sample is divided into two groups. The sample is divided into two groups. In the first group are involved 29 passive football players average age 35.58 ± 2.36 who have been engaged in recreational futsal 2-3 times a week by 2×20 min to a playground between 20 and 25 meters wide, and between 38 and 42 meters long, and in the second group were involved 29 passive football players who has not conducted

recreational physical activity average age 36.17 ± 2.42 . The only condition that was applied in the sample determination was that the passive football players involved in the research voluntarily agreed to be a part of this research.

Anthropometric measurements and assessment of body composition

The body composition was assessed by TANITA BC-601, the method of bioelectrical impedance, which became a reference method in research studies in the body composition analysis. Upon receiving data for each respondent, data were provided on body height, age and gender of respondents. Following the entry of these parameters in the memory of the measuring device, data on the body composition of the respondents were obtained. The variables obtained are: body height (cm), body weight (kg), fat mass (%), muscle mass (kg), bone mass (kg), body mass index (kg/m^2), calorie consumption – daily calorie intake (kcal), vitality of the body, quantity of water in the body (%), visceral fat (%). The evaluation of the parameters of the body composition was performed in the recreational sports centers in the city of Gjilan, Ferizaj and Prishtina in the Republic of Kosovo.

Statistical analysis

For all variables that are applied for measurement of the body composition are calculated basic statistical parameters and Independent Samples Test. All the analyses were performed using the Statistical Package for Social Sciences software (SPSS, v. 22.0 for Windows; SPSS Inc., Chicago, IL, USA), and values of $p < 0.05$ were considered statistically significant.

Results

In the following text we will try to look at the results obtained from the basic statistical analysis and Independent Samples Test that have been made to respond to the objectives of the work.

Table 1 shows the difference between the group of passive football players engaged in recreational futsal and the

Table 1. Basic statistical parameters and difference between groups

Variables	N	Passive football players in recreational futsal	Passive football players	t	p
		Mean $\pm$ SD	Mean $\pm$ SD		
Body height (cm)	29	178.55 $\pm$ 7.15	178.03 $\pm$ 4.20	0.336	0.738
Body weight (kg)	29	73.65 $\pm$ 13.19	81.30 $\pm$ 14.748	-2.083	0.042
Fat mass (%)	29	17.47 $\pm$ 5.97	21.35 $\pm$ 7.58	-2.167	0.035
Muscle mass (kg)	29	58.11 $\pm$ 7.96	53.43 $\pm$ 7.09	2.363	0.022
Bone mass (kg)	29	3.40 $\pm$ 0.34	3.19 $\pm$ 0.37	2.230	0.030
BMI	29	22.76 $\pm$ 2.79	27.05 $\pm$ 4.28	-4.514	0.000
DCI	29	3018.55 $\pm$ 524.52	3284.24 $\pm$ 574.41	-1.839	0.071
BMR	29	34.65 $\pm$ 8.65	37.03 $\pm$ 11.74	-0.879	0.383
TBW	29	59.30 $\pm$ 4.81	58.11 $\pm$ 5.88	0.843	0.403
AVF	29	3.24 $\pm$ 1.48	4.83 $\pm$ 3.09	-2.490	0.016

group of passive football players who were not engaged in physical recreational activities. This table shows the one-sided differences in the same variables. Independent Samples Test shows significant differences in most body composition variables. Groups are not distinguished in variables body height (HBH), calorie consumption – daily calorie intake (DCI), vitality of the body (BMR), and quantity of water in the body (TBV) because $p > 0.05$. In variables where were assessed body mass, body fat tissue and muscle mass, body weight (BWT), fat mass (BFP), muscle mass (TBM), bone mass (BMD), body mass index (BMI) and visceral fat (AVF) a statistically significant difference was gained $p < 0.05$ in favor of the group of passive football players who are involved in recreational futsal.

Discussion

The conducted research is defined as a transversal study in order to determine the effect of kinesiological recreational activity, respectively recreational futsal in the body composition of passive football players. What should be emphasized is the fact that it is clear that there is a certain influence of this recreational kinesiological activity on some parameters of body composition, especially on the parameters of body fat tissue. The presented results of the analysis of the differences in the arithmetic mean for the assessment of body composition in passive football players involved in recreational futsal, show that there has been a significant reduction in body weight, body mass index, reduction in the amount of subcutaneous adipose tissue and visceral fat.

The results of this research are in line with the results of other research where it is emphasized that in the game of recreational futsal there are sequences with high physical loads, with an average heart rate of 80-85% of the maximum heart rate (Krustrup et al, 2009), which is similar to the values observed in professional football players (Altavilla et al., 2018) which significantly affect the reduction of body weight and subcutaneous adipose tissue. The results obtained also show that aerobic recreational content, such as recreational futsal, contributes significantly to the reduction of adipose tissue, body mass and other parameters of body composition that is consistent with research (Donnelly et al., 2009; D'Elia, 2018; D'Isanto et al., 2019; D'Isanto, 2019).

Some research shows that more intense forms of physical activity offer more benefits when it comes to reducing a person's body mass and health than moderate-intensity activities (Tsourlou, 2006). This is mainly due to the reduction of the risk of cardiovascular diseases as well as the increase of the function of the locomotor apparatus (Swain et al., 2006). In addition, the positive effects of high-intensity activities on reducing and maintaining optimal body weight, both in women and men, are well known (Donnelly et al., 2009).

It has been proven the fact that recreational futsal affects the increase of muscle strength and thus the increase of muscle mass at the expense of the reduction of body fat tissue. Many studies confirm the positive effects of exercise with sequences of submaximal intensity on muscle mass and strength (Binder et al., 2005; Hanson et al., 2009). Benefits from recreational kinesiological activity, respectively recreational futsal are evident in the increase of bone mass, which is confirmed in this research. Passive football players who practice recreational futsal have higher bone mass than

passive football players who are not involved in recreational physical activity. For this reason, many authors suggest that physical activity with an intensity of 75% -85% and a duration of more than 30 minutes is a key factor in strengthening and developing healthy bones at all stages of development (Vicente-Rodriguez, 2006; Khan et al., 2001; Gracia-Marco et al., 2011). Passive football players who practice recreational futsal have a higher percentage of water by 1.2%, (although statistically insignificant) compared with passive football players who are not involved in recreational physical activity.

The decrease in the percentage of water in the body is partly due to the increase in fat mass and the reduction in muscle mass which is consistent with the research of other authors (Gallagher et al., 1997; Baumgartner, 1998). Programs in the form of recreational activities such as recreational futsal significantly lead to more significant improvements in body composition compared to other recreational activities (Ho, 2012). As a conclusion, maintaining total body water is of utmost importance. Therefore, it is especially necessary to consider whether programs, such as those that increase muscle mass, and by increasing the total amount of water in the body, improve the body water decline that naturally occurs with age.

Conclusions

As a conclusion, it can be said that recreational futsal as physical activity is an effective tool to improve body composition not only in passive football players, but to all persons of all ages regardless of gender. Intensity and duration in recreational futsal is an effective way to reduce body fat in the population of passive middle-aged football players.

The data found showed that recreational futsal is less strenuous and less stressful than many recreational activities due to the fact that recreational futsal is a sport based mainly on fun and not on achieving a specific result or optimal performance, therefore it is more easily both physically and psychologically, so, participants feel better both physically and mentally when practicing this type of recreational activity.

This can be determined by the fact that participants, when practicing this activity, relax emotionally, forgetting that they are actually practicing. So recreational futsal reduces the factors that cause the appearance of many non-communicable diseases improves the overall well-being of the person.

Conflicts of interest

The authors declare that they have no conflicts of interest concerning this article.

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ВПЛИВ ОЗДОРОВЧОГО ФУТЗАЛУ НА СКЛАД ТІЛА В ПАСИВНИХ ФУТБОЛІСТІВ

Арбен Малікі^{1ABCD}, Блерім Сулеймані^{1ABCD}, Назім Міртай^{1ABCD}

¹Коледж ААВ

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів
Реферат. Стаття: 5 с., 1 табл., 30 джерел.

Метою цього дослідження була оцінка впливу оздоровчого футзалу на пасивних футболістів середнього віку в показниках складу тіла.

Матеріали та методи. Дослідження проводили на вибірці з 58 чоловіків віком від 30 до 40 років, середній вік $35,88 \pm 2,39$. Вибірку розподілили на дві групи. До першої групи входили 29 пасивних футболістів середнім віком $35,58 \pm 2,36$, які займалися оздоровчим футзалом 2-3 рази на тиждень, а до другої групи входили 29 пасивних футболістів середнім віком $36,17 \pm 2,42$, які не займалися оздоровчою фізичною активністю. Склад тіла оцінювали за допомогою аналізатора TANITA BC-601, методом біоелектричного імпендансу, який став еталонним методом аналізу складу тіла в наукових дослідженнях. Одержані такі змінні: висота тіла (см), маса тіла (кг), маса жиру (%), маса м'язів (кг), маса кісток (кг), індекс маси тіла ($\text{кг}/\text{м}^2$), споживання калорій – добове споживання калорій (ккал), життєздатність тіла, кількість води в тілі (%), вісцеральний жир (%).

Результати. Групи не відрізняються за такими змінними: висота тіла (висота тіла, НВН), споживання калорій –

добове споживання калорій (добове споживання калорій, DCI), життєздатність тіла (рівень базального метаболізму, BMR) та кількість води тілі (загальний об'єм крові, TBV), тому що $p > 0,05$. У тих змінних, за якими оцінювали масу тіла, масу жирової тканини та м'язів тіла, масу тіла (маса тіла, BWT), масу жиру (відсоток жиру в організмі, BFP), масу м'язів (загальна маса тіла, TBM), масу кісток (мінеральна щільність кісток, BMD), індекс маси тіла (індекс маси тіла, BMI) та вісцеральний жир (черевний вісцеральний жир, AVF), було одержано статистично значущу відмінність $p < 0,05$ на користь групи пасивних футболістів, які займалися оздоровчим футзалом.

Висновки. Можна сказати, що оздоровчий футзал як фізична активність є ефективним засобом покращення складу тіла не лише для пасивних футболістів, але й для всіх осіб усіх вікових категорій, незалежно від статі. Інтенсивні й тривалі заняття оздоровчим футзалом є ефективним способом зменшення вмісту жиру в організмі в генеральній сукупності пасивних футболістів середнього віку.

Ключові слова: оздоровчий футзал, склад тіла, пасивні футболісти, змінні.

Information about the authors:

Maliqi A.: arben.maliqi@aab-edu.net; <https://orcid.org/0000-0002-5324-7686>; Faculty of Physical Culture and Sports, AAB College in Pristina, Kosovo; Elez Berisha, 56, Industrial Zone, Pristina, 10000, Kosovo.

Sylejmani B.: blerim.sylejmani@aab-edu.net; <https://orcid.org/0000-0001-6814-560X>; Faculty of Physical Culture and Sports, AAB College in Pristina, Kosovo; Elez Berisha, 56, Industrial Zone, Pristina, 10000, Kosovo.

Myrtaj N.: nazim.myrtaj@aab-edu.net; <https://orcid.org/0000-0003-0590-3519>; Faculty of Physical Culture and Sports, AAB College in Pristina, Kosovo; Elez Berisha, 56, Industrial Zone, Pristina, 10000, Kosovo.

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ORIGINAL SCIENTIFIC ARTICLE

MODERN APPROACHES FOR THE PHYSICAL TRAINING OF YOUNG FEMALE BASKETBALL PLAYERS

Oksana Komotska^{1ABCDE} and Ruslana Sushko^{1ABCDE}

¹Borys Grinchenko Kyiv University

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

Corresponding Author: Ruslana Sushko, E-mail: r.sushko@kubg.edu.ua

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Abstract

The study purpose was to substantiate, develop and test the effectiveness of the author's program for physical training of young female basketball players in the pre-competition period of the macrocycle preparatory stage, and to experimentally test its effectiveness.

Materials and methods. The subjects were 15 young female basketball players born in 2007-2008, third year of study (1st year of study in the basic training group), members of the All-Ukrainian Youth Basketball League (AUYBL), who participated in the experimental program to improve their physical fitness. Three tests on six indicators of physical fitness were conducted. The results of a consecutive experiment for young basketball players during their training in the camp were analyzed and interpreted.

Results. The author's program for physical training of young female basketball players was developed and implemented during the training camp in order to increase their level of physical fitness and preparation for participation in the AUYBL competitions. The results of the study, which were obtained during a series of experiments, allowed to examine and analyze six indicators of physical fitness, and to substantiate the effectiveness of modern approaches to physical training of young female basketball players in the pre-competition period of the macrocycle preparatory stage. They were based on the minimization of additional workload and focused concentration of female athletes on the quality of specific exercises in a limited period.

Conclusions. The analysis of the results, the indicators of physical fitness of young female basketball players, allows to state that the use of the author's program for physical training makes it possible to record the improvement of physical fitness on tests that have speed-strength and strength orientation, namely: high jump, long jump, run for 40 s, flexion-extension of the arms at thrust lying for 30 s. According to the indicators of speed tests (20 m run and 60 m sprint), no statistically significant differences were recorded, with a tendency to their improvement.

Keywords: basketball, program, physical training, physical fitness, training camp.

Introduction

Competitiveness of national basketball teams (national, youth, junior, and cadet) at the international level is due to the presence of an effective process for training (theoretical, technical, tactical, psychological, physical, and integral) at all stages of long-term improvement (Pluta & Andrzejewski, 2018; Teck, Wang, & Mallett, 2012). The final unresolved complex issues of the correlation between general and special physical training, taking into account the role and age characteristics of players, indicates the possibility of improvement in this area, which is emphasized by the publications of influential scientists (Villa & Lozano, 2018; Koryahin, Blavt,

& Ponomaryov, 2019). The motivational orientation of physical training taking into account the basketball players' psychotype, their leading representative system (audio, visual, and kinaesthetic) are substantiated with the experimental research of specialists. The issues of diagnosis of psychological sex, determination of sexual dominance of the individual (androgyny, muscularity and femininity) taking into account the level of psychophysiological stress in competitive activities are the matter of importance too (Sushko et al., 2019).

Coaching approaches to technical and tactical training based on morph functional specialization of the body, which is a necessary prerequisite for physical training of athletes, are noted to be effective (Tyshchenko et al., 2018; Doroshenko et al., 2019; Koryahin et al., 2018; Oliynyk et al., 2021).

The exploring of the possibilities of theoretical training and a significant contribution to the effectiveness of the

training process through the immersion of athletes in a thorough understanding of the methodology and selection of effective tools are proven by specialists studying this subject (Bohuslavska et al., 2020). Professional scientific discussion is more focused on different attitudes to integrated training, the basis of which is physical training that requires strategically new approaches, generalization and systematization of experimental results (Chucha et al., 2020). The issues of athletes' recovery and stimulation of their working capacity in various structural components of the macrocycle remain promising for further implementation (Mustafa Asaad Munsheed Al-Fartusi, & Sushko, 2015; Scanlan et al., 2018). However, the current level of physical fitness of players is the priority for influence on the result of the match at the present stage of basketball development. It allows in specific conditions of competitive activity and highly competitive struggle to effectively realize the available technical and tactical potential of athletes (Ricardo Ferraz et al., 2021). These characteristics are not the exclusive advantage of professional players, but relate to the problematic issues of physical training at all stages of sports improvement of basketball players (Cieslicka et al., 2019). From this perspective, the normative indexes of indicators of physical fitness in the curricula of children's and youth sports schools have reduced informativeness due to the heterochrony of physical development of young basketball players. This indirectly affects the level of young basketball players' motor skills development and performance indicators of their competitive activities. Increasing the volume and intensity of physical activity at a young age leads to a temporary improvement in performance, but with further negative consequences for both integrated fitness and the health of athletes (Platonov & Bolshakova, 2013; Koryahin, Blavt, & Ponomaryov, 2019).

Thus, modern methodological approaches to physical training of young basketball players should be formed taking into account the following factors: determining the optimal ratio of general and special exercises in physical training, individualization of training based on the pace of physical development and the formation of positive emotional background during training.

This study presents the author's program of physical training for girls born in 2007 during their training in a camp, which aims to predominantly develop the motor skills of young female basketball players in the pre-competition period of the macrocycle's preparatory stage for quality preparation for the All-Ukrainian Youth Basketball League (AUYBL).

Hypothesis. Directed use of special exercises in the limited period of the preparatory process would help to increase the level of physical fitness of young female basketball players.

The study purpose was to substantiate, develop and test the effectiveness of the author's program of physical training of young female basketball players in the pre-competition period of the macrocycle's preparatory stage, and to experimentally test its effectiveness.

Materials and methods

Study participants

15 young female basketball players born in 2007-2008, third year of study (1st year of study in the basic training

group), members of the All-Ukrainian Youth Basketball League (AUYBL), took part in the experimental program to improve physical fitness.

Study organization

Experimental research was conducted on August 16-30, 2020 in Bar (Ukraine) during the training camp of young female basketball players born in 2007-2008 with the implementation of the author's physical training program for further participation in the All-Ukrainian Youth Basketball League with the Basketball Federation of Ukraine's patronage.

The author's program of physical training is implemented and the pedagogical testing on six indicators according to the curriculum for children's and youth sports school, sports children's and youth school of the Olympic reserve, school of higher sporting skills and specialized educational institutions in a sports field (Poplavsky et al., 2019) is carried out, the received results of an interpreted experiment are analyzed.

The implementation of the author's program involved three stages of control through comparative analysis of the results of testing the level of physical fitness. 16.08.2020 – the first stage (control and diagnostic), before starting the program implementation; 29.08.2020 – the second stage (control and analytical), after the implementation of the program; 14.09.2020 – the third stage (control-comparative), to check the delayed effect of the implementation of the physical training program. All participants and their parents gave informed consent to participate in a pedagogical experiment in accordance with the bioethical standards of the Helsinki Declaration of the World Medical Association "Ethical principles of medical research with human participation as an object of study" (latest version 1.10.2008 Helsinki Declaration, 2008).

Tests and their organizational and methodological guidelines are presented below:

1. 20 m run, s

It is recommended to run the 20 m distance at maximum speed without stopping at the finish line.

2. Jumping height, cm

First, the player's point is fixed with the raised hand up standing in a profile at the wall. The jump is performed in a convenient position for the player near the wall (face, side). The second point is fixed after the player jumps out vertically upwards as high as possible. The difference between the indicators is the height of the player's jump. The best result of three attempts is scored.

3. Long jump, cm

The point of the maximum long jump is fixed from the defined line; the measurement is registered on the player's heels. The best result of three attempts is scored.

4. Run for 40 c, m

The player expects his own strength to move for 40 s (running face forward) from one to another front line of the basketball court, trying to overcome a greater distance as possible, which is scored as the result. After the whistle, the player must stop to count the distance.

5. 60 m sprint, s

It is recommended to run the 60 m distance at maximum speed, without stopping at the finish line.

6. Flexion-extension of the arms at thrust lying for 30 s.

The number of flexions / extensions of the arms performed at a flat torso position and the maximum possible bending angle is scored.

Table 1. Indicative indicators of the effectiveness of tests to determine the level of physical fitness according to the children's and youth sports school's curriculum (basic training, 1st year of study, girls)

Value	Test number / Result					
	1, s	2, cm	3, cm	4, m	5, s	6, qty
satisfactory	4.1-4.3	35-41	160-174	172-175	9.6-10.1	10
good	3.6-4.0	42-46	175-189	175-181	8.9-9.5	11
excellent	3.5	47	190	182	8.8	12

Notes: 1 – 20 m run, s; 2 – Jumping height, cm; 3 – Long jump, cm; 4 – Run for 40 s, m; 5 – 60 m sprint, s; 6 – Flexion-extension of the arms at thrust lying for 30 s, qty.

The team of young female basketball players born in 2007-2008 from Kyiv sports children's and youth school of the Olympic reserve in basketball took the 4th place in the championship of the AUYBL season 2019/2020. The desire to improve the result in the next game season has led to the combined efforts of the scientific group and coaching staff to improve approaches to physical, technical, tactical and psychological training of young female basketball players.

The planned work provided a comprehensive interaction in the training process during the preparatory and competitive periods with the use of modern approaches to coaching and taking into account the proposals of the scientific group on load correction. The experiment is based not on the novelty of exercises and increasing the volume and intensity of loads, but modern coaching approaches to achieving quality performance of simple exercises by maximizing the specification of tasks and specifying the requirements for their implementation.

The selected tests and the author's program provided for the identification of informative indicators and further targeted work to improve the speed and strength qualities of female players. The set of exercises of the program does not contain a direct repetition of test exercises.

The first joint work was implemented during the training camp for physical training of young female basketball players. It is worth noting that before the first test, the young athletes

spent two weeks of a macrocycle after a long rest. The second test was made immediately after the end of the training camp with the use of the author's program to improve physical fitness, the third test required to identify the delayed effect of the work.

After the first testing, an experimental program for improving physical fitness was implemented into the training process of young female basketball players, which consisted of performing special exercises, which are additionally designed for 15-20 minutes of work after each training session. The program has three blocks, each of which consists of seven training sessions.

Statistical analysis

The obtained informative data of experimental researches were processed by descriptive statistics. Methods of the parametric statistics (the arithmetic mean value, standard deviation) were used in the study due to the fact that samples of testing results of the level of physical fitness of young female basketball players born in 2007-2008 complied with the law of normal distribution (verified by the Shapiro-Wilk index).

The statistical significance of the difference between the indicators of testing the level of physical fitness of young female basketball players by dates, namely 16.08.2020, 29.08.2020, 14.09.2020, was determined using the Student's criterion for paired samples (Vincent, 2005; Lang, Altman, 2013; Alexandropoulos et al., 2019).

Mathematical and statistical processing and analysis of data were performed using the computational and graphical capabilities of such software program, as Statistica (StatSoft, version 10.0) and Microsoft Excel 2010.

Results

Analysis of indicators of physical fitness, presented in table 2, allows to state that during the training camp (16.08.2020 – 29.08.2020), the use of the author's program of physical training resulted in improving of physical fitness on tests that have speed-strength and strength orientation, namely:

- Jumping height, 37+3 cm (16.08.2020) and 38+2 cm (29.08.2020) accordingly; differences are statistically significant at the level, $p < 0.001$;
- Long jump, 181+23 cm (16.08.2020) and 184+20 (29.08.2020) accordingly; differences are statistically significant at the level, $p < 0.01$;

Table 2. Dynamics of results of testing the level of physical fitness of young female basketball players born in 2007-2008

No	Test	Date of the test				29.08.2020 vs		Date of the test		14.09.2020 vs	
		16.08.2020		29.08.2020		16.08.2020		14.09.2020		29.08.2020	
		X	S	X	S	t	p	X	S	t	p
1	20 m run, s	3.89	0.13	3.86	0.13	2.09	0.055	3.83	0.12	2.80	0.014
2	Jumping height, cm	37	3	38	2	4.01	0.001	39	2	1.78	0.096
3	Long jump, cm	181	23	184	20	3.09	0.008	188	15	2.36	0.033
4	Run for 40 s, m	176	9	180	6	5.08	0.001	181	5	4.73	0.001
5	60 m sprint, s	9.59	0.47	9.51	0.41	1.47	0.165	9.36	0.42	4.55	0.001
6	Flexion-extension of the arms at thrust lying for 30 s, qty	13.8	2.3	15.3	1.4	3.77	0.002	16.3	1.5	4.30	0.001

EXPERIMENTAL PROGRAM
for improving physical fitness of young female basketball players
(21 training sessions)

Block I (7 training sessions)

No	Content	Dosage	Organization and methodology of the exercise
1	Lifting and lowering on toes (stairs, bench)	3 sets of 15-20 times on each leg	the pace is dynamic, but not fast; the maximum amplitude is important
2	Steppe on the spot + steppe across the line + 6 m acceleration	3 sets of 10 s + 10 s	arms up, elbows bent – 90° angle
3	Jumping rope on two legs	3 sets of 100 times	jumps due to elastic repulsion of the feet, the heel does not touch the floor, the knees are almost straight
4	Running on the spot with a high rise of the thigh	3 sets of 10 s	performance with the maximum frequency and amplitude, special concentration on the arm movements speed
5	Plank in the supine position	3 sets of 15 s	arms bent at the elbows, armrests at the expense of elbows and palms

Block II (7 training sessions)

No	Content	Dosage	Organization and methodology of the exercise
1	Lifting and lowering on toes (stairs, bench)	3 sets of 15-20 times on each leg	the pace is dynamic, the amplitude is maximum
2	Steppe on the spot + jumping line with both feet back and forth + 6 m acceleration	3 sets of 10 s + 10 s	arms up, elbows bent – 90° angle
3	Jumping rope on two legs	3 sets of 100 times	jumping as fast as possible with an emphasis on the minimum time for repulsion
4	Running on the spot against the wall	3 sets of 15 s	maximum speed, emphasis on the height of the knee
5	Plank in the supine position	3 sets of 20 s	arms bent at the elbows, armrests at the expense of elbows and palms

Block III (7 training sessions)

No	Content	Dosage	Organization and methodology of the exercise
1	Lifting and lowering on toes (stairs, bench)	3 sets of 15-20 times on each leg	the pace and amplitude are maximum
2	Steppe on the spot + steppe running on the bench + 6 m acceleration	3 sets of 10 s + 10 s	arms up, elbows bent – 90° angle
3	Jumping rope on two legs	3 sets of 100 times	jumping as fast as possible with an emphasis on the minimum time for repulsion
4	6 m starting acceleration	5 times	it is important to perform with maximum concentration and powerful repulsion
5	Plank in the supine position	3 sets of 30 s	arms bent at the elbows, armrests at the expense of elbows and palms

- Run for 40 s, 176+9 m (16.08.2020) and 180+6 m (29.08.2020) accordingly; differences are statistically significant at the level, $p < 0.01$;
- Flexion-extension of the arms at thrust lying for 30 s, 13.8+2.3 (16.08.2020) and 15.3+1.4 (29.08.2020) accordingly; differences are statistically significant at the level, $p < 0.001$.

According to the indicators of speed tests (20 m run and 60 m sprint) no statistically significant differences were recorded, with a tendency to improve the indicators of physical fitness of speed orientation:

- 20 m run, 3.89+0.13 (16.08.2020) and 3.86+0.13 (29.08.2020) accordingly;

- 60 m sprint, 9.59+0.47 (16.08.2020) and 9.51+0.41 (29.08.2020) accordingly.

Experimental studies of the level of physical fitness of young female basketball players also included checking the presence of the delayed effect of the author's program of physical training.

A comparative analysis of the indicators of physical fitness of young female basketball players after the training camp (29.08.2020) and two weeks later (14.09.2020) shows (see Table 1) that the results of tests of speed-power, speed and power orientation are statistically significant differences – higher indexes were recorded in the tests conducted after the training camp and two underlying microcycles

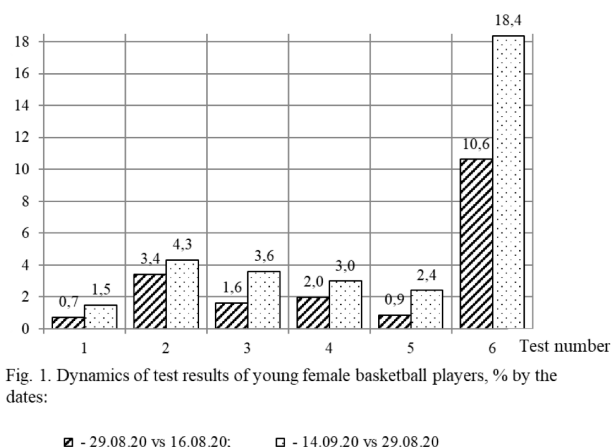


Fig. 1. Dynamics of test results of young female basketball players, % by the dates:

■ - 29.08.20 vs 16.08.20; □ - 14.09.20 vs 29.08.20

(14.09.2020). Exceptions are the results of testing the Jumping height 38+2 cm (29.08.2020) and 39+2 cm (14.09.2020), accordingly, while maintaining the general trend to improve the physical fitness of young female basketball players based on the accumulation of delayed effect during the next two consecutive underlying microcycles.

Figure 1 shows the dynamic characteristics of testing the level of physical fitness of young female basketball players after the implementation of the author's program of physical training.

To visually compare the results of testing the physical fitness of young female basketball players in the dynamics (according to the exercises shown in Table 1), which have different units of measurement, the data are scaled so that they fall into a specific interval (see Fig. 2).

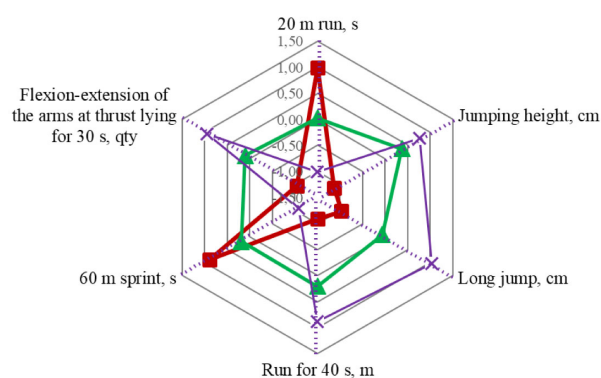


Fig. 2. Dynamics of test results (standardized indexes) of young female basketball players by the dates:

■ - 16.08.20 ▲ - 29.08.20 × - 14.09.20

It is recommended to use this operation for processing certain comparison indicators and their evaluation in order to remove data limits and turn them into dimensionless universal value. Thus, different, according to the scales of the test results, you can compare the results in different units or indexes. The most typical, in this context, is the standardization of data; precisely their equal distribution is reflected in the range (0,1).

In the process of mathematical and statistical processing of experimental results, standardization includes the trans-

formation of data by subtracting each value from a reference value (usually the average value of the sample) and dividing it by the standard deviation (usually sample SD). When applied to inputs, standardization makes the results of various statistical methods completely independent of ranges of values or units of measurement. This procedure allows to unify the values of indicators (regardless of their distribution and initial units of measurement) to compatible units of distribution with an average value of 0 and a standard deviation of 1. This procedure has a wide range of applications in the processes of mathematical and statistical processing of indicators, as it provides a distribution of values that can be used in the process of comparative analysis of experimental parameters in the dynamics of the preparation process.

Discussion

The basis for crucial issues of the study is the hypothesis of the possibility of targeted use of special exercises in a limited time of the preparatory process of young female basketball players in order to increase their level of physical fitness. The substantiation of such possibility is based on the analysis and systematization of scientific literature, personal pedagogical observations and authors' pedagogical experience. The results of experimental research allow us to state that the targeted use of special exercises in the limited period of the preparatory process helps to increase the level of physical fitness of young female basketball players, and the hypothesis is true.

Certain positions of scientific novelty have been defined in the process of elaboration and systematization of the obtained results of experimental researches. For the first time, the possibility of improving the physical fitness of young female basketball players based on the targeted use of special exercises in the limited period of the preparatory process has been proven in contrast to current theoretical and methodological provisions on the development of motor skills in basketball, which do not specify their timing (Koryahin et al., 2018, 2020; Doroshenko et al., 2019).

In other studies, the chronological limits of the use of special exercises are determined, but without taking into account the structural period of the macrocycle of training – the micro- or mesocycles of training, training camps. In particular, 6-week programs of plyometric training are considered by Gokmen Ozen, Ozdemir Atar, and Hurmuz Koc (2020) to be effective for young basketball players' physical abilities. This thesis also applies to a study (Tuan Tran Minh & Cuong Tran Ngoc, 2022), which identified the effects of a 15-week club-based basketball training program for the integrated development of physical and technical-tactical abilities without limiting the use of special exercises.

Also, for the first time, the possibility of using the author's training program in the preparatory process of young female basketball players as an integral part of preparation for the official national competitions – the All-Ukrainian Youth Basketball League games – has been proven. At the same time, the study (Doroshenko et al., 2020) emphasizes that training programs in the preparatory process of young female basketball players, which are aimed at intensifying their training, can negatively affect the integrated training of athletes in the subsequent stages of sports improvement – the stage of preparation for higher sporting achievements, the stage of maximum realization of individual capabilities, etc.

However, the thesis of the short-term positive effect of training programs on the level of physical fitness of young female basketball players is not denied (Platonov & Bolshakova, 2013), which, in our opinion, makes it possible to use such programs, although with some caution - no often than 1-2 times per macrocycle training.

Besides, the data on the development and improvement of young female basketball players' physical abilities in the preparatory period of the macrocycle were supplemented based on the results of the study. At the theoretical level, the results of scientific research (Platonov, 2017) on the development of leading physical qualities of female athletes in team sports games (speed-power and special endurance) and their implementation in the process of long-term improvement were deepened. At the methodological level, the scientific results (Ricardo Ferraz et al., 2021) have been supplemented, regarding the effect of similar training programs on the indicators of integrated basketball players, including the accuracy of throwing the ball into the basket.

The dialectical issues of improving the physical fitness of young female basketball players, namely, their early game specialization, have also been supplemented. Onishchenko and Mitova (2015) emphasized that the factors of heterochrony of physical development and the current level of physical capabilities are important in the problematic issues of early game specialization of young female basketball players. At the same time, without taking into account prognostic markers in the process of physical training, early specialization significantly reduces the competitiveness of young female basketball players in the subsequent stages of sports improvement due to reduced performance and tactical experience in other (adjacent) positions (Kozina et al., 2017; Chucha et al., 2020).

A group of data of scientific novelty and the further development of theoretical and methodological provisions has been also identified while processing the results of experimental research. In particular, the results of scientific research on the motivational component in the educational process of young female basketball players were further developed due to the peculiarities of communication with this specific group and the formation of motivation for sports improvement (Koryagin et al., 2019; Sushko et al., 2019) the influence of psychological factors on the results of test exercises on physical fitness of young female basketball players has been revealed.

Data on finding the most rational correlations of general and special means in the process of physical training programs for young female basketball players at the stages of preliminary or specialized basic training were further developed (Doroshenko et al., 2020; Gokmen Ozen et al., 2020). This indicates the need to modify modern approaches to the training programs aimed at the effective realization of the individual potential of young female basketball players based on the morpho-functional specialization of their body.

Perspectives for further research are based on in-depth study and testing of modern methodological approaches to improving special physical fitness in various structural elements of the macrocycle of training young female basketball players aimed at developing speed and strength through the use of special physical training exercises.

Conclusions

Analysis of the results, precisely indicators of physical fitness of young female basketball players, allows us to

state that the use of the author's program of physical training made it possible to record the improvement of physical fitness on tests that have speed-strength and strength orientation, namely: jumping height, long jump, run for 40 s, flexion-extension of the arms at thrust lying for 30 s. According to the indicators of speed tests (20 m run and 60 m sprint) no statistically significant differences were recorded, with a tendency to their improvement.

The hypothesis of the effectiveness of targeted use of special exercises in the limited period of the preparatory process (in the training camps), which contributes to the positive dynamics of improving physical fitness and individual potential of young female basketball players is confirmed based on the results of the study.

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Conflict of interest

Authors have declared that no competing interest exists.

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СУЧАСНІ ПІДХОДИ ДО ФІЗИЧНОЇ ПІДГОТОВКИ ЮНИХ БАСКЕТБОЛІСТОК

Оксана Комоцька^{1ABCDE}, Руслана Сушко^{1ABCDE}

¹Київський університет імені Бориса Грінченка

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

Реферат. Стаття: 8 с., 2 табл., 2 рис., 28 джерел.

Мета дослідження – обґрунтувати, розробити і перевірити ефективність програми фізичної підготовки юних баскетболісток у передзмагальному періоді підготовчого етапу макроциклу і експериментально перевірити її ефективність.

Матеріали та методи. Контингент – 15 юних баскетболісток 2007-2008 р.н., третього року навчання (1й рік навчання у групі базової підготовки), учасниць Всеукраїнської юнацької баскетбольної ліги (ВЮБЛ), які взяли участь у експериментальній програмі з метою підвищення рівня фізичної підготовленості. Тричі проведено тестування за 6 показниками фізичної підготовленості. Проаналізовано та інтерпретовано результати послідовного експерименту під час навчально-тренувального збору юних баскетболісток.

Результати. Розроблено і під час навчально-тренувального збору впроваджено авторську програму фізичної підготовки юних баскетболісток з метою підвищення їх рівня фізичної підготовленості і підготовки до участі у змаганнях ВЮБЛ. Результати дослідження, отримані в ході проведення послідовного експерименту, дозволили вивчити і проаналізувати 6 показників фізичної підготовленості,

обґрунтувати ефективність сучасних підходів до фізичної підготовки юних баскетболісток у передзмагальному періоді підготовчого етапу макроциклу, засновані на мінімізації додаткового навантаження і акцентованій концентрації уваги спортсменок на якості виконання специфічних вправ у лімітований період.

Висновки. Аналіз отриманих результатів - показників фізичної підготовленості юних баскетболісток дозволяє констатувати, що використання авторської програми фізичної підготовки дозволило зафіксувати покращення показників фізичної підготовленості за тестами, які мають швидко-силову та силову спрямованість, а саме: висота підскоку, стрибок у довжину з місця, біг протягом 40 с, згинання-розгинання рук в упорі лежачи за 30 с. За показниками тестів швидкісної спрямованості (біг 20 м і спринт 60 м) статистично значущих відмінностей не зафіксовано, при наявній тенденції до їх покращення.

Ключові слова: баскетбол, програма, фізична підготовка, фізична підготовленість, навчально-тренувальні збори.

Information about the authors:

Komotska Oksana: o.komotska@kubg.edu.ua; <https://orcid.org/0000-0003-3109-1120>; The Faculty of Health, Physical Training and Sports, Borys Grinchenko Kyiv University, Marshala Tymoshenko St, 13-B, Kyiv, Ukraine.

Sushko Ruslana: r.sushko@kubg.edu.ua; <https://orcid.org/0000-0003-3256-4444>; The Faculty of Health, Physical Training and Sports, Borys Grinchenko Kyiv University, Marshala Tymoshenko St, 13-B, Kyiv, Ukraine.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF DAY TIME ON COGNITIVE PERFORMANCES OF PREADOLESCENT ATHLETES NURTURED IN A CONTROLLED ENVIRONMENT

Manohar Kumar Pahan^{1,2ABCD} and Mahendra Kumar Singh^{1AD}

¹Lakshmbai National Institute of Physical Education

²Ramakrishna Mission Vivekananda Educational and Research Institute

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

Research purpose. The study aimed to examine how the cognitive performances of preadolescent sports trainees living and training under a controlled environment are affected during the three different day times.

Materials and methods. The research involved 16 male sports trainees from the Jharkhand State Sports Promotion Society, Ranchi, who varied in age from 11 to 14 years and had a minimum of two years of training experience in the same academy. To assess cognitive performance like long-term focused attention, ability to react, logical reasoning, reactive stress tolerance, and visual perception, the TATEENS 2 test set from the Vienna Test System was administered. The percentile ranks of all five tests were compared between three different times of the day. The Friedman test and rANOVA were employed to analyze the data of repetitive measurements. The significance level was set at $p < 0.05$.

Results. The p-values for statistical comparisons of reactive stress tolerance, visual perception, logical reasoning, reaction abilities (reaction time and motor time), and long-term focused attention at three different times of the day were all more than 0.05.

Conclusion. Different day times did not significantly affect the cognitive performances of preadolescent sportspersons who lived and trained under similar conditions.

Keywords: time of day, long-term focused attention, reaction ability, logical reasoning, reactive stress tolerance, visual perception, young athletes, Jharkhand.

Introduction

The primary objective of performance research is to find ways to improve physical and mental performances by discovering strategies that provide marginal improvements. Athletic success is determined by the tiniest of margins at the greatest levels of competition and the demand for determining new ways in which to obtain an advantage remains highly desirable (Facer-Childs et al., 2018). Sporting success is not a result of few training years rather it is a result of several training years. Enhancing the physical abilities of children throughout childhood and adolescence to maximize athletic success at adulthood is the goal of youth-based training program used for long term athletic development (Bompa, 1999). For enhancing sporting performance from

grass root level along with physical training, psychological training is necessary to inculcate psychological skills to tackle psychological issues that affect sporting performance (Bali, 2015). As performance is not only influenced by physical features, but also by cognition, social context, and the environment in which the activity is carried out (Georgiou et al., 2007; Becchio et al., 2008). Sports are considered to be composed of 90% mental and 10% physical activity (Sinclair & Geige, 2000; Abbas & Jasim, 2018). The behaviour observed in sport is apparent, but the psychological aspect that is responsible for such behaviour may not be directly detected (Raglin, 2001). There are several psychological factors that affect motor behaviour (Stefani et al., 2015) one such ability that influences both motor behaviour and athletic performance is information processing capability (Plessner & Haar, 2006).

The information processing under cognitive approach describes encoding and flow of information by the recep-

tors, and the stages through which this information is processed until a decision is made and a response is executed (Marteniuk, 1976; Singer, 1980). In the stage between perceiving the information through the sensory system (input) and implementing a motor response (output), the cognitive-perceptual mechanism identifies, organizes, and analyzes the information for the purpose of decision making (Singer, 1980).

Biological cycles, in addition to cognitive factors, may have an impact on performance (Ayala et al., 2020). All living organisms' internal cycles (Postolache et al., 2020; Okusaga & Postolache, 2013) are responsible for periodic natural changes in chemical or biological processes (Gabbey, 2019). This is an internal master clock that regulates the body's other clocks, such as the circadian, diurnal, ultradian, and infradian clocks (Ayala et al., 2020). The circadian refers to the periodic changes that follow a 24-hour cycle (Postolache et al., 2020) synchronised by exogenous factors such as light and social cues (Dijk et al., 2012; Shanahan et al., 1997). A day and night cycle is referred to as a diurnal rhythm (Vitaterna et al., 2001). The ultradian cycle is a daily cycle that lasts less than 20 hours, whereas the infradian cycle is a biological cycle that lasts more than 28 hours (Ballastella et al., 2019).

Aside from biological cycles, the time of day at which a skill is performed affects athletic performance (Rodahl et al., 1976). This is determined by an athlete's chronotypology, or sleep-wake rhythm (Putilov, 2017). It is often divided into three chronotypes: early, late, and intermediate (Roenneberg et al., 2003). The sleep-wake cycle has an impact on an individual's psychological and physiological functioning as well as their behaviour (Roenneberg et al., 2003; Bailey & Heitkemper, 2001). The early chronotype, also known as the morning lark, has an earlier sleep-wake cycle than the late chronotype, often known as the night owl (Putilov et al., 2015).

According to evidence from previous studies, type of task and time of day influence cognitive performance (Heijden et al., 2010; Mazzucco et al., 2017), attention and memory (Guerrien et al., 1993), executive control and processing speed (Allen et al., 2008), alertness (West et al., 2002), long-term explicit memory (Maheu et al., 2005; Ramírez et al., 2006; Ralph et al., 2002), sustained attention (Riley et al., 2017), and executive functions (Lara et al., 2014).

Cognitive and physical task performed at day time has a relation with the sleep-wake pattern of an individual (Van Dongen, & Dinges, 2005) that influences psychomotor performance (Payne, 1989), attentional performance, response time, and visual scanning, physical performance, maximum-intensity power (Petit et al., 2013), and psychomotor vigilance; reaction time, and attention (Rosa et al., 2021).

Research indicated, physical performance is linked to an individual's cognitive functioning in a specific setting. However, the previous study only tested one or a few aspects of cognitive capacity. Competitions, like sports, may be planned at any time of day and need strong executive functioning for extended periods of time (Sanders, 1983). As a result, all of the executive functions that are necessary in any sport, regardless of how high or low the stakes must be evaluated in a single trial.

There are various mental activities that may be used to determine or test an individual's cognitive level. (Schuhfried, 2016a) identified some common cognitive dimensions

required in every sports, such as focused attention, logical reasoning, reaction time, reactive stress tolerance, and visual perception. The capacity to filter out information pertinent to a choice from a distracting backdrop is referred to as "focused attention." The capacity to recognise systematic methods, patterns, or relationships and make accurate conclusions is referred to as logical reasoning. The ability to respond refers to the ability to react rapidly and efficiently to stimuli, and it is separated into two sections which are reaction speed and motor speed. Reaction speed refers to how quickly an athlete can react to a stimulus, while motor speed refers to how quickly an athlete can complete a single activity. Reactive stress tolerance is a component of attention that evaluates ability to quickly and appropriately reaction to the stimuli along with mental resilience. Visual perception is the ability to see and understand complicated visual clues (Schuhfried, 2016-b).

The study's purpose: The goal of the study was to see how the cognitive performances of preadolescent sports trainees living and training in a controlled environment for minimum of two years are altered at various times of the day.

Materials and methods

Study participants

Selection of Subjects: The study included 16 male sports participants from the Jharkhand Sports Promotion Society. The participants ranged in age from 11 to 14 years old, with a minimum of two years of training and living experience at the academy.

Study organization

Selection of Variables: Focused attention, reaction ability (both reaction and motor speed), logical reasoning, reactive stress tolerance, and visual perception were the factors considered for the research. The independent variables were three separate time ranges (morning 7am-9am, lunchtime 11am-1pm, and evening 3pm-5pm), while the percentile rankings of the chosen variables were preserved as dependent variables.

Selection of Test and Instrument: The administration was done using the TATEENS 2 test set. Five independent tests are included in the test set, each measuring a different characteristic, such as focused attention, reaction ability (which measures reaction and motor speed), logical reasoning, reactive stress tolerance, and visual perception. The test set is described in full in Table 1. The Vienna test system, developed by Schuhfried GmbH, a computerised testing tool, was used to evaluate the cognitive domain. The PR (percentile rank) of the chosen variables was used for scoring.

Consent: Because the athletes were minors (under the age of 18), permissions were obtained from the academy's administration and the athlete's in-charge. Each participant was told about the test ahead of time, and their consent was also obtained.

Test procedure and time frame: To minimise a sudden shift in score from the first to the third test and to familiarise the participant, seven days of training with comparable activities were provided. The time and day of the tests were assigned at random, such that a participant who was tested

Table 1. Test Description of Cognitive Tasks

Dimensions	Tests	Test form	Duration in minutes	Scoring (Percentile Ranks)
Long-term focused attention	SIGNAL	S3	Approx. 25	Number of correct and delayed
Ability to react	RT	S3	Approx. 6	Mean reaction time
	MT			Mean motor time
Logical reasoning	AMT	S4	Approx. 15	General intelligence
Reactive stress tolerance	DT	S1	Approx. 6	Correct response
Visual perception	LVT	S2	Approx. 13	Test Score
Total length if all dimensions presented			Approx. 65	

SIGNAL = Signal Detection, RT = Reaction Time, MT = Motor Time, AMT = Adaptive Matrices Test

DT = Determination Test, LVT = Visual Pursuit Test

in the morning would be retested at noon or evening in the follow-up test. The first test was administered after a ten-day break from training, and the subsequent tests were given at one-month intervals. The instructions were presented in the same consistent way each time the subject requested administration. The date and time of the tests were notified in advance. The tests were administered from 7am to 5pm (morning 7am-9am, noon 11am-1pm, and evening 3pm-5pm). The participants were only permitted to depart when the test had been successfully completed. A practise set was provided by the computer software prior to the start of each test. The actual testing began when the subject acknowledged the practise set. An introspective report (feedback) was gathered at the end of test, and the incentive was delivered.

Statistical Analysis

To ensure data normality, the Shapiro-Wilk test was used. Friedman test was used to compare measures of logical reasoning (AMT) and rANOVA was used to compare measures of reaction ability (AR) and reactive stress tolerance (DT) for data collected at three different times of the day. The level of significance was preserved at $p < 0.05$. The mean values of percentile rankings were used to develop the profile chart.

Results

Table 2 shows the descriptive statistics for the examined variables. In the result, it can be observed that the mean scores of reactive stress tolerance (DT), focus attention (SIGNAL), visual perception (LVT), and reaction speed (RT) and motor speed (MT) associated with to the ability to react (AR) are nearly equal to their median values. Following Shapiro-Wilk tests, it was inferred that these data were normally distributed. The descriptive scores of focused attention (SIGNAL) and visual perception (LVT) were found to be exactly equal in the morning, noon, and evening sessions. Data for logical reasoning (AMT) was not normally distributed in any sessions.

A descriptive graph of cognitive functions at three distinct times of the day is shown in Figure 1. The descriptive information of SIGNAL and LVT in Table 2 were determined to be equivalent. The visual presentation of data in Figure 1 (A) SIGNAL and Figure 1 (F) LVT showed minimal variations.

Table 3 displays the results of comparative statistics using the Friedman test for non-normal data sets (NP) and the rANOVA test for normally distributed data (P). Because the data for SIGNAL and LVT were determined to be equivalent, no comparisons were made for these variables (NCP). As the RT and MT under AR were shown to violate the sphericity assumption, Greenhouse-Geisser degrees of freedom were

Table 2. Descriptive Statistics of Percentile Ranks of Cognitive Performances at Three Different Times of Day

Dimension (Variable)	Time									
	Morning			Noon			Evening			
	Mean ± SD	Median (IQR)	Shaipro- Wilk	Mean ± SD	Median (IQR)	Shaipro- Wilk	Mean ± SD	Median (IQR)	Shaipro- Wilk	
SIGNAL	88.68 ± 6.71	88 (8.25)	0.443	88.68 ± 6.71	88(8.25)	0.443	88.68 ± 6.71	88(8.25)	0.443	
AR	RT	95.31 ± 3.77	95.5 (6.75)	0.121	95.18 ± 3.69	95.5 (6)	0.918	95.25 ± 3.78	95 (6.75)	0.907
	MT	85.75 ± 5.80	86.5 (7.5)	0.419	85.56 ± 5.46	86.5 (6.5)	0.406	85.25 ± 5.58	86.5 (7.5)	0.305
AMT	48.06 ± 13.77	45 (26.25)	0.006*	48.13 ± 13.81	45 (27)	0.007*	48.44 ± 14.19	45 (27)	0.010*	
DT	62.37 ± 11.73	61 (23)	0.276	62 ± 11.49	61 (22.5)	0.22	61.93 ±11.15	62 (20.75)	0.278	
LVT	74.31 ± 15.66	76 (28)	0.262	74.31 ± 15.66	76 (28)	0.262	74.31 ± 15.66	76 (28)	0.262	

AMT = Logical Reasoning, DT = Reactive Stress Tolerance, SIGNAL = Focused Attention, LVT = Visual Perception, AR = Ability to React, RT = Reaction Time, MT = Motor Time.

* Sig at 0.05 level at Shapiro-Wilk statistics.

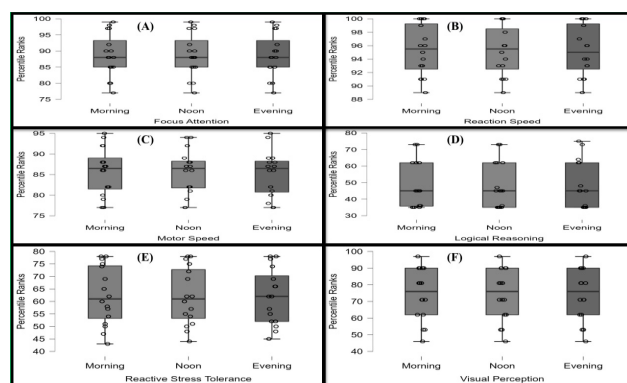


Figure 1. Data Distribution of Cognitive Performances on Three Different Times of Day

Table 3. Comparative Statistics of Cognitive Performances across Three Different Times of Day

Dimension (Variable)	Main Effect				Test Used
	df	F/Chi-square	p-value		
SIGNAL	xxx	xxx	xxx		NCP
AR	RT	1.445#	1	0.359	P
	MT	1.424#	1.022	0.352	P
AMT	2	2.923	0.232		NP
DT	2	0.703	0.503		P
LVT	xxx	xxx	xxx		NCP

*Significant at 0.05 level.

NP= Non-Parametric Test (Friedman), P= Parametric Test (rANOVA), NCP= No Comparison Possible

#= Greenhouse-Giesser Applied

utilised to perform comparisons. When examined at three different times of day, none of the factors were found to be significantly different at $p < 0.05$.

The profile chart in Figure 2 was generated by taking the mean values of each variable. The profile chart summarizes the results depicted in Figure 1 and Table 2.

Discussion

The participants in the study strictly stayed and trained for a minimum of two years in Jharkhand State Sports Promotion Society. According to the past studies, it was observed that the performance of cognitive tasks differed when tested at different times of the day. However, it is not clear whether those studies were conducted in sportsperson living and training under uniform condition. The study aimed to examine the performance of cognitive tasks measured at three different times of the day for the athletes who lived and trained in the same academy, having a similar daytime schedule and lifestyle.

According to the findings, it can be stated that disparities in scores of each parameter did not exist when tested at three different times of the day.

Before reaching a valid conclusion, it is necessary to understand the training and academic schedule of the academy. During regular school days, the cadets trained twice (morning and evening) for six days a week. The duration of training was two hours per session. During the academic vacations,

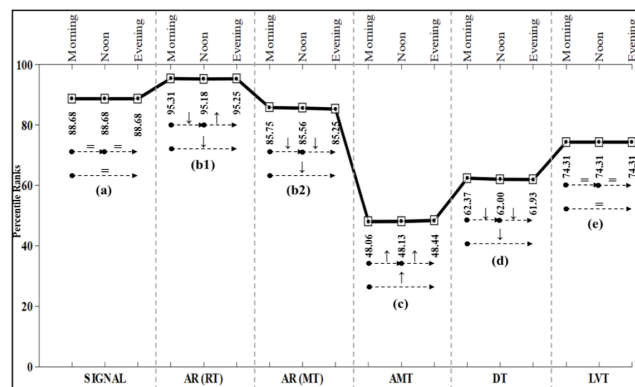


Figure 2. Profile Chart Depicts Percentile Ranks of Cognitive Performances at Three Different Times of Day

the training sessions were scheduled at forenoon that continued till mid-noon or sometimes afternoon. According to the protocol for avoiding premature specialisation in sports (CSMF, 2000; Launay, 2015; Travassos et al., 2017; Buckley et al., 2017), the subjects received general training appropriate to their age category (chronological, developmental, and training). The majority of trainings were recreational in character, with a focus on long-term athletic development. The institution had a very strict academic programme that ran six days a week from late morning to early afternoon. As cognition is essential in both physical training (Kim et al., 1996) and academic learning (Graizi et al., 2021), it is possible that cadets adapted to the physical and mental load given to them, which may be a reason why the homogeneity in scores existed.

Previous studies implied that such stability of cognitive performance could be attributed to task type, inhibition attentional control, and adaptability.

Task Type: The type of task can be classified into two categories: 1) novel or unfamiliar task, and 2) practised or familiar task. The familiar or well-learned task shows similar or constant performance when performed at any time of the day (Li et al., 1998) whereas the performance on unfamiliar or novel tasks is influenced by the fluctuations of peak and non-peak circadian arousal during the day (May et al., 2005). As it happens in sports competitions, first the athletes are trained, and then they were allowed to participate in competition. Similarly, in the current study, the subjects were trained and then, after an interval, the tests were administered. While the subjects were trained, they were well informed about the task they had to perform. Since the tasks and testing environment were familiar, it can be inferred that due to known and already practised tasks, the time of the day showed no significant differences in the scores of cognitive tasks.

Inhibition Attentional Control: Attentional inhibition is the regulation of an individual's attention and attentional processing priorities, as well as the allocation of attention to target stimuli. Three fundamental components of attentional control, e.g. blocking distractor stimuli, volitional control of attention, and working memory are necessary for processing priorities (Lavie et al., 2004). Because the trainees were engaged in physical and academic activities throughout the day, it's possible that it helped them to learn how to deal with distractors.

Adaptation: As it was mentioned that subjects had strictly trained and stayed in the same academy for two years, it

is possible that after spending so much time in the same setting, the cadets learned and adapted to function their body at any time of the day. Lally et al. (2010), stated a new habit may take anywhere from 18 to 254 days to establish with an average of 66 days for a new behaviour to become automatic. In addition Chtourou & Souissi 2012, suggested, training adaptations are stronger during the time of day when activities are consistently practiced. Training is fun because it is recreational in nature, which contributes high level of readiness. Pleasure-based behaviours are especially simple to change as they cause the production of dopamine, a chemical that reinforces the habit and generates the desire to repeat the action again (NIH, 2012).

Performing familiar task, developing good control over attentional distractor, and adapting the environmental needs can be related to extended-U model of Hancock et al., 2007, that describes the relationship of stress to performance and adaptation. Chtourou & Souissi, 2012; Gritton, et al, 2012; Rae, et al, 2015 also confirmed that training at a given time of day has no impact on an athlete's cognitive or physical performance. If athletes are nurtured in a controlled environment, the stability on cognitive performance can be gained.

In a prior study, Pahan & Singh, 2022, observed no significant difference in the percentile ranks of correct response, but the study group differed in terms of committing errors in cognitive task. When the controlled participants were assessed, the findings on cognitive performance were similar (Pahan & Singh, 2021). According to Chtourou and Souissi (2012), Gritton et al. (2012), Rae et al. (2015) training at a given time of day has no impact on an athlete's cognitive or physical performance. As a result, rather of analysing overall task performance, each scoring parameter, such as the number of correct and incorrect responses, the number of stimuli presented and attempted, and the duration of each cognitive activity, can be utilised to arrive at a meaningful conclusion. To confirm the effect of controlled living and training environment, similar study can be conducted by involving sportsperson who travel another venue for competition.

Conclusion

According to the findings of this research, varied day-times had no substantial impact on the cognitive performances of preadolescent athletes who lived and trained in identical settings for minimum of two years. The number of stimuli presented and attempted, as well as the overall duration of task completion for each task, may be considered in future research to get a better understanding of cognitive functioning at various times of day.

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ВПЛИВ ЧАСУ ДОБИ НА ПОКАЗНИКИ КОГНІТИВНОЇ ДІЯЛЬНОСТІ СПОРТСМЕНІВ ПЕРЕДПІДЛІТКОВОГО ВІКУ, ЯКИХ ВИХОВУЮТЬ У КОНТРОЛЬОВАНОМУ СЕРЕДОВИЩІ

Манохар Кумар Пахан^{1,2ABCD}, Махендра Кумар Сінгх^{1AD}

¹Національний інститут фізичного виховання імені Лакшмі Бай

²Місія Рамакришні Навчально-науковий інститут Вівекананда

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

Реферат. Стаття: 8 с., 2 табл., 2 рис., 58 джерел.

Мета дослідження. Це дослідження мало на меті вивчення впливу на показники когнітивної діяльності спортсменів-вихованців передпідліткового віку, які живуть і тренуються в умовах контрольованого середовища, протягом трьох різних часів доби.

Матеріали та методи. У дослідженні брали участь 16 спортсменів-вихованців академії «Товариство зі сприяння

розвитку спорту штату Джаркханд», місто Ранчі (Індія), які були віком від 11 до 14 років і мали принаймні два роки досвіду тренувань у зазначеній вище академії. Для оцінки показників когнітивної діяльності, таких як тривала сконцентрована увага, здатність реагувати, логічне мислення, стійкість до реактивного стресу та зорове сприйняття, був призначений набір тестів «TATEENS 2» з Віденської тесто-

вої системи. Процентильні ранги всіх п'яти тестів було порівняно в три різні часи доби. Для аналізу даних повторних вимірювань застосовували критерій Фрідмана та дисперсійний аналіз повторних вимірювань. Рівень значущості було задано значенням $p < 0,05$.

Результати. Усі p -значення для статистичних порівнянь показників стійкості до реактивного стресу, зорового сприйняття, логічного мислення, здатності реагувати (час реагування та час рухової реакції) та тривалої сконцентованої уваги в три різні часи доби були вищими за 0,05.

Висновок. Різні часи доби не справляли суттєвого впливу на показники когнітивної діяльності спортсменів передпідліткового віку, які жили та тренувалися в аналогічних умовах.

Ключові слова: час доби, тривала сконцентована увага, здатність реагувати, логічне мислення, стійкість до реактивного стресу, зорове сприйняття, юні спортсмени, Джаркханд.

Information about the authors:

Manohar Kumar Pahan: contrapahan@gmail.com; <https://orcid.org/0000-0003-2087-5456>; Lakshmibai National Institute of Physical Education, Gwalior, 474002, and Assistant Professor, Department of Sports Science and Yoga, Ramakrishna Mission Vivekananda Educational and Research Institute, Belur Math, Howrah, 711202, India.

Mahendra Kumar Singh: mahendra30singh@yahoo.com; <https://orcid.org/0000-0001-9989-9420>; Lakshmibai National Institute of Physical Education, Gwalior, 474002, India.

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ORIGINAL SCIENTIFIC ARTICLE

MARTIAL ARTS AND DOPING (THE CASE OF SAMBO)

Bogdan Mytskan^{1ABCDE}, Tetyana Mytskan^{1BCD}, Yuriy Oliinyk^{1ABC}, Georgiy Korobeynikov^{2CD}, Wojciech Cynarski^{3CD}, Stanisław Zaborniak^{3BCD} and Carlos Gutiérrez-García^{4CD}

¹Vasyl Stefanyk Precarpathian National University

²National University of Ukraine on Physical Education and Sport

³University of Rzeszów

⁴University of León

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

Corresponding Author: Bogdan Mytskan, E-mail: bogomdan_21@ukr.net

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Abstract

Background. Today, the problem of doping is the most well-known negative phenomenon in modern sport, which has become widespread in response to its active commercialization. The majority of people would agree that doping issue has moral and ethical basis, therefore the educational component of anti-doping policies is most promising in achieving the desired result – doping-free sport.

Research purpose. The study was aimed to investigate the peculiarities of the ideas sambo athletes may have about the problem of doping in modern sport.

Materials and methods. The study involved 97 highly professional sambo athletes from 21 countries, namely Russia, Ukraine, Mexico, Japan, the USA, Canada, Cuba, Guatemala, Republic of Korea, Colombia, Paraguay, Venezuela, Peru, Brazil, Nicaragua, El Salvador, Dominican Republic, Puerto Rico, Honduras, Uruguay, and Costa Rica.

Results. A survey conducted among the professional sambo athletes, participants of the 2018 World Cup, made it possible to establish their knowledge about and their attitude to doping. It became known that 76.29% of the athletes were well familiar with the doping control procedure, while 23.71% were not. At the same time, 78.35% of the respondents believed that they knew their rights and responsibilities during the doping control procedure, and 21.65% of the athletes did not. 77.32% of the respondents knew the organizer of doping control and 22.68% did not.

Conclusions. The analysis of the study results and WADA statistics give grounds to state that the problem of doping in modern athletes remains an urgent problem in professional sports, including sambo.

Keywords: anti-doping education, sambo athletes, doping.

Introduction

The history of the ancient Greek Olympic Movement shows that the doping problem was relevant during the ancient Games. In the II century BC Greek athletes ate sesame seeds and psychotropic mushrooms before competitions. It is known that wrestlers rubbed their bodies with oil rendering it difficult for rivals to take hold of each other. In the V century BC Roman gladiators also used stimulants to block fatigue and pain. And in the Middle Ages Scandinavian warriors ate the fly agaric infusion, which increased

aggression and blocked fatigue and pain (Morente-Sanchez et al., 2013; Wagner et al., 2014; Geeraets, 2018).

The active modern sport development and the expansion of its geographical and social areas have contributed to a number of problems and negative phenomena, namely: doping use by athletes, sport politicization and commercialization, etc. These aspects cause modern Olympic movement vulnerability, as they do not correspond to the ideas and values of Olympism, according to which all sports are trying to develop. In this regard, the doping, ecology, politics issues have been repeatedly discussed at international conferences and IOC, IOA, UNESCO, UN, Greenpeace events (FIAS, 2018). The problem of doping today is the most well-known negative phenomenon of modern sport, which has become widespread under the conditions of its active commercialization (Barabanova, 2010; Platonov, 2016; Geeraets, 2018).

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The active doping scandals growth has necessitated the IOC to hold meetings, sessions and conferences on this issue. The largest event was the Lausanne Conference (February 2-4, 1999), attended by more than 600 delegates. It resulted in the Lausanne Declaration on Doping in Sport, which contains six sections, namely: "Education, prevention and rights of athletes"; "Olympic Movement Anti-Doping Code"; "Sanctions"; International Independent Anti-Doping Agency; "Responsibility of the IOC, International Sports Federations (IFS) and the Court of Arbitration for Sport"; "Cooperation of the Olympic Movement with NGOs" (FIAS, 2018).

The purpose of the research is to study sambo athletes' ideas peculiarities of doping problem in modern sports.

Materials and methods

Participants of the research

The article presents the survey results of athletes participating in the World Sambo Championship in Bucharest (Romania) in 2018.

The survey involved 97 highly professional athletes from 21 countries, namely: Russia, Ukraine, Mexico, Japan, USA, Canada, Cuba, Guatemala, Republic of Korea, Colombia, Paraguay, Venezuela, Peru, Brazil, Nicaragua, El Salvador, Dominican Republic, Puerto Rico, Honduras, Uruguay, Costa Rica.

This study was conducted with the support of the Medical and Anti-Doping Commission of the International Sambo Federation (FIAS).

Research organization

In order to ensure the maximum obtained data reliability, athletes were asked to fill out a questionnaire anonymously.

The main questionnaire items were formed at the International Seminar for Young Scientists of the International Olympic Academy (IOA) in Olympia (Greece) in 2015. Also, some questionnaire items were improved and adapted for sambo by FIAS Medical and Anti-Doping Commission members in 2018.

The questionnaire contains three questions blocks (Table 1). The first block contains 15 questions with 2 answers types ("yes" and "no"). The other block contains 6 questions with 5 answer options, in particular: fully agree, agree, neutral, disagree, completely disagree. The last block contains only one question with 5 already formulated possible answers.

It should be noted that of the three proposed questions blocks, respondents answered the first block questions in the best way, although sometimes had difficulties with some questions and did not answer them.

Statistical analysis

Descriptive analysis methods were used, including tabular representation of individual variables, calculation of arithmetic mean (M) and standard deviation (s).

Results

WADA and the International Sports Federations annually conduct doping control, increasing tests number. However we can see that these measures are not enough to

Table 1. The structure of the survey of athletes

List of questionnaire questions	
The first block of questions	
1.	Do you know anything about the list of banned WADA drugs?
2.	Are you familiar with the doping control procedure?
3.	From what sources did you receive information about doping control?
4.	Have you received information about doping control from the International and National Sambo Federation?
5.	Do you know the organizers of doping control?
6.	Do you know your rights and responsibilities in the doping control procedure?
7.	Have you been doped?
8.	Have you used banned substances and methods?
9.	Have you participated in anti-doping educational activities?
10.	From whom did you receive information about doping measures?
11.	Have you been a member of an internationally or nationally registered group of athletes "for out-of-competition doping"?
12.	Should athletes be required to participate in doping education activities?
13.	Have you been encouraged to use doping substances and who?
14.	Do you know about the negative effects of doping substances on the body?
15.	Do you share the opinion about the legalization of doping?
The second block of questions	
1.	Do you know anything about the list of banned WADA drugs?
2.	Are you familiar with the doping control procedure?
3.	From what sources did you receive information about doping control?
4.	Do you have enough information on doping control?
5.	Do you know the organizers of doping control?
6.	Do you know your rights and responsibilities in the doping control procedure?
The third block of questions	
1.	What are your actions if you became aware of doping by other athletes?
	a) I ignore the information received
	b) tell the athlete about the dangers of doping for health
	c) inform the coach
	d) pass the information to the doping officer
	e) I will ask about the effectiveness of doping to use it as well.

reduce the number of cases of using doping by athletes, not even mentioning the complete problem overcoming. This is evidenced in particular by WADA official statistics, which reflects the positive samples dynamics in sambo whreslers. In the period from 2015 to 2020, the largest positive samples number was observed in 2016, while the largest tested whreslers' number was in 2019 (Table 2).

Obviously, it is almost impossible to overcome the doping phenomenon in Olympic sports due to its total commercialization and current trends in pharmacology and genetic engineering. We assume that this phenomenon can be minimized. The anti-doping procedure should be based on comprehensive, systematic and specific educational activities, which is confirmed by our previous studies (Oliynyk et al., 2014).

Currently, sambo is a particularly popular sport in Ukraine. Analyzing the achievements of Ukrainian sambo wrestlers at the World and European Championships, we

Table 2. WADA statistics on doping testing in sambo (2015-2020)

Testing and sanctions	Years					
	2015	2016	2017	2018	2019	2020
In-competition testing	171	177	183	184	243	70
Out-of-competition testing	40	28	18	29	35	25
Therapeutic use exemption (TUE)	1	2	0	0	0	0
Adverse and atypical findings (AAF)	7	15	4	5	10	Specified
Anti-Doping Rule Violations (ADRV)	7	15	4	5	11	Specified

Table 3. The total number of medals won by Ukrainian sambo wrestlers of all ages at the World Championships, Europe, European Cups and European Games (2015-2020)

Year	Bronze medals	Silver medals	Gold medals	The total number of medals per year	Team rank, FIAS
2015	27	28	26	111	II
2016	83	39	23	145	II
2017	60	48	19	127	II
2018	74	54	39	167	II
2019	62	37	35	134	II
2020	40	26	15	81	II

can conclude that Ukraine takes one of the leading world positions, constantly competing for the championship with the country-founder of this sport the Russian Federation. According to the unofficial record of FIAS 2015-2020, the Ukrainian National Sambo Team by total number of medals, won during the year, consistently occupies the second team place (Table 3).

This confirms sambo popularity in Ukraine and great human resources capacity in this sport. Worthy competition is also made by the national teams of Bulgaria, Uzbekistan, France, Georgia, Tajikistan, Mongolia, Romania, Spain, Italy and others.

It is obvious that gaining popularity in Ukraine and the world this type of wrestling becomes vulnerable to such negative professional sports phenomena as doping.

A survey conducted among professional sambo athletes, participants of the 2018 World Cup, allowed to establish the knowledge level and their attitude to doping.

The first questions block

Do you know anything about the list of WADA banned drugs? Only 79.38% of respondents answered "Yes" and 20.62% answered "No". 82.47% of respondents point that they were acquainted with the WADA list in their country, while 17.53% did not receive such information in their country. In general, 84.54% of respondents indicate that they receive enough information from sports federations in their country, while 15.46% believe that such information is not enough for them. It was found that 61.86% of the respondents underwent doping control at competitions and 38.14% did not. Interestingly, only 23.71% vs. 76.29% were members of an internationally or nationally registered group of athletes for doping outside the competition.

It became known that 76.29% of athletes are well acquainted with the doping control procedure, while 23.71% do not. At the same time, 78.35% of respondents believe that they know their rights and responsibilities in doping control procedure, and 21.65% of athletes do not know. 77.32% of respondents know the organizer of doping control and 22.68% do not.

Interestingly, 57.73% of surveyed athletes participated in anti-doping education symposia or seminars, while 42.27% didn't participate in such events. At the same time it was found that 50.52% of respondents received information about anti-doping seminars or other similar events from their national federation and 49.48% did not receive such information.

It should be noted that 91.75% of athletes believe that anti-doping education should be mandatory for professional athletes, while 8.25% do not share their opinion. Thus, 81.44% believe that anti-doping education implementation will reduce the use of doping by athletes and 18.56% do not share this opinion.

It was found that 11.34% of athletes were encouraged to use doping substances by other team members, but the majority (88.66%) did not have such an effect. It is worth noting

Table 4. The survey results of professional sambo athletes attitude to doping use in sports, %

Question	Answer options				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Doping are using in sambo	10.31±2.53	30.93±4.15	31.96±3.82	9.28±1.57	17.53±2.03
Doping is a problem in every sport	48.45±5.12	37.11±3.48	7.22±0.97	2.06±0.05	5.15±0.87
Doping affects world records	30.93±4.53	40.21±5.01	11.34±1.27	10.31±2.41	7.22±0.98
Doping should not be prohibited	6.19±0.56	3.09±0.09	5.15±0.86	16.49±2.09	69.07±6.55
All highly qualified athletes use doping	-	2.06±0.08	22.68±2.89	37.11±3.98	38.14±3.67
Doping is a remedy helping in training process	6.19±0.59	7.22±0.96	32.99±4.58	26.80±3.07	26.80±3.18

that 6.19% of athletes were proposed to use doping by their coaches. It should be noted that 93.81% of athletes are well aware of doping effects on the body.

The *second questions block* was aimed at determining the attitude to certain doping use problems by athletes. The results are given in Table 4.

The open question, offered to athletes with already formed answers, was reflected in the following results.

Asking the athlete "If your fellow athlete uses doping, how will you do?", We obtained the following answers, namely: 18.56% ignore this fact, 46.39% will tell a friend about doping dangers and health risks, 29.90% of respondents tell the coach about it, 3.09% will tell the doping officer about it and 2.06% of athletes will ask about the doping effectiveness in order to use it too.

Discussion

Analysis of research results, scientific literature (Barabanova, 2010; Halabchi, 2009; Mottram, 2018) and WADA statistics (WADA, 2010, 2015) suggest that the problem of doping by modern athletes continues to be a pressing problem in Olympic sports and sambo in particular.

It was found that highly qualified sambo athletes are mostly familiar with the list of banned substances and WADA methods. At the same time, they are aware of their rights and responsibilities in the doping control procedure (Bloodworth et al., 2012; Morente-Sanchez et al., 2013). At the same time, according to the survey and data from special literature (Backhouse, 2011; Wagner et al., 2014), athletes are aware of the negative effects of doping on the body and receive sufficient information on these issues from their national federations (Oliynyk et al., 2014) and WADA Centers (WADA, 2015; Van Bottenburg Maarten, 2021). The question arises, why measures to prevent the use of doping substances are not able to overcome this detrimental phenomenon for both athletes and sports? First, it is the excessive commercialization of sports (for winning an athlete receives a significant financial reward). Secondly, sports victories at major international sports competitions increase the prestige of the state. Third, the winning athlete becomes a national hero, his victory in major competitions becomes the meaning of his life ambitions. This view is fully shared by other researchers of the problem of doping in sport (Johnson, 2012; Ivanova et al., 2012; Faria, 2018).

International and national sambo federations are educating about doping among both coaches and athletes (McNamee, 201; Wagner et al., 2014)

To this end, appropriate programs have been developed, including in Ukraine (Oliynyk et al., 2014). However, according to the results, a significant number of athletes are tolerant of doping.

Apparently, this is due to the fact that some experts are in favor of legalizing doping (Coleman et al., 2011). At the same time, the data obtained indicate that this largely depends on the coaches. After all, they must be aware that modern research on the physiology of sports proves that there are unused reserves in sports training. They allow athletes to show record results without the use of doping (Loland et al., 2012; Petróczy et al., 2017).

The survey found that 91.75% of athletes are in favor of making anti-doping education compulsory in the training

system. According to researchers of this problem (Drozd et al., 1998; Kornbeck, 2013; Mottram, 2018), this will reduce the use of doping by athletes.

Against the background of increasing doping substance use, including among martial arts athletes, scandals with doping test results in a large number of well-known athletes encourage the search for effective approaches to minimize this phenomenon (Thomas, 2017; Geeraets, 2018).

We believe, like other researchers (WADA, 2010; Johnson, 2012; Motoarca, 2015), that the doping education paradigm should be based on a set of ideals, traditions, ethical norms, taboos, ie a set of values based on the spiritual and moral attitudes of the past and present of sport.

Conclusions

Analysis of research results and WADA statistics give reason to believe that the problem of doping by modern athletes continues to be an urgent problem of professional sports and sambo in particular.

It is established that highly qualified athletes are mainly acquainted with the list of prohibited substances and WADA methods. At the same time, they are aware of their rights and responsibilities in doping control procedure. Athletes are aware of the negative doping effects on the body and receive sufficient information on these issues from their national federations and WADA centers.

It was found that 7.22% of sambo athletes were offered doping drugs by coaches, and 11.34% of their team members were inclined to use doping. At the same time, a significant number of sambo athletes are convinced that doping is used in sambo and that it is a problem in all sports. Sambo athletes are also convinced that doping affects world records.

The majority of sambo athletes (91.75%) consider anti-doping education an important component of training and competitive activities, and 81.44% are convinced that anti-doping education will reduce the doping use by athletes.

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Conflict of interest

Authors state that there is no conflict of interest

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БОЙОВІ МИСТЕЦТВА ТА ДОПІНГ (НА ПРИКЛАДІ САМБО)

Богдан Мицкан^{1ABCDE}, Тетяна Мицкан^{1BCD}, Юрій Олійник^{1ABC}, Георгій Коробейников^{2CD},
Войцех Цинарський^{3CD}, Станіслав Заборняк^{3BCD}, Карлос Гутьєррес-Гарсія^{4CD}

¹Прикарпатський національний університет імені Василя Стефаника

²Національний університет фізичного виховання і спорту України

³Жешувський університет

⁴Леонський університет

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

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Передумови і мета дослідження. Проблема допінгу сьогодні є найбільш відомим негативним явищем сучасного спорту, яке набуло поширення в умовах його активної комерціалізації. Більшість спеціалістів погодиться, що питання допінгу має морально-етичну основу, тому освітня складова антидопінгової політики є найбільш перспективною для досягнення бажаного результату – спорту без допінгу.

Метою дослідження було вивчити особливості уявлень спортсменів – самбістів про проблему допінгу у сучасному спорті.

Матеріал і методи. В анкетуванні взяли участь 97 високопрофесійних атлетів з 21 країни світу, а саме: Росія, Україна, Мексика, Японія, США, Канада, Куба, Гватемала, Республіка Корея, Колумбія, Парагвай, Венесуела, Перу, Бразилія, Нікарагуа, Сальвадор, Домініканська Республіка, Пуерто Ріко, Гондурас, Уругвай, Коста Ріка.

Результати. Проведене анкетування серед професійних спортсменів самбо, учасників Чемпіонату світу 2018 дали змогу встановити рівень знань та їх ставлення до вживання допінгу. Стало відомо, що 76% спортсменів добре знайомі з процедурою допінг контролю, тоді як 24% вона не відома. Водночас, 78% опитаних вважають що їм відомі їх права і обов'язки під час процедури допінг контролю, і 21% спортсменів про них не знають. Для 77% опитаних відомо хто є організатором допінг контролю і 23% цього не знають.

Висновок. Аналіз результатів досліджень та статистики ВАДА, дають підстави стверджувати, що проблема вживання допінгу сучасними атлетами продовжує бути актуальною проблемою професійного спорту і самбо зокрема.

Ключові слова: антидопінгова освіта, самбо, допінг.

Information about the authors:

Mytskan, B. M.: bogomdan_21@ukr.net; <http://orcid.org/0000-0002-5853-713X>; Department of Theory and Methods of Physical Culture, Vasyl Stefanyk Precarpathian National University, 760018 Ivano-Frankivsk, Shevchenka St, 57, Ukraine.

Mytskan, T. S.: tania_mytskan@ukr.net; <http://orcid.org/0000-0002-4164-2961>; Department of Theory and Methods of Physical Culture, Vasyl Stefanyk Precarpathian National University, 760018 Ivano-Frankivsk, Shevchenka St, 57, Ukraine.

Oliinyk, Y. O.: yuriy1215@ukr.net; <https://orcid.org/0000-0002-4384-7805>; Department of Theory and Methods of Physical Culture, Vasyl Stefanyk Precarpathian National University, 760018 Ivano-Frankivsk, Shevchenka St, 57, Ukraine.

Korobeynikov, G. V.: k.george.65.w@gmail.com; <http://orcid.org/0000-0001-5588-4825>; Department of Martial Arts of the National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03680, Ukraine.

Cynarski, W.: ela_cyn@wp.pl; <http://orcid.org/0000-0003-1252-5456>; Department of Cultural Foundations of Physical Education, Tourism and Recreation, University of Rzeszow, aleja Tadeusza Rejtana 16c, 35-959 Rzeszów, Poland.

Zaborniak, S.: zaborniaks@wp.pl; <https://orcid.org/0000-0003-4407-0353>; Department of Humanities and Social Sciences, University of Rzeszow, aleja Tadeusza Rejtana 16c, 35-959 Rzeszów, Poland.

Gutierrez-Garcia, C.: cgutg@unileon.es; <https://orcid.org/0000-0002-9895-7438>; Department of Physical Education and Sports, Institute of Physical Culture, University of León, Education Campus de Vegazana S/N, 24071 León, Spain.

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ORIGINAL SCIENTIFIC ARTICLE

DETERMINATION OF MODEL CHARACTERISTICS AND EVALUATION CRITERIA FOR STRENGTH TRAINING OF QUALIFIED ARMWRESTLING STUDENT-ATHLETES

Dmytro Bezkorovainyi^{1ABCD}, Oleg Kamayev^{2ABC}, Stanislav Vlasko^{1BDE},
Leonid Plotnyskyi^{3ABE} and Irina Sadovska^{1BD}

¹O. M. Beketov National University of Urban Economy in Kharkiv

²Kharkiv State Academy of Physical Culture

³Kharkiv National University of Civil Engineering and Architecture

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

Corresponding Author: Dmytro Bezkorovainyi, E-mail: bezkor@ua.fm

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Abstract

Research purpose. The aim of the study was to determine the model indicators of strength readiness of qualified armwrestling student-athletes in the weight category from 80 to 100 kg in 4 strength exercises: flexion of the fingers, stretch with a hammer, hook and bending of the hand.

Materials and Methods. The study involved 16 qualified armwrestling student-athletes weighing from 80 to 100 kg ($M = 86,63$ kg), 7 of which are participants of national championships of Ukraine, and 9 of which are prize-winners of competitions of regional level. During the study, strength indicators were determined in 4 competitive exercises. Strength indices in all test exercises were measured in a static mode by an FB5k series digital force gauge (Poland) with an accuracy class of up to 100 g, which was mounted on a special armwrestling table using a specially made block device. The created design was called the "ARM1 Device" (patent 43082). During the statistical analysis, the following parameters were calculated: arithmetic mean (M), standard deviation (σ), error of representativeness (m) and the coefficient of variation (V).

Results. The analysis of the strength capabilities of the qualified student-armwrestlers and the presented models of their strength readiness made it possible to develop assessment criteria for the level of strength readiness of the qualified student-armwrestlers. Three levels of strength readiness have been identified: low ($M - \sigma$), high ($M + \sigma$) and medium, i.e. more than ($M - \sigma$) but less than ($M + \sigma$). Comparative analysis of the ratios of different levels of strength training in this group of armwrestling athletes allowed to determine from 128 indicators of strength 14.84% ($n = 19$) of low level, 62.50% ($n = 80$) of medium level and 22.66% ($n = 29$) of high level.

Conclusions. The study made it possible to establish the features of the levels of development of strength training of qualified armwrestling athletes weighing from 80 to 100 kg. The model indicators of strength training of qualified armwrestlers were also determined. The analysis found that the subject athletes have an insufficient level of strength training and are not fully realized in terms of strength capabilities (62.50% indicators of the average level of strength).

Keywords: armsport, armwrestling, student-armwrestlers, model characteristics, power indicators.

Introduction

Armwrestling according to the analysis of the fulfillment of competitive exercises belongs to the group of sports of a speed-strength nature. The structure of competitive

movements and the value of overcoming the opponent's resistance indicate the need for the manifestation of maximum dynamic, and with an increase in resistance from the opponent, static efforts (Ahamed et al., 2013; Ilyushina, 2008).

The nature of dynamic efforts when overcoming resistances can be different: explosive, fast, slow. Explosive strength is characterized by the fact that overcoming resistances that do not reach the limit values is performed with maximum acceleration.

The fast nature of efforts, or fast force, manifests itself during overcoming resistances that do not reach their limit values with acceleration below the maximum. The slow nature of efforts, or slow force, manifests itself during overcoming boundary resistances at a constant speed (Kamayev et al., 2013).

It is important to distinguish that explosive strength is manifested only with overcoming muscle work. Rapid strength is manifested in both overcoming and yielding movements. Also during their combination. Slow strength is manifested during overcoming or yielding muscle work (Karakurt & Aggon, 2018). During the manifestation of slow force, the duration of the limiting stresses is greater than during the manifestation of explosive force.

The practice of sports and special studies indicate that there is no direct connection between the levels of development of certain types of dynamic and static strength (Burdukiewicz et al., 2018). Research results have shown that high static force does not provide for the possibility of its rapid manifestation (Mazurenko, 2019). Comparison of individual indices of manifestation of static and dynamic strength indicates that there is no direct connection between the level of development of certain types of muscle strength in athletes. Thus, from a methodological point of view, this means that the effective development of any kind of strength in the training of qualified athletes involves the use of a specialized methodology (Gibadullin et al., 2014). In this regard, the determination of the ability to show strength capabilities in various strength exercises allows you to effectively control and correct the training process for the development of strength.

Several studies (Bezkorovainyi, 2013; Podrigalo et al., 2017, 2019) determine the structural orientation of special strength training, respectively, thereby determining the structure of the special strength development of armwrestlers. The results of the study show that the structure of special strength training ensures the predominant development of specific muscle groups. Structurality also contributes to technical improvement, which in turn helps to increase the magnitude of the manifestation of strength.

It was found that qualified armwrestling athletes have a relatively equally high level of technical readiness. Therefore, the result of the fight will mainly depend on the level of strength readiness (Matyushenko, 2020, 2022; Nikulin et al., 2021; Podrihalo et al., 2020).

In the armwrestling technique, the main element is the attack phase, the purpose of which is to achieve quick superiority over the opponent. According to Zhivora & Rakhmatov (2001), there are three main methods of attack: top attack, hook attack and push attack. A questionnaire survey of specialists and research by Bezkorovainyi (2013) showed that highly qualified athletes use hook attack in 55% of cases, top roll attack in 40% and push attack in 5%. It was found that when performing a hook attack, the greatest load is applied to the flexors of the hand and forearm. Top roll attack requires excessive flexor force of the fingers and hand. During the push attack, the greatest load falls on the elbow joint and fingers. Usanov & Chuglina (2010) classified the fourth method of attack – a side attack. During this technique, a great deal of stress falls on the flexors of the hand.

In connection with the above, four strength exercises were selected as test indicators: flexion of the fingers, stretch with a hammer, hook and bending the hand. These exercises

were chosen to determine the level of strength readiness of qualified student-armwrestlers.

Materials and methods

Study participants

The study involved 16 qualified armwrestling student-athletes of 2-5 courses who studied at O.M. Beketov National University of Urban Economy in Kharkiv and Kharkiv National University of Civil Engineering and Architecture weighing from 80 to 100 kg ($m = 86,63$ kg), 7 athletes from which are participants of national championships of Ukraine, 9 – prize-winners of competitions of regional level.

Study organization

Measurements of strength indicators were carried out in the study group of participants one week after the end of the regional competitions. Within 4 days, one competitive movement of each athlete was measured, the order of the participants was determined by lot, which created a competitive effect.

Strength indices in all test exercises were measured with an FB5k series electrical tenzodynamometer (Poland) with an accuracy class of up to 100 g, which was fixed on a specialized armwrestling table using a specially made block device. The created design was called the “ARM1 Device” (patent #43082).

During the measurement of the strength of the muscles of the hands, the subject became facing the table, grabbed the device holders with his hand and squeezed them with maximum force, without tearing the elbow of the working arm from the table. The distance between the holders of the device easily changed and was selected individually for each subject.

The special computer program AXIS FM made it possible to process the measurement data in real time (on-line) and the previously collected data from the memory of the electrical tenzodynamometer (of-line). AXIS FM is compatible with the operating systems Windows XP, Vista, Windows 7.

Statistical analysis

Statistical analysis of the obtained data was carried out using the licensed program STATISTICA 10. Statistical analysis calculated the following parameters: arithmetic mean (M), standard deviation (σ), error of representativeness (m) and the coefficient of variation (V). On the basis of the obtained digital data, three levels of strength readiness were determined: low, medium and high.

Results

A comparative analysis of certain test exercises shows that most arm athletes do not accidentally use a hook attack during competitions. Because in all weight categories in this exercise, athletes show the highest strength in comparison with the data of other strength exercises (Table 1).

Analysis of the results of the study shows that the strength of the right hand is on average better than the strength of the

Table 1. Model indicators of strength training of qualified armwrestling athletes (n = 16; M = 86.63 kg)

Indicator	left arm				right arm			
	M	m	σ	V	M	m	σ	V
Flexion of fingers (kg)	42.78	0.95	3.80	8.90	44.33	1.31	5.24	11.82
Stretch with a hammer (kg)	49.99	1.10	4.40	8.80	51.19	1.25	5.00	9.76
Hook (kg)	53.16	1.30	5.20	9.63	54.51	1.40	5.60	1,27
Bending the hand (kg)	54.94	1.21	4.84	8.80	56.61	1.01	4.04	7.13
Total strength of the hands (kg)	200.87				206.64			
General indicator of arm strength (kg)					407.51			
Indicator of variability (%) V					36.13			
$\Sigma V, \%$					75.11			

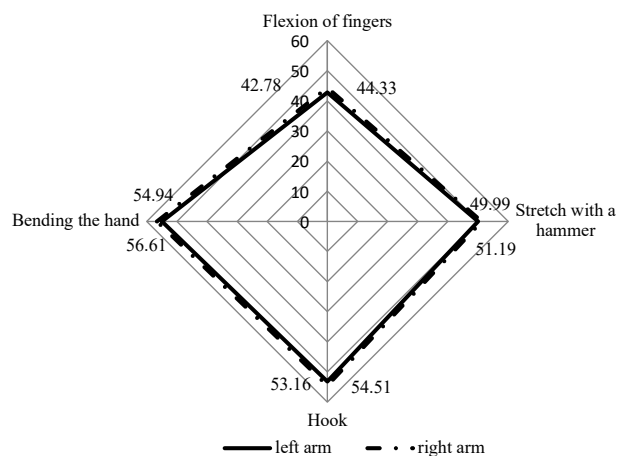
left by 2.87% (the difference ranges from 1.20 to 1.67 kg). The highest indicators of strength were registered in the test exercise of bending the hand: with the left hand – 54.94 kg, with the right – 56.61 kg (Table 1; Fig. 1). The strength of the left hand ranges from 42.87 to 54.94 kg, the right – from 44.33 to 56.16 kg. The coefficient of variation (V) or digital display of variability of left arm strength indicators indicates the homogeneity of the obtained results ($V = 8.81\text{--}9.63\%$).

Data on the strength capabilities of the right hand indicate increased variability in test results ($V = 10.27\%; 11.82\%$), in addition to data on flexion of the hand ($V = 7.13\%$).

The analysis of strength capabilities of qualified armwrestling athletes and the presented models of their strength

Table 2. Evaluation criteria for the level of strength training of qualified armwrestling athletes (n = 16; M = 86.63)

Arm	Low level (kg)	Medium level (kg)	High level (kg)
Flexion of fingers			
left	< 38.98	39.98 – 46.58	> 46.58
right	< 39.09	39.09 – 49.57	> 49.57
Stretch with a hammer			
left	< 45.59	45.59 – 54.39	> 54.39
right	< 46.19	46.19 – 56.19	> 56.19
Hook			
left	< 47.96	47.96 – 58.36	> 58.36
right	< 48.91	48.91 – 60.11	> 60.11
Bending the hand			
left	< 50.10	50.10 – 59.78	> 59.78
right	< 52.57	52.57 – 60.65	> 60.65

**Figure 1.** Model characteristics of the power capabilities of qualified armwrestling athletes

training made it possible to develop assessment criteria for the level of strength training of armwrestlers of average qualification (Table 2). Three levels of strength training are determined: low ($M - \sigma$), high ($M + \sigma$) and medium – more ($M - \sigma$), but less ($M + \sigma$).

Comparative analysis of the ratios of different levels of strength training in this group of arm athletes allowed to determine from 128 indicators of strength 14.84% ($n = 19$) low level, 62.50 % medium ($n = 80$) and 22.66% high ($n = 29$) levels (Table 3). Out of 16 athletes, only one participant in the experiment performed all eight test exercises at a high level. In all other athletes, the figures fluctuate in all three levels.

Table 3. Ratios of strength readiness levels of qualified armwrestling athletes (n = 16; M = 86.63)

Level	Flexion of fingers		Stretch with a hammer		Hook		Bending the hand		$\Sigma, \text{un.}$	$\Sigma, \%$
	left	right	left	right	left	right	left	right		
low	3	3	2	3	1	3	2	2	19	14,84
medium	9	10	10	10	10	9	10	12	80	62,50
high	4	3	4	4	5	4	4	2	29	22,66

The range of indicators of medium strength in this group ranges from 19.30% to 28.34% and is 62.50% of the total. This result proves that this indicator fully characterizes the overall level of training of qualified arm athletes.

Discussion

Arm wrestling refers to sports in which performance directly depends on the level of strength readiness, in particular, the development of arm strength. It was confirmed that the main predictions of success in hand wrestling include: muscle development, physical strength, the value of conditional moments of strength of limb segments Podrihalo et al. (2020). Strength fitness in many sports is used as criteria for assessing the physical fitness of athletes (Burdukiewicz et al., 2018; Karakurt & Aggon (2018). In arm wrestling, according to Voronkov et al. (2014), the strength component is of decisive importance in highly qualified athletes in competitive exercises.

Confirmed data based on the use of ergonomic approaches by the authors of Podrigalo et al. (2010) that high-level arm wrestlers have a significantly higher indicator of hand strength, hand flexion, forearm muscle strength, arm pronation and supination.

Kamayev et al. (2020, 2021) investigated model indicators of arm wrestlers of the highest qualification of three weight categories: to 80 kg, from 80 to 100 kg and over 100 kg. So, at qualified arm wrestlers of a weight category from 80 to 100 kg power indicators of the right hand in comparison with data of the left are identical with data of highly skilled, namely it is better, but less expressively. Thus, the difference in highly qualified arm wrestlers was 12.47%, and in the group of arm athletes we studied only 5.77%.

The studied athletes achieved higher results in the exercise of bending the hand, and highly qualified in the right hook. This condition is not accidental. Given that the hook exercise is of great importance in competitive activities, athletes of medium level of qualification should provide in the training program emphasis on the method of developing the strength capabilities of the hook exercise.

The range of indicators of medium strength in the study group is 62.50% of the total. This result proves that this indicator fully characterizes the overall level of training of athletes, because the highly qualified arm athletes weighing from 80 to 100 kg, the number of indicators of the average level of strength training was 65.50%.

Hand strength indicators are the most important in hand wrestling. All athletes are characterized by high results of hand power indices, and the higher the results of these indices, the higher the success of competitive activity. Similar data are provided by Rovnaya et al. (2019). The results of Akpina et al. (2013) also confirm that the indicators of arm muscle strength is an important predictor of success in arm wrestling (Rovnaya et al., 2019).

Victory largely depends on the athlete's ability to squeeze the opponent's hand as much as possible. This technique was used by Iermakov et al. (2016) to predict success in martial arts.

Conclusions

The study made it possible to establish the features of the levels of development of strength training of qualified arm wrestling athletes weighing from 80 to 100 kg. Model

indicators of strength training of qualified arm athletes are also determined. The analysis revealed that the studied athletes have an insufficient level of strength training and are not fully realized in terms of strength capabilities (62.50% of the average level of strength). It is obvious that athletes at this stage of preparation need to pay maximum attention to the development of strength indicators.

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Conflict of interest

The authors declare no conflict of interest.

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ВИЗНАЧЕННЯ МОДЕЛЬНИХ ПОКАЗНИКІВ Й ОЦІНОЧНИХ КРИТЕРІЇВ СИЛОВОЇ ПІДГОТОВЛЕНOSTІ КВАЛІФІКОВАНИХ СТУДЕНТІВ-АРМРЕСТЛЕРІВ

Дмитро Безкоровайний^{1ABCD}, Олег Камаєв^{2ABC}, Станіслав Власко^{1BDE}, Леонід Плотницький^{3ABE}, Ірина Садовська^{1BD}

¹Харківський національний університет міського господарства імені О. М. Бекетова

²Харківська державна академія фізичної культури

³Харківський національний університет будівництва та архітектури

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

Реферат. Стаття: 6 с., 3 табл., 1 рис., 23 джерела.

Метою дослідження було визначення модельних показників силової підготовленості кваліфікованих студентів-спортсменів з армрестлінгу вагової категорії від 80 до 100 кг у чотирьох силових вправах: згинання пальців, згинання молотком, гак та згинання кисті.

Матеріали та методи. У дослідженні взяло участь 16 кваліфікованих студентів-спортсменів з армрестлінгу

вагою від 80 до 100 кг (M = 86,63 кг), 7 спортсменів з яких є учасниками національних чемпіонатів України, 9 – призерами змагань обласного рівня. Під час дослідження визначали силові показники у 4 змагальних вправах. Показники сили у всіх тестових вправах вимірювалися в статичному режимі електричним тензодинамометром серії FB5k (Польща) з класом точності до 100 г, який закріплювався

на спеціальному столі для армрестлінгу за допомогою спеціально виготовленого блочного приладу. Створений прибор отримав назву «Пристрій ARM1» (патент № 43082). Під час статистичного аналізу були розраховані такі параметри: середнє арифметичне (M), стандартне відхилення (σ), похибка репрезентативності (m) та коефіцієнт варіації (V).

Результати. Аналіз силових можливостей кваліфікованих студентів-армрестлерів та представлені моделі їхньої силової підготовленості дозволили розробити критерії оцінювання рівня силової підготовленості кваліфікованих студентів-армрестлерів. Визначено три рівні силової підготовленості: низький ($M - \sigma$), високий ($M + \sigma$) і середній – більший ($M - \sigma$), але менший ($M + \sigma$). Порівняльний аналіз співвідношення різних рівнів силової підготовки у

цій групі спортсменів з армрестлінгу дозволив визначити із 128 показників сили 14,84 % ($n = 19$) низький рівень, 62,50 % середній ($n = 80$) і 22,66 % високий ($n = 29$) рівні.

Висновки. Дослідження дозволило встановити особливості рівнів розвитку силової підготовленості кваліфікованих студентів-спортсменів з армрестлінгу вагою від 80 до 100 кг. Визначено модельні показники силової підготовленості кваліфікованих армрестлерів. Аналіз виявив, що досліджувана група спортсменів має недостатній рівень силової підготовленості та не повністю реалізована за силовими можливостями (62,50 % показників середнього рівня сили).

Ключові слова: армспорт, армрестлінг, студенти-армрестлери, модельні характеристики, силові показники.

Information about the authors:

Bezkorovainyi Dmytro: Dmytro.Bezkorovainiy@kname.edu.ua; <https://orcid.org/0000-0001-9719-6131>; Department of Physical Education and Sports; O. M. Beketov National University of Urban Economy in Kharkiv, Marshal Bazhanov St, 17, Kharkiv, 61002, Ukraine.

Kamayev Oleg: kamaevoi45@gmail.com, <https://orcid.org/0000-0001-6307-1007>; Department of Olympic and Professional Sports; Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Vlasko Stanislav: Stanislav.Vlasko@kname.edu.ua; <https://orcid.org/0000-0001-8505-8452>; Department of Physical Education and Sports; O. M. Beketov National University of Urban Economy in Kharkiv, Marshal Bazhanov St, 17, Kharkiv, 61002, Ukraine.

Plotnytskyi Leonid: ernm@ukr.net; <https://orcid.org/0000-0003-4218-4023>; Department of Physical Education and Sports; Kharkiv National University of Civil Engineering and Architecture, Sumska St, 40, Kharkiv, 61002, Ukraine.

Sadovska Irina: Irina.Sadovska@kname.edu.ua; <https://orcid.org/0000-0002-0324-2377>; Department of Physical Education and Sports; O. M. Beketov National University of Urban Economy in Kharkiv, Marshal Bazhanov St, 17, Kharkiv, 61002, Ukraine.

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ЧАСОВІ ХАРАКТЕРИСТИКИ ТЕХНІЧНОЇ ПІДГОТОВЛЕНOSTІ СТИБУНОК ПОТРІЙНИМ ВИСОКОЇ КВАЛІФІКАЦІЇ

Володимир Конестяпін^{ABCD}, Ольга Павлось^{ABCD}, Олена Ханікянц^{ABCD},
Антоніна Дунець-Лесько^{ABCDE}, Тетяна Дух^{ABCDE}, Ярослав Свищ^{ABCDE}

Львівський державний університет фізичної культури імені Івана Боберського

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

Автор кореспондент: Ольга Павлось, E-mail: olha_slisenko@ukr.net

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Анотація

Невпинний ріст спортивних результатів та відсутність порівняльного аналізу комплексу показників технічної підготовленості стрибунів потрійним високої кваліфікації вказує на перспективність досліджень у цьому напрямку.

Мета дослідження: уточнити часові характеристики технічної підготовленості стрибунів потрійним високої кваліфікації.

Матеріали і методи. Нами використано такі методи дослідження: теоретичний аналіз та узагальнення даних науково-методичної літератури, педагогічне спостереження, інструментальні методики (відеозйомка) та методи математичної статистики. Дослідження проводилося на основі вивчення часових характеристик технічної підготовленості висококваліфікованих стрибунів потрійним. Педагогічний експеримент проходив під час змагань Кубка України та Чемпіонату України з легкої атлетики. У дослідженні брали участь 9 стрибунів потрійним (середній вік стрибунів $25,3 \pm 5,1$ роки), з них двоє майстрів спорту міжнародного класу України, чотири майстри спорту України, троє – кандидатів в майстри спорту України.

Результати. У ході дослідження нами встановлено, що показники тривалості опорних періодів 6-ти останніх кроків розбігу у стрибунів потрійним високої кваліфікації характеризуються низьким рівнем варіативності. У показниках тривалості польотних періодів найвища варіативність спостерігалась на 3-му, передостанньому та останньому кроках розбігу. За результатами дослідження ритмо-темпових характеристик стрибунів потрійним високої кваліфікації встановлено, що найвищі показники темпу бігового кроку є на останньому кроці розбігу і сягають 4,67 кр/с. Виявлено кореляційний взаємозв'язок таких часових характеристик, як тривалість польотного періоду передостаннього кроку розбігу ($r = -0,85$), темпі передостаннього ($r = 0,60$) і останнього кроків ($r = 0,78$), та темпова інтенсивності ($r = 0,76$) зі спортивним результатом. У стрибунів потрійним високої кваліфікації показники тривалості фаз «скоку», «кроку», «стрибка», їх загальної тривалості та середньої швидкості виконання стрибкових фаз характеризуються низьким рівнем варіативності. Тривалість «скоку» становить $0,66 \pm 0,06$ с. Найдовшою за тривалістю виконання є фаза «стрибка» ($0,78 \pm 0,06$), а найкоротшою – фаза «кроку» ($0,51 \pm 0,04$ с).

Висновки. Встановлено, що за рахунок зменшення тривалості польотних періодів на останніх кроках розбігу спостерігається зростання швидкості розбігу стрибунів високої кваліфікації. Варіативність контрастності зростання темпу 31,90 % та темпової мобілізації 35,12% свідчать про те, що стрибунки високої кваліфікації використовують різні варіанти поєднання розбігу з відштовхуванням. Аналіз ритмічної структури техніки потрійного стрибка свідчить, що у всіх стрибунів переважає фаза «стрибка» 40,05%, а найкоротшою є фаза «кроку» 26,30%. Встановлено, що такі часові характеристики: тривалість польотного періоду передостаннього кроку розбігу ($r = -0,85$), темп передостаннього ($r = 0,60$), темп останнього кроку ($r = 0,78$), та темпова інтенсивність ($r = 0,76$) мають статистично достовірний взаємозв'язок зі спортивним результатом ($p < 0,05$).

Ключові слова: потрійний стрибок, технічна підготовленість, часові характеристики, стрибунки високої кваліфікації.

Вступ

Постійний ріст спортивних результатів та посилення конкуренції в легкій атлетиці на міжнародній арені вимагає впровадження нових засобів та методів контролю за технічною підготовленістю спортсменів. Потрійний стрибок відносять до складно-координаційних швидко-силових видів легкої атлетики, який у порівнянні з іншими видами передбачає подолання великих динамічних навантажень (Бобровник, 2005; Козлова, 2015; Колот, 2016).

Аналіз фахової літератури (Козлова, 2015; Конестяпін, & Ханікянц, 2017; Marinova, & Peev, 2020) свідчить, що спортивний результат у потрійному стрибку залежить від рівня фізичної та технічної підготовленості стрибунів, а інформація про часові характеристики техніки стрибунів дає змогу оптимізувати процес технічної підготовки.

Незважаючи на великий накопичений практичний досвід і численні роботи, присвячені проблемам підготовки кваліфікованих стрибунів потрійним (Креер, & Попов, 1986; Валиуллин, Шатунов, Оганджанов, & Ломов, 2020; Дух, Лемешко, Дунець-Лесько, & Свищ, 2018), питання технічної підготовленості стрибунів різної кваліфікації залишається не достатньо дослідженим.

На сьогодні очевидним є положення про те, що наявність у стрибунів потрійним високої кваліфікації оптимальних показників технічної підготовленості має важливе значення для досягнення високих спортивних результатів (Козлова, 2015; Колот, 2016). У сучасній науковій літературі (Pavlović, 2018) трапляються дослідження окремих кінематичних параметрів фіналістів чемпіонатів світу в Берліні, 2008 р. та Тегу, 2011 р. Змістовні результати щодо визначення часових характеристик техніки потрійного стрибка фіналісток чемпіонату світу 2017 року та учасниць зимового чемпіонату світу 2018 року отримали спеціалісти Всесвітньої атлетики на підставі застосування сучасної методики відео знімання та обробки отриманих даних. У цих роботах наведені індивідуальні часові характеристики техніки виконання двох останніх кроків розбігу, «скоку», «кроку», «стрибка» у висококваліфікованих стрибунів (Tucker, Nicholson, Cooke, Bissas, & Merlino, 2017; Tucker, Bissas, & Merlino, 2019). Окрім того, існує низка досліджень, присвячених розробкам модельних характеристик технічної підготовленості у фазі розбігу та опорно-польотних фазах потрійного стрибка (Čoh, & Kugovnik, 2011; Pavlović, 2018). Отримані результати дозволяють виявляти сильні та слабкі сторони підготовленості стрибунів та вносити корективи у тренувальний процес.

Сьогодні у численних працях учені аналізують ритм потрійного стрибка у чоловіків та оптимальне співвідношення опорно-польотних фаз (Benison, & M. Kumar, 2017), кути відштовхування у фазах «скоку», «кроку» та «стрибка» (Abdelkader, Madani, & Bouabdellah, 2018; Su Jin, & Fang Liu, 2014; Miladinov, 2018). У фаховій літературі трапляються дослідження кінематичних показників техніки останнього кроку розбігу потрійного стрибка (Ilie, 2010). Отримані показники можуть слугувати інформативними критеріями оцінювання технічної підготовленості стрибунів потрійним.

Дослідження численних фахівців (Čoh, Žvan, & Burnik, 2013; Eissa, 2014; Joo-Ho Songa, & Jae-Kyun Ryu, 2011) присвячені аналізу окремих кінематичних характеристик

потрійного стрибка. Проте, у вказаних вище працях, практично відсутні дані щодо часових характеристик техніки потрійного стрибка у стрибунів різної кваліфікації. Не вивченими залишаються питання інформативності часових характеристик технічної підготовленості стрибунів.

Мета роботи: уточнити часові характеристики технічної підготовленості стрибунів потрійним високої кваліфікації.

Матеріал і методи

Учасники дослідження

Педагогічне спостереження проводилося під час змагань кубку України та чемпіонату України з легкої атлетики. У дослідженні брали участь 9 стрибунів потрійним (середній вік стрибунів $25,3 \pm 5,1$ роки), з них двоє майстрів спорту міжнародного класу України, четверо майстрів спорту України та троє кандидатів у майстри спорту України.

Організація дослідження

Методи дослідження: теоретичний аналіз та узагальнення даних науково-методичної літератури, педагогічне спостереження, інструментальні методики (відеозйомка) та методи математичної статистики.

За допомогою відеозйомки (відеокамера Sony DCR-XR 150E) було відібрано та проаналізовано (програма – Tracker – 4.87) відео найкращої за результатом спроби 9 учасниць змагань. Визначали такі часові характеристики техніки потрійного стрибка: тривалість опорних та польотних періодів кожного з шести останніх кроків розбігу (с); тривалість першого, другого, третього відштовхування (с); тривалість польотних фаз «скоку», кроку, стрибка (с). За допомогою програмного забезпечення Statistica розраховано: темп кожного з шести останніх кроків розбігу ($\text{кр}^{-1} \text{с}$); контрастність зростання темпу розбігу (різниця темпу останнього кроку і четвертого кроку розбігу, $\text{кр}^{-1} \text{с}$), темпова інтенсивність (середній темп трьох останніх кроків розбігу, $\text{кр}^{-1} \text{с}$), темпова мобілізація (добуток контрастності та темпової інтенсивності, ум. од.); сумарна тривалість фаз «скоку», «кроку» та «стрибка» (с); відсоткове співвідношення тривалості фаз «скоку», «кроку», «стрибка» (%); середня швидкість фаз «скоку», «кроку», «стрибка» (м/с).

Статистичний аналіз

Статистичний аналіз отриманих даних проводили з використанням стандартних процедур програм Microsoft Excel 2010. Серед математико-статистичних методів нами розраховувалися середні значення, стандартне відхилення ($X \pm \sigma$), варіативність часових характеристик (V%) та коефіцієнт кореляції Брауна-Пірсона (r). Кореляційний взаємозв'язок часових характеристик технічної підготовленості з результатом потрійного стрибка проведено для виявлення інформативних показників технічної підготовленості стрибунів.

Результати

Відштовхування є одним з найважливіших елементів техніки потрійного стрибка, який визначає дальність

і ефективність стрибка. У фазі опори закладається динамічна основа високих спортивних результатів і створюються умови для ефективної взаємодії внутрішніх і зовнішніх сил, які сприяють траєкторії польоту стрибунка. Аналізуючи тривалість опорних періодів шести останніх кроків розбігу та відштовхувань у «скоку», «кроці», «стрибку» стрибунки потрібним високої кваліфікації

встановлено низьку варіативність показників ($V < 10\%$) (табл. 1).

Тривалість опорного періоду відштовхування у «кроці» і «стрибку» і є дещо довшою, у порівнянні зі «скоком» і становить $0,13 \pm 0,02$ с, що є особливістю техніки фази «стрибка» та пов'язане зі специфікою виконання третього відштовхування на меншій горизонтальній швидкості.

Таблиця 1. Тривалість опорних періодів шести останніх кроків розбігу та відштовхувань у «скоку», «кроці» та «стрибку» стрибунки потрібним високої кваліфікації, (n = 9)

Показники	X	$\pm \sigma$	V %
Спортивний результат, м	13,76	0,46	3,34
Тривалість опорного періоду 6-го кроку розбігу, с	0,12	0,00	0,00
Тривалість опорного періоду 5-го кроку розбігу, с	0,11	0,01	9,11
Тривалість опорного періоду 4-го кроку розбігу, с	0,11	0,01	9,68
Тривалість опорного періоду 3-го кроку розбігу, с	0,11	0,01	9,68
Тривалість опорного періоду передостан. кроку розбігу, с	0,10	0,01	7,90
Тривалість опорного періоду останнього кроку розбігу, с	0,10	0,01	7,90
Тривалість відштовхування у «скоку», с	0,10	0,01	7,90
Тривалість відштовхування у «кроці», с	0,13	0,02	12,25
Тривалість відштовхування у «стрибку», с	0,13	0,02	12,25

Таблиця 2. Тривалість польотних періодів шести останніх кроків розбігу та польоту у «скоку», «кроці», «стрибку» стрибунки потрібним високої кваліфікації (n = 9)

Показники	X	$\pm \sigma$	V %
Спортивний результат, м	13,76	0,46	3,34
Тривалість польотного періоду 6-го кроку розбігу, с	0,17	0,02	9,80
Тривалість польотного періоду 5-го кроку розбігу, с	0,16	0,00	0,00
Тривалість польотного періоду 4-го кроку розбігу, с	0,15	0,02	10,65
Тривалість польотного періоду 3-го кроку розбігу, с	0,14	0,02	14,39
Тривалість польотного періоду передостан. кроку розбігу, с	0,14	0,02	12,78
Тривалість польотного періоду останнього кроку розбігу, с	0,12	0,02	12,90
Тривалість польотного періоду у «скоці», с	0,55	0,02	4,38
Тривалість польотного періоду у «кроці», с	0,38	0,03	7,44
Тривалість польотного періоду у «стрибку», с	0,65	0,06	8,86

Таблиця 3. Темп та ритмо-темпові характеристики шести останніх кроків розбігу стрибунки потрібним високої кваліфікації (n = 9)

Показники	X	$\pm \sigma$	V %
Спортивний результат, м	13,76	0,46	3,34
Темп останніх 6-го кроку розбігу, $\text{кр}^{-1}\text{с}$	3,55	0,23	6,61
Темп останніх 5-го кроку розбігу, $\text{кр}^{-1}\text{с}$	3,67	0,10	2,82
Темп останнього 4-го кроку розбігу,	3,83	0,20	5,13
Темп останнього 3-го кроку розбігу, $\text{кр}^{-1}\text{с}$	4,13	0,30	7,28
Темп передостаннього кроку розбігу, $\text{кр}^{-1}\text{с}$	4,13	0,30	7,28
Темп останнього кроку розбігу, $\text{кр}^{-1}\text{с}$	4,67	0,30	6,45
Контрастність, $\text{кр}^{-1}\text{с}$	0,83	0,27	31,90
Темпова інтенсивність, $\text{кр}^{-1}\text{с}$	4,28	0,21	4,99
Темпова мобілізація, ум.од.	3,62	1,27	35,12

Переходячи до аналізу динаміки тривалості польотних періодів 6-ти останніх кроків розбігу та трьох польотних періодів «скоку», «кроку» і «стрибка» нами виявлена дещо більша їх варіативність. Найвища варіативність у тривалості польотних періодів наявна на 3-му, передостанньому та останньому кроках розбігу (14,39, 12,78 та 12,90% відповідно) (табл. 2). Тривалість польотних періодів з 6-го кроку розбігу $0,17 \pm 0,02$ с поступово зменшується до $0,12 \pm 0,02$ с в останньому кроці, що сприяє зростання швидкості розбігу стрибунки та активній постановки ноги на відштовхування. Тривалість польоту під час виконання «скоку» в стрибунки знаходиться у межах $0,55 \pm 0,02$ с, і має низьку варіативність. «Крок» є найкоротшим за тривалістю у співвідношенні зі «скоком» та «стрибком».

Причиною відносно невеликої тривалості польоту «кроку» є те, що після виконання «скоку» опорно-руховий апарат стрибунки перебуває під дією великого навантаження, що істотно знижує ефективність другого відштовхування. Тривалість польоту «стрибка» у спортсменок становить $0,65 \pm 0,06$ с, варіативність даного показника становить 8,86%.

Темп шести останніх кроків розбігу у стрибунки потрійним високої кваліфікації має низьку варіативність, а максимальних значень досягає на останньому кроці $4,67 \pm 0,30$ кр./с (табл. 3). Стрибунки потрійним високої кваліфікації виконують останній крок розбігу у високому темпі, характеризуються високими показниками контрастності зростання темпу, середньої темпової інтенсивності та темпової мобілізації перед початком першого відштовхування. Найвищу варіативність ритмо-темпових характеристик нами виявлено у показниках контрастності зростання темпу та темпової мобілізації (31,90% та 35,12% відповідно). Це говорить про те, що стрибунки використовують різні варіанти поєднання розбігу з відштовхуванням.

Висока траєкторія польоту під час «скоку» збільшує навантаження на поштовхову ногу під час приземлення, що негативно впливає на довжину наступних стрибків. У цій частині виконання стрибка важливим є перетворення горизонтальної швидкості у вертикальну, та досягнення оптимальної траєкторії польоту. На траєкторію польоту впливають кут і швидкість вильоту, горизонтальна і вертикальна швидкості, та висота загального центру маси тіла під час вильоту.

Важливим є збереження горизонтальної швидкості під час виконання польотних фаз стрибка. Тривалість фаз «скоку», «кроку», «стрибка», їх загальна тривалість, відсоткове відношення, середня швидкість у стрибунки потрійним різної кваліфікації мають низьку варіативність (табл. 4). Тривалість «скоку» у стрибунки потрійним становить $0,66 \pm 0,02$ с. Найдовшою за тривалістю виконання є фаза «стрибка» ($0,78 \pm 0,06$ с), а найкоротшою – фаза «кроку» ($0,51 \pm 0,04$ с).

Середня швидкість стрибкових фаз «скоку», «кроку», «стрибка», знаходиться у межах $7,07 \pm 0,36$ м/с. Співвідношення виконання «скоку», «кроку» та «стрибка» є важливим показником технічної підготовленості стрибунки потрійним. У таблиці 5 наведено ритмічну структуру опорно-польотних фаз потрійного стрибка у відсотковому співвідношенні за тривалістю їх виконання. У всіх стрибунки переважає фаза «стрибка» $40,05 \pm 1,80\%$, а найкоротшою є фаза «кроку» $26,30 \pm 1,89\%$.

Таблиця 4. Тривалість стрибкових фаз та їх середня швидкість у стрибунки потрійним високої кваліфікації, $n = 9$, результат = $13,76 \pm 0,46$ м

Показники	X	$\pm \sigma$	V %
Тривалість «скоку», с	0,66	0,02	2,99
Тривалість «кроку», с	0,51	0,04	7,66
Тривалість «стрибка», с	0,78	0,06	7,81
Тривалість «сумарна», с	1,95	0,08	4,23
Середня швидкість «скоку», «кроку», «стрибка», м/с	7,07	0,36	5,12

Таблиця 5. Ритмічна структура потрійного стрибка стрибунки потрійним високої кваліфікації, $n = 9$; результат = $13,76 \pm 0,46$ м

Показники	«Скок», %	«Крок», %	«Стрибок», %
X	33,65	26,30	40,05
$\pm \sigma$	1,07	1,89	1,80
V %	3,18	7,18	4,49

Кореляційний аналіз низки часових показників технічної підготовленості стрибунки потрійним високої кваліфікації показав, що статистично достовірний взаємозв'язок ($p < 0,05$) зі спортивним результатом мають показники тривалості польотного періоду передостаннього кроку розбігу ($r = -0,85$) темпі передостаннього ($r = 0,60$) темпе останнього кроків ($r = 0,78$) та темповій інтенсивності ($r = 0,76$).

Дискусія

Потрійний стрибок відносно молодий вид жіночої легкої атлетики. Змагання з потрійного стрибка серед жінок почали проводитись на початку XX століття. Існує низка напрацювань щодо визначення інформативних показників технічної підготовленості. Однак, досі триває пошук об'єктивних критеріїв оптимізації процесу технічної підготовки у потрійному стрибку.

У ході дослідження нами отримано нові дані щодо тривалості опорних, польотних періодів, темпу, ритмо-темпових характеристик шести останніх кроків розбігу та відсоткового співвідношення фаз «скоку», «кроку», «стрибка» у стрибунки потрійним високої кваліфікації. Креером & Папановим (1992) було проведено аналіз кінограми потрійного стрибка Інесси Кравець (результат 14,95 м). Порівнюючи наші дані з даними (Креер & Папанов, 1992) нами виявлено незначні відмінності у тривалості: першого – 0,12 с, другого – 0,17 с, третього – 0,17 с відштовхувань (показники Інесси Кравець). У показниках тривалості польотних стрибкових фаз виявлено суттєві відмінності між даними І. Кравець та нашими показниками. Польотна фаза «скоку» в Інесси Кравець становила «кроку» – 0,50 с, «стрибка» – 0,79 с. За нашими даними відмінності виявлено у тривалості фаз польоту «кроку» ($0,38 \pm 0,03$ с) та фази «стрибка» ($0,66 \pm 0,02$ с), фаза «скоку» у І. Кравець (0,58 с) та наших спортсменок ($0,55 \pm 0,02$ с) майже однакові.

Порівнюючи результати дослідників (Креер & Папанов, 1992) з нашими даними виявлено схоже ритміч-

ну структуру виконання трьох стрибкових фаз. В Інесси Кравець «крок» становив 26,7% та «стрибок» – 42,3% співпадає з отриманими нами даними. Відмінність полягала у більшому внеску «скоку» 33,65% (за нашими даними), а за даними Креера та Папанова (1992) вклад «скоку» в стрибунки Інесси Кравець становить 31%.

Однією зі сторін підвищення ефективності рухів в горизонтальних стрибках є зниження високих ударних навантажень при відштовхуванні – зниженням траєкторії «скоку». Стрибунки зменшують ударні вертикальні навантаження в другому відштовхуванні потрійного стрибка, компенсуючи зменшення довжини цієї фази кращим використанням горизонтальної швидкості під час «скоку» і збільшенням зв'язки «крок + стрибок».

Провівши аналіз часових характеристик тривалості відштовхування за даними (Бобровник, 2005) та за нашими даними виявлено схожі результати. Так, при середньому результаті потрійного стрибка $13,10 \pm 0,14$ м, тривалість відштовхування у «скоку» становить $0,10 \pm 0,02$ с, «кроці» – $0,12 \pm 0,01$ с, «стрибку» – $0,14 \pm 0,02$ с. Автори дослідження (Panoutsakopoulos, & Kollias, 2008) на підставі аналізу відео зйомки змагань наводять індивідуальні та групові значення таких часових характеристик стрибунки: тривалість опорних та польотних періодів останнього кроку розбігу, «скоку», «кроку» та «стрибка». Результати стрибка – $14,32 \pm 0,67$ м відповідають: тривалість опори – $0,11 \pm 0,01$ с, польоту – $0,10 \pm 0,01$ с останнього кроку розбігу; за нашими даними при середньому результаті $13,76 \pm 0,46$ м, встановлено тривалість опори на останньому кроці розбігу – $0,10 \pm 0,01$ с, польоту – $0,12 \pm 0,02$ с. Порівнюючи результати тривалості першого відштовхування – $0,12 \pm 0,01$ с, другого – $0,14 \pm 0,01$ с, третього – $0,15 \pm 0,02$ с відштовхувань за даними авторів (Panoutsakopoulos, & Kollias, 2008) і нашими даними «скок» – $0,10 \pm 0,01$ с, «крок» – $0,13 \pm 0,02$ с, «стрибок» – $0,13 \pm 0,02$ с, видно схожу тенденцію, дещо різняться тривалість третього відштовхування.

Аналіз тривалості польотних фаз «скоку» і «кроку» наших даних та даних авторів (Panoutsakopoulos, & Kollias, 2008) показує відмінності. У наших дослідженнях фаза польоту під час виконання «скоку» та «кроку»

є коротшою, так «скок» становить $0,54 \pm 0,03$ с, «крок» – $0,38 \pm 0,03$ с, тоді як за даними авторів (Panoutsakopoulos, & Kollias, 2008) «скок» – $0,65 \pm 0,03$ с, «крок» – $0,50 \pm 0,04$ с. Довша фаза польоту дає підстави говорити про вищу траєкторію польоту стрибунки.

Проаналізувавши результати досліджень авторів (Čoh, Štuhec, & Vertič, 2011) часових характеристик нами встановлено відмінності у показниках тривалості польоту стрибкових фаз потрійного стрибка, і схожі результати у тривалості опорних періодів. Іншими фахівцями (Santhosh & Shabu, 2019) доведений кореляційний взаємозв'язок між довжиною «скоку» та деякими кінематичними показниками техніки потрійного стрибка, а саме кутом вильоту, середньою швидкістю, горизонтальною і вертикальною швидкостями.

Висновки

Встановлено, що за рахунок зменшення тривалості польотних періодів на останніх кроках розбігу спостерігається зростання швидкості розбігу стрибунки високої кваліфікації. Варіативність контрастності зростання темпу 31,90% та темпової мобілізації 35,12% свідчать про те, що стрибунки високої кваліфікації використовують різні варіанти поєднання розбігу з відштовхуванням. Аналіз ритмічної структури техніки потрійного стрибка свідчить, що у всіх стрибунки переважає фаза «стрибка» 40,05%, а найкоротшою є фаза «кроку» 26,30%.

Встановлено, що такі часові характеристики: тривалість польотного періоду передостаннього кроку розбігу ($r = -0,85$), темп передостаннього ($r = 0,60$), темп останнього кроку ($r = 0,78$), та темпова інтенсивність ($r = 0,76$) мають статистично достовірний взаємозв'язок зі спортивним результатом ($p < 0,05$).

Конфлікт інтересів

Автори відзначають, що не існує ніякого конфлікту інтересів.

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TIME CHARACTERISTICS OF TECHNICAL READINESS OF FEMALE TRIPLE JUMPERS OF HIGH QUALIFICATION

Volodymyr Konestyapin^{ABCD}, Olha Pavlos^{ABCD}, Olena Khanikiants^{ABCDE}, Antonina Dunets-Lesko^{ABCDE}, Tetiana Dukh^{ABCDE} and Yaroslav Svyshch^{ABCDE}

Lviv State University of Physical Culture named after Ivan Boberskyj

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection Report. Article: 8 p., 5 tabl., 23 sources.

Background. The relentless growth of sports results and the lack of comparative analysis of a set of indicators of technical readiness of female triple jumpers of various qualifications indicates the viability of research in this regard.

The study purpose was to specify the time characteristics of technical readiness of female triple jumpers of high qualification.

Materials and methods. We used the following research methods: theoretical analysis and generalization of data from scientific and methodological literature, pedagogical observation, instrumental methods (video recording) and methods of mathematical statistics. The study was conducted on the basis of investigating the time characteristics of the technical readiness of skilled triple jumpers. The pedagogical experiment took place

during the competitions of the Cup of Ukraine and the Championship of Ukraine in Athletics. The study involved 9 female triple jumpers (average age 25.3 ± 5.1), including two masters of sports of international class of Ukraine, four masters of sports of Ukraine, and three candidates for masters of sports of Ukraine.

Results. In the course of the study, we found that the indicators of the duration of the reference periods of the last 6 steps of the run in the triple jump by female jumpers of high qualification are characterized by a low level of variability. In terms of flight duration, the highest variability was observed in the 3rd, next to last and last steps of the run. According to the results of the study of rhythmic-tempo characteristics of a triple jump of high qualification, it was established that the highest indicators of the pace of the running step are at the last step of

the run and reach 4.67 ± 0.03 st./s. The correlation between such time characteristics as the duration of the flight period of the next to last run step ($r = -0.85$), the rate of the next to last ($r = 0.60$) and last step ($r = 0.78$), and the rate of intensity ($r = 0.76$) with a sports result. In the triple jump by female jumpers of high qualification, indicators of the duration of the phases of "jump", "step", "jump", their total duration and the average speed of the jumping phases are characterized by a low level of variability. The duration of the "hop" is 0.66 ± 0.06 s. The longest phase is the "jump" phase (0.78 ± 0.06 s), and the shortest is the "step" phase (0.51 ± 0.04 s).

Conclusions. It was established that due to the reduction of the duration of flight periods in the last steps of the take-off, there is an increase in the take-off speed of high-skilled jump-

ers. The variability of the contrast between the growth rate of 31.90% and the rate of mobilization of 35.12% indicates that high-skilled jumpers use different options to combine take-off and repulsion. Analysis of the rhythmic structure of the triple jump technique shows that all jumps are dominated by the phase of "jump" (40.05%), and the shortest is the phase of "step" (26.30%). It was found that the following time characteristics: the duration of the flight period of the next to last run step ($r = -0.85$), the pace of the next to last step ($r = 0.60$), the pace of the last step ($r = 0.78$), and the pace intensity ($r = 0.76$) have a statistically significant relationship with sports results ($p < 0.05$).

Keywords: triple jump, technical readiness, time characteristics, female jumpers of high qualification.

Інформація про авторів:

Конестяпін В.Г.: vladkonec@gmail.com; <https://orcid.org/0000-0002-6606-3448>; кафедра легкої атлетики, Львівський державний університет фізичної культури імені Івана Боберського, вул. Костюшка 11, Львів, 79007, Україна.

Павлось О.О.: olha_slisenko@ukr.net; <https://orcid.org/0000-0002-0679-7909>; кафедра легкої атлетики Львівський державний університет фізичної культури імені Івана Боберського, вул. Костюшка 11, Львів, 79007, Україна.

Ханікянц О.В.: olena071viv@gmail.com; <https://orcid.org/0000-0001-7518-3532>; кафедра теорії і методики фізичної культури, Львівський державний університет фізичної культури імені Івана Боберського, вул. Костюшка 11, Львів, 79007, Україна.

Дунець-Лесько А.В.: tonia_d@ukr.net; <https://orcid.org/0000-0002-0512-7989>; кафедра легкої атлетики, Львівський державний університет фізичної культури імені Івана Боберського вул. Костюшка 11, Львів, 79007, Україна.

Дух Т.І.: tatanadukh88@gmail.com; <https://orcid.org/0000-0002-2401-9203>; кафедра легкої атлетики, Львівський державний університет фізичної культури імені Івана Боберського, вул. Костюшка 11, 79007, Львів, Україна.

Свищ Я.С.: yarsvysch@ukr.net; <https://orcid.org/0000-0002-1573-8599>; кафедра легкої атлетики, Львівський державний університет фізичної культури імені Івана Боберського, вул. Костюшка 11, Львів, 79007, Україна.

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