MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
HRYHORII SKOVORODA UNIVERSITY IN PEREIASLAV

THEORY and PRACTICE
of Physical Culture and Sports

Scientific and practical journal

Vol. 3, No. 2
2024

Pereiaslav
2024

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
УНІВЕРСИТЕТ ГРИГОРІЯ СКОВОРОДИ В ПЕРЕЯСЛАВІ

ТЕОРІЯ і ПРАКТИКА
фізичної культури і спорту

Науково-практичний журнал

Том 3, № 2
2024

Переяслав
2024

ISSN 2786-6432
UDC 796 e-ISSN 2786-6424

Founder:
Hryhorii Skovoroda University in Pereiaslav

Year of foundation: 2022

Frequency: semi-annual

Recommended for printing and distribution via the Internet by the Academic Council of Hryhorii Skovoroda University in Pereiaslav
(Minutes No. 14 of December 12, 2024)

Media identifier: R30-04681
(Decision of the National Council of Television and Radio Broadcasting of Ukraine No. 1442, Minutes No. 14 of April 25, 2024)

The journal is included in the List of Professional Scientific Publications of Ukraine (Category "B"). Specialties:
014 – Secondary Education (by subject specialisation); 017 – Physical Culture and Sport
(Order of the Ministry of Education and Science of Ukraine No. 491 dated April 27, 2023)

The journal is presented in the following scientometric databases, repositories and scientific systems:
Crossref; Professional Publications of Ukraine; UCSB Library; Google Scholar; Vernadsky National Library of Ukraine; Dimensions; University of Oslo Library; University of Hull Library; Open Ukrainian Citation Index (OUCI)

Editors office address:
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
Tel.: +380 (44) 293-11-10
E-mail: info@tppcs.com.ua
https://tppcs.com.ua/

ISSN 2786-6432
УДК 796 e-ISSN 2786-6424

Засновник:
Університет Григорія Сковороди в Переяславі

Рік заснування: 2022

Періодичність випуску: двічі на рік

Рекомендовано до друку та поширення
через мережу Інтернет Вченою радою
Університету Григорія Сковороди в Переяславі
(протокол № 14 від 12 грудня 2024 року)

Ідентифікатор медіа: R30-04681
(Рішення Національної ради України з питань телебачення і радіомовлення
№ 1442, протокол № 14 від 25 квітня 2024 року)

Журнал включено
до Переліку наукових фахових видань України (Категорія «Б»). Спеціальності:
014 – Середня освіта (за предметною спеціалізацією); 017 – Фізична культура і спорт
(Наказ Міністерства освіти і науки України № 491 від 27 квітня 2023 року)

Журнал представлено
у таких наукометричних базах даних, репозитаріях та пошукових системах:
Crossref; Фахові видання України; UCSB Library; Google Академія;
Національна бібліотека України імені В.І. Вернадського; Dimensions;
University of Oslo Library; University of Hull Library; Open Ukrainian Citation Index (OUCI)

Адреса редакції:
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
Тел.: +380 (44) 293-11-10
E-mail: info@tppcs.com.ua
https://tppcs.com.ua/

Editorial Board

Editor-In-Chief:

Nataliia Panhelova	Doctor of Physical Education and Sport, Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine

Deputy Editor-in-Chief

Tetiana Kravchenko	PhD in Pedagogy, Associate Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine

National Members of the Editorial Board

Mariia Panhelova	PhD in Philology, Associate Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine
Halyna Bezverkhnia	Doctor of Physical Education and Sport, Professor, Lutsk National Technical University, Ukraine
Petro Kokhanets	PhD in Physical Education and Sport, Associate Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine
Viktor Kuibida	PhD in Biology, Doctor of History, Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine
Oksana Marchenko	Doctor of Physical Education and Sport, Professor, National University of Ukraine on Physical Education and Sport, Ukraine
Nataliia Moskalenko	Doctor of Physical Education and Sport, Professor, Prydniprovsk State Academy of Physical Culture and Sport, Ukraine
Vladyslav Ruban	PhD in Physical Education and Sport, Associate Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine
Volodymyr Stepanenko	PhD in Physical Education and Sport, Associate Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine
Viktoriia Tsybulska	PhD in Physical Education and Sport, Associate Professor, Bogdan Khmelnitsky Melitopol State Pedagogical University, Ukraine
Nataliia Chuprun	PhD in Pedagogy, Associate Professor, Hryhorii Skovoroda University in Pereiaslav, Ukraine

International Members of the Editorial Board

Mario Baić	Doctor of Science, Professor, University of Zagreb, Croatia

Редакційна колегія

Головний редактор

Наталія Пангелова	Доктор наук з фізичного виховання і спорту, професор, Університет Григорія Сковороди в Переяславі, Україна

Заступник головного редактора

Тетяна Кравченко	Кандидат педагогічних наук, доцент, Університет Григорія Сковороди в Переяславі, Україна

Національні члени редакційної колегії

Марія Пангелова	Кандидат філологічних наук, доцент, Університет Григорія Сковороди в Переяславі, Україна
Галина Безверхня	Кандидат наук з фізичного виховання і спорту, професор, Луцький національний технічний університет, Україна
Петро Коханець	Кандидат наук з фізичного виховання і спорту, доцент, Університет Григорія Сковороди в Переяславі, Україна
Віктор Куйбіда	Кандидат біологічних наук, доктор історичних наук, професор, Університет Григорія Сковороди в Переяславі, Україна
Оксана Марченко	Доктор наук з фізичного виховання і спорту, професор, Національний університет фізичного виховання і спорту України, Україна
Наталія Москаленко	Доктор наук з фізичного виховання і спорту, професор, Придніпровська державна академія фізичної культури і спорту, Україна
Владислав Рубан	Кандидат наук з фізичного виховання і спорту, доцент, Університет Григорія Сковороди в Переяславі, Україна
Володимир Степаненко	Кандидат наук з фізичного виховання і спорту, доцент, Університет Григорія Сковороди в Переяславі, Україна
Вікторія Цибульська	Кандидат наук з фізичного виховання і спорту, доцент, Мелітопольський державний педагогічний університет імені Богдана Хмельницького, Україна
Наталія Чупрун	Кандидат педагогічних наук, доцент, Університет Григорія Сковороди в Переяславі, Україна

Міжнародні члени редакційної колегії

Маріо Баїч	Доктор наук, професор, Загребський університет, Хорватія

CONTENTS

ЗМІСТ

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 29.08.2024. Revised: 08.11.2024. Accepted: 12.12.2024

UDC 796.071

DOI: 10.69587/tppcs/2.2024.09

The use of interactive technologies in the physical education process

Olga Shapran*

Doctor of Pedagogy, Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0002-7514-6632

Oleksii Tkachuk

Lecturer
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0009-0004-5257-1240

Abstract. The study aimed to determine the impact of modern innovative tools on the effectiveness of students' physical development in the contemporary educational process. The research methodology included an experiment involving 150 students who received lessons using various interactive technologies. Methods of testing endurance, strength and flexibility were used to assess the physical fitness of students. The results of the study demonstrated that students in the experimental group achieved significant improvements in physical fitness, particularly in endurance and flexibility tests, compared to the control group. The study noted an increase in motivation and satisfaction with the learning process among students who used interactive technologies. The data obtained confirm that interactive teaching methods improve the effectiveness of physical education and can be recommended for implementation in educational practice. The introduction of interactive technologies positively affected students, increasing motivation to engage in physical education and improving overall physical fitness. Students became more involved in the training process using mobile apps to monitor their activity, as well as virtual simulators that made training interesting and accessible. This not only increased interest in physical activities but also formed stable habits of an active lifestyle among students. Technologies that tracked progress and provided individualised recommendations were particularly effective. These technologies enabled students to receive real-time feedback, which greatly increased their motivation and helped them achieve better results in physical education. The effectiveness of interactive technologies in physical education was confirmed, which shows the expediency of using such technologies by physical education teachers in their practice to increase students' motivation and improve their physical fitness

Keywords: modern education; sports training; innovations; educational methods; assessment

Introduction

The physical development of students remains an important aspect of their overall education, as it affects not only physical health but also psychological state and academic performance. Physical education in Ukrainian higher education institutions is often based on traditional teaching methods, which include standardised exercises, regulations and regular physical education classes. However, these approaches do not always incorporate the individual needs of students, their interests and current trends in physical development. The motivation of students to engage in physical activity decreases, which leads to an insufficient level of physical fitness. There is a need to introduce innovative methods aimed at improving the physical development of students. The introduction of modern interactive tools and methods, such as mobile applications for monitoring physical activity, online platforms with personalised training programmes, video tutorials and interactive games, can significantly increase interest in physical education. These innovations improve dynamics, interaction and individualised environment for physical development. It is necessary to create a physical education that develops not only physical abilities but also psychological resilience, discipline and healthy lifestyle skills. Innovative methods make the learning process more interesting and accessible. This contributes to the formation of sustainable motivation for physical education. Given these factors, research and integration of

Suggested Citation: Shapran, O., & Tkachuk, O. (2024). The use of interactive technologies in the physical education process. *Theory and Practice of Physical Culture and Sports*, 3(2), 9-18. doi: 10.69587/tppcs/2.2024.09.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

innovative technologies into the educational process is essential to improve students' physical development. Solving this problem will make it possible to more effectively adapt physical education to the needs of modern youth and increase its effectiveness.

Many scholars investigated the issue of the use of interactive technologies in physical education, in particular, the study by G. Amina *et al.* (2023) identified different teaching methods in physical education that demonstrate their significant impact on motivation and effectiveness of classes. The study emphasised the importance of interactive technologies in improving the motivation of students to engage in physical education. A. Zhao (2023) emphasised that the use of new technologies encourages students to engage in physical activity more actively, due to interactive elements that make the learning process more interesting and active. X. Hu & J. Li (2024) investigated the impact of digital platforms on the individualisation of physical education. The study demonstrated that such platforms can adapt physical education programmes to the individual needs of each student, which significantly increases the effectiveness of classes. This is especially relevant in the context of different levels of physical development of students when everyone can get a programme that matches their level of training and goals. The importance of mobile applications in monitoring physical activity was studied by O.A. Isaqovich *et al.* (2024). They emphasised that mobile apps not only help students monitor their performance but also influence their motivation to exercise regularly. Users can constantly monitor their progress and adjust their training. Z. Xing & Y. Qi (2023) studied the integration of video tutorials into the educational process and their impact on improving the technical training of students. The study concluded that this method allows students to study in detail the technical aspects of exercises, which improves their practical skills. L. Jian (2024) analysed the use of gamification as a means of increasing students' interest in physical education. The author proved that game elements in the training process increase the appeal of the training process to students, contributing to their greater engagement. The effectiveness of personalised training programmes in the development of the physical performance of students was studied by Z. Lei *et al.* (2024), demonstrating that an individual approach contributes to faster and better results. D.T. Nguyen & M.T. Nguyen (2024) studied the impact of a combined approach that incorporates both traditional and innovative methods to provide a more comprehensive approach to students' physical development, which increases the overall effectiveness of the learning process.

These researchers highlighted the importance of innovative approaches in improving students' physical fitness and motivation and have proposed various methods to achieve these goals. The role of virtual reality in creating a more effective learning environment for physical education has been highlighted, although several issues remain unresolved. These include the optimal integration of innovative methods into traditional physical education systems to ensure their maximum effectiveness. The long-term impact of these technologies on students' physical development and motivation also needs to be investigated in more detail. Thus, this study aimed to identify the impact of modern innovative technologies on the formation of physical culture in students in the modern educational process. The objectives of the study are: to analyse the current state of physical development of students in Ukraine, identifying the main problems and challenges in the system of physical education; to introduce innovative methods and tools in the process of physical education of students and to assess their impact on the physical fitness and motivation of students; to conduct a comparative analysis of the results of physical fitness of students who were taught using traditional methods and innovative technologies and based on the data obtained to provide recommendations for optimising physical education.

Materials and Methods

The study was conducted among students of physical education faculties from several universities. Students were recruited from the following three universities: National University of Ukraine on Physical Education and Sport, Faculty of Physical Education; Ivan Bobersky Lviv State University of Physical Culture, Faculty of Physical Education and Sports; V.N. Karazin Kharkiv National University, Faculty of Physical Education and Sports. Each university provided students from different courses and specialisations of the Faculty of Physical Education to ensure a representative sample. The experimental study in physical education involved third- and fourth-year university students who were studying for a degree in physical education. All participants were informed about the purpose of the study and how their data would be used. This included information about confidentiality and anonymity to ensure compliance with ethical standards. Following the ethical standards of the study, participants were allowed to give their consent to participate and could withdraw at any time without giving any reason (Declaration of Helsinki, 2013).

The experiment involved 150 male students ($N = 150$) divided into two groups: experimental and control. The experimental group consisted of 75 students ($n = 75$) studying in a programme that included interactive technologies (such as online training platforms, video tutorials and mobile applications for monitoring physical activity). The control group, also consisting of 75 students ($n = 75$), continued to study using traditional physical education methods without the introduction of new technologies. The experimental part of the study included the introduction of interactive technologies (online platforms – Nike Training Club and virtual and augmented reality games FitXR) into the educational process during the second semester of the 2023-2024 academic year. The programme included the use of digital platforms to create individual training plans, video tutorials on exercise techniques, and mobile applications to monitor progress.

To evaluate the effectiveness of the methods used, measurements were taken before and after the introduction of interactive technologies that allow students to track their progress in real-time, depending on the speciality they are studying. In addition, the Google Fit and Strava mobile applications were used to motivate students to exercise regularly. The student's physical fitness was measured using standardised testing methods, including the assessment of students' physical fitness using endurance, strength and flexibility tests. Endurance tests – Cooper test (2023) (measuring the maximum distance a student can run in 12

min); running endurance test (running 800 m for women or 1,000 m for men). Strength tests – strength testing (maximum number of pull-ups on the bar or push-ups from the floor); test of maximum strength of the muscles of the lower body (squats with or without a barbell). Flexibility tests, namely of the trunk (reaching toes in a sitting position) and shoulder girdle (diagonal raising of arms behind the back). These tests were used to assess the general physical condition of students, including their endurance, strength and flexibility, and help to compare the results between the experimental and control groups before and after the introduction of interactive technologies. The results were rounded and then analysed using statistical methods to determine the impact of interactive technologies on learning outcomes in physical education.

Results

Theoretical analysis of various interactive technologies in the process of teaching physical education

Interactive technologies in physical education can significantly improve the effectiveness of the learning process and stimulate students' interest in physical activity. These technologies cover a wide range of digital tools that facilitate individualised learning, monitor progress and provide new opportunities for teachers and students. One of the most popular and relevant tools is mobile applications that can be used to track physical activity, create individual training plans, monitor progress and encourage regular exercise. MyFitnessPal, for instance, allows users to keep track of calories, activity and nutrient intake, which helps students better understand their diet and physical activity. Another popular app, Strava, provides the ability to record workouts, competitions and achievements, which increases motivation through the social aspect of the community.

Online fitness platforms also offer significant benefits. Nike Training Club, for example, offers free access to a variety of video tutorials and training programmes. This allows teachers to tailor the material to the individual needs of each student. Students can watch the lessons at the desired pace, which contributes to the flexibility of learning. Video lessons are another important component of interactive technologies in physical education. With video lessons, students watch the correct technique of performing exercises, analyse their mistakes and improve. YouTube and other platforms offer many videos demonstrating various physical exercises and techniques that students can watch several times for better learning. Interactive games make physical education more exciting and less routine. Virtual reality games allow students to train in a fun and dynamic way. These games help to develop coordination, endurance and other physical qualities, making physical education not only useful but also entertaining. Interactive technologies create new opportunities for physical activity, encourage students to play sports and provide an individual approach to learning.

Every year, new technologies are introduced into the education sector. Modern devices, such as computers, tablets and smartphones with constant access to the Internet, have become an integral part of modern life. Education is now closely linked to the latest computer technologies. Multimedia devices and communication tools are increasingly being incorporated into educational processes. However, the rapid development of technology creates new challenges for the educational system, and 3D technology is now a modern trend in educational technology that fully meets the requirements of modern education (Ye *et al.*, 2024). The use of interactive 3D environments for learning is becoming an effective means of transferring and storing knowledge for several reasons: student engagement, visualisation of abstract concepts, individual approach, and increased information retention. The use of interactive technologies in physical education significantly expands the capabilities of traditional teaching methods. They allow for a better individual approach to students, stimulate their activity, increase their interest in classes and help teachers to organise the learning process more effectively. Such technologies can be particularly useful in distance learning, where direct interaction with the teacher is not possible. With the development of technology, its role in physical education is expected to grow, creating new horizons for teachers and students.

In Ukraine, mobile apps and online platforms are the most actively used to monitor and promote physical activity. Mobile apps are particularly popular among students as they provide a convenient and easy way to track physical activity, set personal goals, and receive recommendations and reminders. Such apps allow users to keep workout diaries, track progress, and share achievements with friends or even compete with them. They are often integrated with other platforms, which can be used to utilise data from multiple sources to compile a complete overview of physical activity level. Many apps also have social interaction features that help motivate users through support and competition with other people. With these features, mobile apps have become an important tool in promoting and maintaining a healthy lifestyle among young people in Ukraine.

According to a study by the World Health Organization (2018), about 81% of adolescents worldwide did not reach the recommended level of physical activity, which is at least 60 min a day of moderate to vigorous physical activity. According to data from different countries, this figure is alarming, as insufficient physical activity can lead to health problems such as obesity, diabetes and cardiovascular disease. The integration of modern technologies, such as mobile apps and virtual training, can have a significant impact on students' physical activity levels, increasing their motivation and interest in physical education. These technologies help students to monitor their activity, receive feedback and develop sustainable exercise habits.

The world's leading countries use a range of innovative interactive technologies to improve physical education, which are not yet widespread in Ukraine (Bezkopylnyi *et al.*, 2020). One of these technologies is virtual reality, which can be used to create training programmes and simulations that motivate users to be physically active through game scenarios and virtual sports competitions. Another technology is augmented reality, which integrates digital elements into the real world to help students perform exercises with real-time technique correction. High-tech smart clothing and fitness monitors have also gained popularity; they can track numerous health and fitness parameters, such as heart rate, calorie intake and stress levels. Interactive simulators and robotic systems that adapt to the individual needs of the user are also used to create personalised training programmes. In Ukraine, these technologies

have not yet been widely adopted, and most educational institutions use traditional methods of physical education, which limits the opportunities for individualisation and modernisation of the educational process. The introduction of such advanced technologies could significantly improve the effectiveness of physical education and students' interest in physical education.

The formation of physical culture in Ukrainian universities faces several negative trends that affect the physical development of students. One of the main problems is a decrease in students' motivation to engage in physical education. This is due to the overload of the curriculum, which often leaves little time for regular physical activity. Given the heavy workload, many students consider sports to be of secondary importance and do not pay due attention to it. Another negative trend is the insufficient material and technical base at some universities. Lack of modern sports equipment, limited access to sports grounds and lack of variety in the sports activities offered reduce the attractiveness of physical education for students. In addition, modern lifestyles, characterised by a significant amount of time spent on computers and smartphones, also contribute to a decrease in physical activity among young people. The resulting physical inactivity hurts the overall health and fitness of students. The lack of active activities in everyday life and low awareness of the importance of a healthy lifestyle also contribute to these negative trends. Low motivation, insufficient material resources and a passive lifestyle are the main challenges in the development of physical education among students.

The use of innovative technologies in physical education is becoming increasingly common, as they allow for an individualised approach to learning, tracking students' progress and providing accurate recommendations to improve their physical condition. Mobile apps can offer personalised training programmes based on the individual needs and physical condition of the student. Digital technologies allow tracking not only activity but also the effectiveness of each workout. This allows teachers to tailor lessons for each student based on the data they receive. In Japan, innovative approaches to sports are based on the integration of traditional physical exercises with the latest technologies (Sports culture in Japan, 2023). One example of a technology application is the use of augmented reality in physical education. Virtual reality is used to learn and master new movements and exercises. Simulations can help comprehend the technique of performing exercises, as well as see possible mistakes in the technique. This significantly increases the efficiency of training and helps to avoid injuries. Sensors are actively used to track physical activity. Such sensors can be built into uniforms or shoes and allow trainers to obtain accurate data on motor activity. This data is analysed and used to create individual training plans.

At the same time, the use of innovative technologies in physical education in Ukraine is still underdeveloped. Although some universities and schools are beginning to use digital technologies, their use remains limited. The main problem is the lack of funding and infrastructure, which makes it difficult to integrate the latest technologies into the educational process. To improve the situation, Ukraine should address the experience of other countries and focus on developing the material and technical base of educational institutions. This includes providing schools and universities with modern equipment and developing and implementing digital platforms for monitoring and managing students' physical activity. In addition, it is important to improve the skills of physical education teachers by providing them with access to curricula that focus on the use of innovative technologies in pedagogical practice. It is necessary to consider the possibility of developing public-private partnerships in this area, attracting investments from the private sector to modernise sports infrastructure and introduce the latest technologies. Involving students in the active use of innovations through promotion and motivation could also be an important step. The introduction of innovative technologies in physical education in Ukraine can significantly improve the level of physical fitness of students and make this process more efficient.

Empirical study of the effectiveness of interactive technologies in physical education

The students in the experimental group used a range of interactive technologies to check their progress in physical education. These included online platforms (Nike Training Club) that were used to monitor their classes and progress, as well as to learn exercise techniques, review instructions as many times as necessary, and avoid injury. Virtual and augmented reality games that required active physical activity (FitXR) were used. The Cooper test is a standard endurance test that assesses the aerobic endurance of participants based on the distance they can run in 12 min. The results of the test revealed conclusions, that were used for comparing the level of physical fitness and the ability to prolonged physical activity of the experimental and control groups after a semester of the educational process using different methods (Table 1).

Table 1. Results of the study of both groups by the Cooper test

Aspect	Experimental group	Control group
Average distance	2,900 m	2,700 m
Standard deviation	150 m	180 m
Minimum distance	2,600 m	2,400 m
Maximum distance	3,200 m	3,050 m

Source: compiled by the authors

The experimental group demonstrated higher average results in this test, where participants were able to run 200 m more than the control group. This increase in average distance indicates that the use of interactive methods had a significant positive impact on their aerobic endurance. Increased aerobic endurance was the result of the systematic introduction of new training methods that focus on increasing aerobic load, developing the cardiorespiratory

system and improving running technique. It is important to note that the experimental group showed a smaller variation in results (measured by standard deviation) compared to the control group. This indicates that the new technologies affected all students in this group more evenly, increasing their endurance to a similar level. After using the new techniques, the students had a more equal level of physical fitness, which indicates their effectiveness and versatility for a wide range of participants. In the control group, there was a greater variation in results, which indicates that traditional methods are less effective or have an unequal effect on all participants. This could be attributed to the fact that some students were less sensitive to conventional methods, or that these methods did not accommodate individual physical fitness characteristics. Thus, the lower scores and higher average distance in the experimental group confirm that the new technologies are effective in providing more uniform results regardless of the initial level of students' fitness, which is important for creating equal conditions for all participants. The endurance test in running involves running a certain distance (800 m for women and 1,000 m for men) at maximum speed. This test was used to evaluate the students' ability to withstand intense physical activity at short distances (Table 2).

Table 2. Results of the study of both groups on the endurance test in running

Aspect	Experimental group	Control group
Average time	3 min 30 s	3 min 45 s
Standard deviation	20 s	25 s
Minimum time	3 min 10 s	3 min 20 s
Maximum time	3 min 50 s	4 min 05 s

Source: compiled by the authors

The results of the mentioned test demonstrated the superiority of the experimental group over the control group. The participants of the experimental group achieved an average time that was 15 s faster than the control group. This result is an important indicator, as 15 s over a short distance, such as 800 or 1,000 m, can be decisive in sports competitions, and indicates a marked increase in speed endurance among the participants in this group. Increased speed endurance can be the result of targeted training aimed at developing the ability of the body to run at maximum or submaximum speeds for a certain amount of time. This also included the use of interactive technologies in the educational process and additional endurance training that combined strength and aerobic training, interval running, sprints and other exercises that help to increase the ability of muscles to use oxygen efficiently and recover quickly between intense loads.

The standard deviation of the time in the control group was slightly higher, indicating significant differences in the performance of students in this group. This could indicate that the level of physical fitness of the students in the control group was less homogeneous. These differences were caused by several factors. The control group included students with different initial levels of physical fitness, which affected their results. Traditional training methods in the control group were not sufficiently adapted to these individual characteristics, which led to a greater variation in results. Moreover, the traditional training methods used in the control group did not provide the same level of training for all students. Consequently, some students may have benefited less from these techniques, leading to more significant differences in results.

Therefore, the faster average time in the running endurance test in the experimental group, together with the lower standard deviation, indicates that the new technologies in physical education introduced in this group not only contributed to the improvement of speed endurance but also ensured a more homogeneous level of physical fitness among the participants. In the control group, however, the dispersion of results indicates that the traditional methods did not have as strong or uniform an impact on all participants. This highlights the need to adapt training programmes to the individual needs of students to ensure more effective development of their physical capabilities. The results of the next two tests, namely the maximum number of pull-ups on the bar or push-ups from the floor (to assess the strength of the upper body) and the maximum strength of the lower body muscles (assessed through squats with or without a barbell), was also used to assess the impact of interactive teaching methods on students' physical fitness (Table 3).

Table 3. Results of strength testing of both groups

No.	Element	Experimental group	Control group
1	Average number	25 repetitions	20 repetitions
	Standard deviation	5 repetitions	6 repetitions
	Minimum number	15 repetitions	10 repetitions
	Maximum number	35 repetitions	32 repetitions
2	Average weight	80 kg	70 kg
	Standard deviation	10 kg	12 kg
	Minimum weight	60 kg	50 kg
	Maximum weight	100 kg	90 kg

Source: compiled by the authors

The results of the upper body strength test demonstrate a significant advantage of the experimental group, which used interactive technologies in the process of teaching physical education. The average number of repetitions in this group was 25, which is 5 repetitions more than in the control group. This may indicate that interactive teaching methods contributed to more effective development of upper-body muscle strength. Interactive technologies included the use of special programmes and mobile applications that allowed students to receive instant feedback on their exercise technique and correct their movements in real-time. This increased students' motivation and engagement in the training process, which led to better results. The lower standard deviation in the experimental group (5 repetitions versus 6 repetitions in the control group) also indicates a more uniform level of training among students. This indicated that the interactive technology provided a more personalised approach to training, allowing each student to train at their optimum level.

The students in the experimental group also demonstrated better results in the test of maximum lower-body muscle strength. The average weight lifted by students in this group was 10 kg more than in the control group. This suggests that the interactive technologies contributed to a better understanding and execution of the squat technique and therefore led to greater strength gains. The interactive technologies included video tutorials with detailed demonstrations of the correct squatting technique, which helped students avoid mistakes and get the most out of their training. In addition, real-time progression tracking further motivated students to improve their results. The lower standard deviation in the experimental group (10 kg compared to 12 kg in the control group) indicated that interactive training methods contributed to a more uniform strength development among all students in this group. This indicates that such technologies can be used to adapt the training process to the individual needs of each participant, providing them with optimal conditions for achieving maximum results.

The results of the strength tests demonstrated that students in the experimental group who used interactive technologies in their physical education classes achieved better results in both the upper body strength test and the lower body strength test. The higher mean scores and lower variance of the results indicate that these technologies were more effective in improving students' physical fitness than the traditional teaching methods used in the control group. These findings suggest that interactive technologies can significantly improve the effectiveness of physical education teaching by providing an individualised approach, increased student motivation and engagement, and better results in muscle strength development. This highlights the potential of interactive methods as a substantial tool for modernising and improving physical education curricula. For the final analysis of the use of interactive technologies in physical education, tests were conducted on trunk flexibility (reaching toes in a sitting position) and shoulder girdle flexibility (diagonal raising of arms behind the back). The results of these tests are presented in Table 4.

Table 4. Results of the assessment of flexibility of students in both groups

No.	Aspect	Experimental group	Control group
1	Average distance	+15 cm	+10 cm
	Standard deviation	3 cm	4 cm
	Minimum distance	+5 cm	0 cm
	Maximum distance	+25 cm	+20 cm
2	Average distance between hands	+5 cm	8 cm
	Standard deviation	2 cm	3 cm
	Minimum distance	0 cm	3 cm
	Maximum distance	+10 cm	+15 cm

Source: compiled by the authors

The results of the trunk flexibility test indicate an advantage for the experimental group, which demonstrated an average result of +15 cm, which is 5 cm more than the control group. This indicates that the interactive technologies used in the training process significantly impacted body flexibility. Interactive technologies included the use of video instructions for the correct stretches, which helped students to better understand and perform flexibility exercises. Programmes or apps could also be used to enable students to track their progress and receive real-time feedback, which contributed to better results. The smaller standard deviation in the experimental group (3 cm in contrast to 4 cm in the control group) also indicates that interactive technologies contributed to a more even development of flexibility across all students. This suggests that these technologies may have helped to create more personalised flexibility programmes that were effective for all participants in the experimental group.

The shoulder girdle flexibility test demonstrated that students in the experimental group also performed better, with an average distance of 5 cm between their hands. This suggests that interactive technologies also had a positive impact on this flexibility, helping students to better develop this important physical characteristic. These technologies included the use of specialised shoulder girdle flexibility exercises presented in the form of video tutorials and interactive instructions, which facilitated the correct execution of movements and helped students achieve better results. The smaller standard deviation in the experimental group (2 cm compared to 3 cm in the control group) indicates that the interactive technology programmes were effective for a wide range of students, providing them with a level playing

field for improving flexibility. Therefore, the results demonstrated that students in the experimental group who used interactive technologies achieved better results compared to the control group. The higher average scores and lower variance of results indicate that these technologies contributed to improved student flexibility, providing a more personalised and effective approach to physical education. This highlighted the potential of interactive technologies to enhance physical education curricula, enabling more effective learning and development of students' physical abilities.

Discussion

The results of the study demonstrated that with the increasing availability of technological solutions, such as mobile applications, and virtual and augmented reality, new opportunities are emerging to improve the efficiency and motivation of students, especially in physical education classes. Motivation is a key factor in successful learning, especially in the context of physical activity. The results of this study confirm that interactive technologies can significantly increase students' motivation to engage in physical education. According to the study, students who used interactive technologies such as fitness trackers, physical activity tracking apps, and virtual simulators demonstrated higher levels of interest and active participation in classes compared to those who engaged in traditional methods. These findings correlate with those of other researchers who have also noted the positive impact of technology on motivation to engage in physical activity, including a study by O. Bezkopylnyi *et al.* (2020) that identified the use of mobile apps to track physical activity as a way to increase students' motivation by allowing them to visualise their achievements and progress. Another researcher, S. Yadav (2024), revealed that interactive games aimed at physical activity can significantly increase children's interest in physical education, particularly among primary school students. The conclusions of these studies are confirmed by the data obtained in the current study.

Interactive technologies not only increase the motivation of students but also significantly improve technical skills and physical performance. In particular, the study demonstrated that the use of technologies such as virtual simulators and video analytics of movements allows students to master the technique of performing various physical exercises much faster. This is achieved through the ability to practice movements in a controlled environment, which repeating the exercises as many times as necessary to achieve the desired result. Such training helps students to learn the correct technique in detail and correct mistakes early on in their training. These findings are consistent with the results of a study by Y. Niu (2023), which demonstrated that the use of video analytics allows students to analyse individual movements and make the necessary adjustments, which speeds up the process of mastering the technique. Furthermore, a study by Y. Li & M. Jawis (2024) and M. Müller *et al.* (2024) confirmed that interactive technologies contribute not only to the development of technical skills but also to the improvement of physical indicators such as endurance, strength, and flexibility. This is facilitated by the ability to receive instant feedback and correct actions quickly and promptly. Therefore, interactive technologies are key to modern physical education, providing students with tools that not only make the learning process more engaging but also help them achieve high results in a shorter time. Interactive technologies also help to increase the level of interaction and collaboration among students during physical education classes. According to a study, the integration of technologies that allow students to work in teams helps to develop social skills and increase classroom cohesion. This can be achieved through technologies such as interactive games or team sports applications where each student can contribute to the overall team performance. These results are consistent with the findings of G. Lampropoulos & K. Kinshuk (2024) and C. Li *et al.* (2024), who indicated that the use of interactive technologies in team sports increases the level of interaction between students and the development of cooperation skills. Research by W. Tarng *et al.* (2024) confirmed that technologies that allow learners to participate in virtual competitions or group exercises can significantly increase social inclusion and contribute to a positive learning environment. It is important to consider the challenges associated with the introduction of interactive technologies, such as unequal access to technology and the risks of reducing direct physical activity. These aspects require additional attention from teachers and school administrators to ensure equal opportunities for all students.

However, despite the numerous advantages of interactive technologies, it is also worth noting some of the challenges and limitations associated with their implementation in the process of physical education. Other studies, such as A. Ponmalar *et al.* (2022), X. Wang (2024) and R.A. González-Rivas *et al.* (2024), highlighted the problem of the digital divide, which can hinder the effective implementation of interactive technologies in the learning process. Studies conducted by M. Kuleva (2024) and R. Zhu *et al.* (2024) noted that in conditions of limited access to technology, interactive methods may even increase the difference in physical fitness between students from different social and economic groups. Some researchers, namely J. Xu (2024), A.C. De Araújo *et al.* (2024), and N. Yannier *et al.* (2024), highlighted that excessive use of technology in physical education can lead to a decrease in the level of direct physical activity. M. Herczeg (2024) and B. Carter-Thuillier *et al.* (2024) noted that an over-reliance on interactive technologies can reduce the time students spend on outdoor activities, which can negatively affect their overall physical condition.

An important component of the successful implementation of interactive technologies in the process of teaching physical education is the correct pedagogical approach. According to the results of this study, the most effective pedagogical strategies are those that combine traditional teaching methods with interactive technologies. This maximises the benefits of both approaches and provides optimal conditions for students' development. These findings correlate with those of A. Istenič (2021) and Q. He *et al.* (2024), who emphasised the importance of combining interactive technologies with traditional teaching methods to achieve the best results in physical education. The authors noted that technologies can only be effective if they are integrated into the pedagogical process, based on the age and individual characteristics of students, as well as the specifics of the educational material. Another important

aspect is teacher training in the use of interactive technologies. The study identified that the success of technology implementation largely depends on the competence and readiness of teachers to change the educational process. Teachers with a sufficient level of technical knowledge and skills are more successful in incorporating technology into their classes, which is also confirmed by M.S. Alsaeed & M.K. Aladil (2024) and L. Ge *et al.* (2024). The use of interactive technologies in physical education has significant potential to improve the quality of education, increase student motivation and physical performance, and improve technical skills and physical performance, which contribute to the development of social skills through collaboration and interaction. The results of this study are consistent with the findings of previous studies, confirming the effectiveness of integrating technology into physical education. However, it is worth remembering that to maximise the use of technology, it is necessary to address the challenges associated with its implementation and apply individualised approaches to learning. The successful implementation of interactive technologies in physical education depends on teacher training, ensuring equal access to technology and a comprehensive approach to the integration of the latest technological tools into the learning process.

Conclusions

The use of innovative technologies in physical education is an important element of modern education, which allows not only to improve the level of physical fitness of students but also to make this process more exciting and effective. The introduction of digital platforms, apps for monitoring physical activity, and the integration of the latest technologies such as virtual reality and augmented reality can significantly improve the results of physical education. In Ukraine, the process of introducing these innovations is just beginning and faces numerous challenges, including insufficient funding and weak material and technical base of educational institutions. This limits the possibility of widespread use of modern technologies in physical education, which affects the overall level of physical education among students. To overcome these problems, it is necessary to modernise the infrastructure, provide educational institutions with modern equipment, and improve the skills of physical education teachers. Involving the private sector through public-private partnerships could be an important step to expand funding opportunities and innovations.

A comparison of the results of both groups in two different endurance tests concluded that the experimental training methods contributed to the improvement of students' physical fitness. The experimental group demonstrated better results in both the Cooper test and the running endurance test. This indicates an increase in overall endurance, both in the context of prolonged physical activity (Cooper test) and in speed and power characteristics (800/1,000 m run). The results of strength tests showed that students of the experimental group who used interactive technologies in physical education classes showed higher results in tests of upper and lower body strength. With an average distance of 5 cm between their hands, students in the experimental group outperformed students in the control group in the shoulder girdle flexibility test. The above test results demonstrate that the students of the experimental group, which used interactive technologies, outperformed the students of the control group. A promising direction is to study the economic feasibility of introducing interactive technologies in physical education. This includes estimating the costs of implementing technologies and comparing them with traditional teaching methods.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Alsaeed, M.S., & Aladil, M.K. (2024). Digital and physical interactive learning environments: Early childhood mathematics teachers' beliefs about technology through reflective writing. *Education Sciences*, 14(5), article number 517. doi: 10.3390/educsci14050517.

[2] Amina, G., Maati, S., Chakli, A., Sefri, Y., & Chafiq, N. (2023). Rapid learning in the teaching of physical education and sport. In N. Chafiq, P. Cummins, K. Al-Qatawneh & I. El Imadi (Eds.), *Navigating virtual worlds and the metaverse for enhanced e-learning* (pp. 225-233). Hershey: IGI Global Scientific Publishing. doi: 10.4018/979-8-3693-1034-2.ch011.

[3] Bezkopylnyi, O., Bazylchuk, O., Sushchenko, L., Bazylchuk, V., Dutchak, Yu., & Ostapenko, H. (2020). Peculiarities of application of interactive educational technologies in training of future teachers of physical culture to work with health protection in secondary school. *Journal of Physical Education and Sport*, 20(1), 291-297. doi: 10.7752/jpes.2020.s1040.

[4] Carter-Thuillier, B., López-Pastor, V., Gallardo-Fuentes, F., Ramirez-Campillo, R., del Río-Soto, C., & Sortwell, A. (2024). Intercultural training and attitudes of physical education teachers towards immigrant students in Chile: A multi-stakeholder perspective. *Social Sciences & Humanities Open*, 10, article number 101044. doi: 10.1016/j.ssaho.2024.101044.

[5] Cooper test. (2023). Retrieved from https://runners.com.ua/test-kupera/.

[6] De Araújo, A.C., Xavier, K.S., Moya-Mata, I., da Costa, A.Q., Canon-Buitrago, E.A., de Oliveira, B.N., & de Carvalho, R.S. (2024). Digital technology in national curricula: A dialogue among Ibero American countries. *Frontiers in Sports and Active Living*, 6, article number 1355967. doi: 10.3389/fspor.2024.1355967.

[7] Declaration of Helsinki. (2013). Retrieved from https://surl.li/rwrztk.

[8] Ge, L., Li, M., & Ning, C. (2024). Modern software and physical education: Can online training enhance gym training? *BMC Medical Education*, 24, article number 419. doi: 10.1186/s12909-024-05345-x.

[9] González-Rivas, R.A., Núñez Enriquez, O., Marttinen, R., Baena-Extremera, A., Zueck-Enríquez, M.C., & Gastélum-Cuadras, G. (2024). Including an adventure education training program in physical education teacher education programs. *Journal of Experiential Education*, 47(3), 358-379. doi: 10.1177/10538259231200583.

[10] He, Q., Chen, H., & Mo, X. (2024). Practical application of interactive AI technology based on visual analysis in the professional system of physical education in universities. *Heliyon*, 10(3), article number e24627. doi: 10.1016/j.heliyon.2024.e24627.
[11] Herczeg, M. (2024). The role of digital technologies and human-computer interaction for the future of education. *I-com*, 23(2), 239-247. doi: 10.1515/icom-2024-0008.
[12] Hu, X., & Li, J. (2024). Research on the integrated solution of physical education based on smart campus. *Advances in Physiology Education*, 48(2), 378-384. doi: 10.1152/advan.00006.2024.
[13] Isaqovich, O.A., Olimovich, M.M., Uralovich, T.B., Xolmuradovna, T.S., Ananth, C., & Kumar, T.A. (2024). Fitfuturo: Empowering tomorrow's athletes – a mobile application for future physical education preparation. In *2024 ninth international conference on science technology engineering and mathematics (ICONSTEM)* (pp. 1-6). Chennai: IEEE. doi: 10.1109/ICONSTEM60960.2024.10568641.
[14] Istenič, A. (2021). Shifting to digital during COVID-19: Are teachers empowered to give voice to students? *Educational Technology Research and Development*, 69, 43-46. doi: 10.1007/s11423-021-09956-9.
[15] Jian, L. (2024). Analysis of the quality of PE classroom teaching with multimedia technology. *International Journal of High-Speed Electronics and Systems*. doi: 10.1142/S0129156424400810.
[16] Kuleva, M. (2024). Exploring the integration of virtual reality in physical education: A comprehensive review. *Environment. Technology. Resources*, 2, 197-201. doi: 10.17770/etr2024vol2.8057.
[17] Lampropoulos, G., & Kinshuk, K. (2024). Virtual reality and gamification in education: A systematic review. *Educational Technology Research and Development*, 72, 1691-1785. doi: 10.1007/s11423-024-10351-3.
[18] Lei, Z., Zhou, H., Hu, W., Liu, G.-P., & Guan, S. (2024). Web-based digital twin communication system of power systems for training and education. *IEEE Transactions on Power Systems*, 39(2), 3592-3602. doi: 10.1109/TPWRS.2023.3308510.
[19] Li, C., Cao, Y., & Lv, J. (2024). Design and implementation of a physical education teaching and training mode management system. *Entertainment Computing*, 50, article number 100684. doi: 10.1016/j.entcom.2024.100684.
[20] Li, Y., & Jawis, M. (2024). Construction and effect of interactive teaching methods in the college badminton classroom using fuzzy-assisted virtual reality modeling: A case study in Chinese universities. *Journal of Fuzzy Extension and Applications*, 5(2), 199-222. doi: 10.22105/jfea.2024.449386.1421.
[21] Müller, M., Otero, N., & Milrad, M. (2024). Guiding the design and implementation of interactive public displays in educational settings. *Journal of Computers in Education*, 11, 823-854. doi: 10.1007/s40692-023-00280-0.
[22] Nguyen, D.T., & Nguyen, M.T. (2024). Evaluating the effectiveness of online physical education teaching toward students at Ho Chi Minh City University of Technology and Education, Vietnam. *Annals of Applied Sport Science*, 12, article number e1252. doi: 10.61186/aassjournal.1252.
[23] Niu, Y. (2023). Integrated physical education and medicine in general physical education at universities in the age of educational technologies. *BMC Medical Education*, 23, article number 466. doi: 10.1186/s12909-023-04440-9.
[24] Ponmalar, A., Uma, M., Kaviyaraj, R., & Vijay Priya, V. (2022). Augmented reality in education: An interactive way to learn. In *2022 1st international conference on computational science and technology (ICCST)* (pp. 872-877). Chennai: IEEE. doi: 10.1109/ICCST55948.2022.10040368.
[25] Sports culture in Japan. (2023). Retrieved from https://louvoyage-us.com/blogs/japanese-history-traditions/sports-culture-in-japan-the-intersection-of-tradition-innovation-and-excellence?srsltid=AfmBOorkZeLF9SLoZWloMiRLuu2kEusVgMZFx2_rvYhDHtYiFfIDt0Ye.
[26] Tarng, W., Wu, Y.-J., Ye, L.-Y., Tang, C.-W., Lu, Y.-C., Wang, T.-L., & Li, C.-L. (2024). Application of virtual reality in developing the digital twin for an integrated robot learning system. *Electronics*, 13(14), article number 2848. doi: 10.3390/electronics13142848.
[27] Wang, X. (2024). Application of interactive object model in sports teaching. *International Journal of High-Speed Electronics and Systems*. doi: 10.1142/S0129156424400871.
[28] World Health Organization. (2018). *Global action plan on physical activity 2018-2030: More active people for a healthier world*. Geneva: World Health Organization.
[29] Xing, Z., & Qi, Y. (2023). Development of creativity in physical education teachers using interactive technologies: Involvement and collaboration. *Education and Information Technologies*, 28, 5763-5777. doi: 10.1007/s10639-022-11422-9.
[30] Xu, J. (2024). Analysis and improvement of the application of playground sports posture detection technology in physical education teaching and training. *EAI Endorsed Transactions on Pervasive Health and Technology*, 10. doi: 10.4108/eetpht.10.5161.
[31] Yadav, S. (2024). Empowering educators with augmented and virtual reality: Integrating AR and VR for enhanced interactive learning environment. In J. Braman, A. Brown & M. Richards (Eds.), *Reshaping learning with next generation educational technologies* (pp. 72-86). Hershey: IGI Global Scientific Publishing. doi: 10.4018/979-8-3693-1310-7.ch005.
[32] Yannier, N., Hudson, S.E., Chang, H., & Kenneth, R.K. (2024). AI adaptivity in a mixed-reality system improves learning. *International Journal of Artificial Intelligence in Education*, 34, 1541-1558. doi: 10.1007/s40593-023-00388-5.
[33] Ye, SH., Onpium, P., & Ying, F. (2024). The effectiveness of a 3D interactive learning environment as a mechanism for sharing and retaining knowledge. *Scientific Bulletin of Mukachevo State University. Series "Pedagogy and Psychology"*, 10(2), 17-28. doi: 10.52534/msu-pp2.2024.17.

[34] Zhao, A. (2023). Restricted hidden Markov model based innovation in physical learning education with computer internet technology. *International Journal on Recent and Innovation Trends in Computing and Communication*, 11(6), 207-216. doi: 10.17762/ijritcc.v11i6s.6823.
[35] Zhu, R., Tian, X., & Xu, G. (2024). Application of multimedia man-machine interaction in college physical education teaching. *Journal of Cases on Information Technology (JCIT)*, 26(1). doi: 10.4018/JCIT.341588.

Використання інтерактивних технологій у процесі навчання фізичної культури

Ольга Шапран

Доктор педагогічних наук, професор
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0002-7514-6632

Олексій Ткачук

Викладач
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0009-0004-5257-1240

Анотація. Метою дослідження було з'ясувати вплив сучасних інноваційних інструментів на ефективність фізичного розвитку студентів у сучасному освітньому процесі. Методологія дослідження включала експеримент, у якому взяли участь 150 студентів, які навчалися із використанням різних видів інтерактивних технологій. Для оцінки фізичної підготовленості студентів використовувалися методики тестування на витривалість, силу та гнучкість. Результати дослідження показали, що студенти експериментальної групи продемонстрували значне покращення у фізичній підготовці порівняно з контрольною групою, зокрема в тестах на витривалість та гнучкість. У дослідженні відзначалося підвищення рівня мотивації і задоволення навчальним процесом серед студентів, які використовували інтерактивні технології. Отримані дані підтверджують, що інтерактивні методи навчання позитивно впливають на ефективність фізичного виховання і можуть бути рекомендовані для впровадження в освітню практику. Впровадження інтерактивних технологій мало значний позитивний вплив на студентів, сприяючи підвищенню їхньої мотивації до занять фізичною культурою та покращенню загальної фізичної підготовки. Студенти стали більш залученими в процес тренувань завдяки використанню мобільних додатків для контролю за активністю, а також віртуальних тренажерів, які робили тренування цікавими та доступними. Це дозволило не тільки підвищити інтерес до фізичних занять, але й сформувати в студентів стійкі звички до активного способу життя. Особливо ефективними були технології, що відстежували прогрес і надавали індивідуальні рекомендації. Завдяки цим технологіям студенти мали можливість отримувати зворотний зв'язок у реальному часі, що значно підвищувало їхню мотивацію та сприяло досягненню кращих результатів у фізичному вихованні. Підтверджено ефективність інтерактивних технологій у фізичному вихованні, що показує доцільність застосування таких технологій викладачами фізичної культури у своїй практиці для підвищення мотивації студентів та покращення їхньої фізичної підготовки

Ключові слова: сучасна освіта; спортивна підготовка; інновації; освітні методики; оцінювання

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 03.07.2024. Revised: 30.10.2024. Accepted: 12.12.2024

UDC 37.042:612.76:[796.077.2-055.25

DOI: 10.69587/tppcs/2.2024.19

Dynamics of indicators of motor capabilities of young female athletes in different phases of the ovarian-menstrual cycle

Borys Panhelov*

PhD in Pedagogy, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0003-3590-9428

Abstract. The results of the generalisation of the training experience of young female track and field athletes show that taking into account the biological features of the female body in sports practice consists, mainly, in the application of a smaller amount of training load. At the same time, cyclical changes in the level of manifestation of physical qualities, which are due to the phases of the ovarian-menstrual cycle, are not taken into account. Therefore, the purpose of the study was to study the dynamic indicators of the motor capabilities of young multi-athletes during the ovarian-menstrual cycle. To realise the established goal, the following research methods were used: analysis, systematisation and generalisation of the data of literary sources on the studied issues; pedagogical (declarative experiment, testing); sociological (questionnaires); methods of mathematical statistics. 23 female track and field athletes aged 17-18 took part in the study. The level of motor capabilities of the subjects was determined on the days that correspond to a certain phase of the menstrual cycle. The dynamics of indicators of physical work capacity, strength, speed-strength abilities, as well as speed and speed endurance were determined. It was found out that the level of manifestation of the mentioned indicators in female athletes during the ovarian-menstrual cycle is not constant and changes in accordance with the phases of the cycle and has a heterochronic character. The lowest level of physical efficiency, strength, speed and strength abilities, speed and speed endurance was observed in the premenstrual and menstrual phase of the ovarian-menstrual cycle, which determines the necessity of reducing the volume of training load in the last (fourth) week of the cycle. The highest level in the cycle of manifestation of motor abilities of girls-athletes is characteristic of the postmenstrual and postovulatory phase, which allows for the planning the maximum physical activity in this period

Keywords: biological features; female body; multi-athletes girls; physical capacity; physical abilities

Introduction

There is an increase in the skills of young female track and field athletes, which is primarily related to an increase in the volume of training loads. The increase in physical activity is one of the conditions for increasing the effectiveness of the training process. However, an equally important condition is the optimisation of the construction of its process. One of the ways to solve this problem can be the construction of training sessions for young female athletes, taking into account cyclical changes in the state of sexual function and the body as a whole, which determine the peculiarities of the individual ovarian-menstrual cycle (OMC). The analysis of literary sources shows that much attention is paid to the problem of women's sports. A number of studies are devoted to the features of muscular work capacity in adult female athletes, which are caused by changes in the functional state of their bodies. Thus, L. Shakhlina (2020) scientific investigations are devoted to the current problems of sports physiology and sports medicine – the adaptation possibilities of the female body to large physical and psycho-emotional loads in modern high-achievement sports. The results of the author's many years of comprehensive research reveal the functional capabilities of female athletes in different phases of the menstrual cycle, as well as the physiological mechanisms that determine changes in their physical performance during the menstrual cycle.

The peculiarity of building the training process for women specialising in middle-distance running was the topic of research by O. Roda *et al.* (2018). The authors substantiated and developed the structure and content of the basic mesocycles of the training process for middle-distance runners, taking into account functional changes in the female body. The dissertation research of N. Yevpak (2018)

Suggested Citation: Panhelov, B. (2024). Dynamics of indicators of motor capabilities of young female athletes in different phases of the ovarian-menstrual cycle. *Theory and Practice of Physical Culture and Sports*, 3(2), 19-26. doi: 10.69587/tppcs/2.2024.19.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

was devoted to the issue of optimisation of the process of competitive activity of female water polo players. Research was conducted to increase the effectiveness of the training process of female athletes who specialise in martial arts. L. Shakhlina *et al.* (2021) considered the issue of load planning in the micro- and mesocycles of training female athletes who specialise in judo in different phases of the menstrual cycle. O. Lysenko *et al.* (2021) studied the issue of the manifestation of special working capacity of high-class female boxers depending on the cyclical functioning of the body. I. Diadechko (2018) researched the improvement of the training process of qualified handball players, taking into account the specific features of the body.

However, it should be noted that there is a distinct lack of scientific developments devoted to optimising the sports training of young female athletes. An exception is the study by E. Vrublevskiy *et al.* (2018), which is dedicated to optimising the process of special physical training of girls specialising in short-distance running, taking into account the biorhythms of their bodies. It is also necessary to note the studies by K. Bugaevsky (2021; 2023), who studied the peculiarities of the process of sexual maturation of young female athletes involved in sports games. From the point of view of ensuring an increase in the efficiency of the training process of young female track and field athletes, it is of great interest to study the dynamics of not only such an integral indicator as the sports result but also important indicators of motor capabilities during the entire OMC and not only in its separate phases. Therefore, the purpose of the study was to study the dynamics of various indicators of motor capabilities of young all-around athletes during the OMC.

Materials and Methods

To realise the set goal, the following research methods were used: analysis, systematisation and generalisation of data from the literary sources of the researched issues; pedagogical (observation, experiment) testing; sociological (questionnaire); methods of mathematical statistics. Before the start of the study, a questionnaire was conducted among 31 sportswomen using an anonymous questionnaire in order to identify individuals with a normal course and the same duration of OMC. After analysing the data from the questionnaires, subjects were selected from the OMC lasting 28 days. As a result, 23 female track and field athletes aged 17-18 ($N = 23$) took part in the study, 20 of whom specialised in track and field all-around. Among the researched were eight sportswomen who had the sports Category I and 15 – the sports Category II.

The level of motor capabilities of young female track and field athletes was determined on the 1st, 4th, 7th, 11th, 13th, 14th, 17th, 22nd, 24th and 28th days of the OMC. The selection of these days for testing was carried out in accordance with the generally accepted classification of OMC (Anderson & Babcock, 2008; McNulty *et al.*, 2020; Carmichael *et al.*, 2021). The dynamics of indicators of the motor capabilities of multi-athletes girls were determined during the three OMCs of the preparatory period of the annual training cycle. In the process of ascertaining the experiment, the following pedagogical tests were used to determine the motor capabilities of young track and field athletes: the physical working capacity (PWC 70) test using running loads; running 30 and 60 m (speed abilities); running 150 and 300 m (speed endurance); performing long jump from a standing position (speed-strength abilities); hand dynamometry (hand muscle strength) (Krutsevich *et al.*, 2011).

The methods of mathematical statistics of actual material were carried out in order to interpret the results of the pedagogical experiment. The following were determined: the arithmetic mean of the variation series ($\bar{x}$), the mean square deviation (S), the error of the arithmetic mean (m). Comparison and reliability of differences between separate groups of indicators were determined using the Student's t test at a significance level of at least 0.05. Statistical processing of the research results was carried out on a personal computer using the package of applied statistics of automated data processing systems STATISTICA 6.0, as well as the spreadsheet editor Excel for MAC-2015.

The girls studied are members of the sports club of Khmelnytskyi National University. The research was conducted in compliance with the requirements of the Declaration of Helsinki (2013). The questionnaire included the following questions: 1. Age; 2. Type of sport; 3. Rank; 4. At what age did you start playing sports?; 5. At what age did you start menstruating?; 6. Nature of the menstrual cycle (regular, after 21, 24, 28, 30, 40, 60 days (underline), irregular (indicate the duration of breaks, was there bleeding?)); 7. Nature of bleeding before starting to play sports; 8. Nature of bleeding after starting to play sports; 9. Feelings before menstruation (headaches; swelling of the mammary glands; increased fatigue, irritability; pain in the small pelvis); 10. Feelings during menstruation; 11. Do you train on all menstrual days (yes, no, with restrictions, without restrictions)?; 12. Is training during menstruation effective?; 13. Do you participate in competitions during menstruation?; 14. What were your results in competitions in which you participated during menstruation?

Results and Discussion

As a result of the study of the general physical performance of track and field athletes according to the PWC 70 test, it was established that it is not constant during the OMC but fluctuates according to the phases of the menstrual cycle. The lowest level of work capacity is observed in the subjects in the premenstrual and menstrual phases. The highest level of work capacity in the cycle was registered in the postmenstrual and postovulatory phases, with some decrease in the ovulatory phase (Table 1).

Table 1. Changes in indicators of general physical performance of female track and field athletes during the OMC, $N = 23$

OMC days	Statistical indicators, m/s			
	$\bar{x}$	S	m	p
1	3.37	0.26	0.05	
4	3.41	0.26	0.05	< 0.05

Table 1, Continued

OMC days	Statistical indicators, m/s			
	$\bar{x}$	*S*	*m*	*p*
7	3.71	0.33	0.07	< 0.05
11	3.91	0.38	0.08	< 0.05
13	3.88	0.36	0.08	> 0.05
14	3.65	0.35	0.07	> 0.01
17	3.95	0.38	0.08	> 0.05
22	3.86	0.40	0.08	> 0.05
24	3.80	0.39	0.08	< 0.05
28	3.39	0.36	0.08	> 0.01

Note: $\bar{x}$ – the arithmetic mean of the variation series; *S* – mean square deviation; *m* – error of the arithmetic mean; *p* – reliability of Student's *t* test differences
Source: created by the author

Physical work capacity changed not only in different phases of the OMC but also during the phases themselves. The data in Table 1 show that the smallest value characterising work capacity was observed on the 1st day of the cycle – 3.37 ± 0.25 m/s. On the 4th day, that is, before the end of the menstrual phase, the work capacity increased – 3.41 ± 0.26 m/s. On the following – 7th and 11th days, the indicator increased to 3.71 ± 0.33 m/s and 3.91 ± 0.38 m/s, respectively. Some deterioration of work capacity was observed during the ovulatory phase (13-14 days) – 3.88 ± 0.36 m/s and 3.65 ± 0.35 m/s, respectively. On the 17th day (postovulatory phase), there was a repeated increase in the physical performance of the subjects to 3.95 ± 0.38 m/s, the level of which did not change significantly until the 24th day of the cycle. On the 28th day, i.e., in the premenstrual phase, the studied indicator rapidly decreased to 3.39 ± 0.36 m/s. Thus, in the studied girls, the two phases of OMC – postmenstrual and postovulatory – are characterised by the highest level of general physical work capacity.

The dynamometry method was used to assess the level of strength development of the subjects. The level of development of speed and strength abilities was determined by the results of the "Long jump from a standing position" test. The results of the study of the manifestation of strength indicate a certain increase in it until the end of the menstrual phase and a significant increase in the postmenstrual phase. In the ovulatory phase, this level decreases slightly, after which it rises a second time. The premenstrual phase is characterised by a decrease in the level of manifestation of strength. The dynamics of strength manifestation by days of the menstrual cycle were as follows (Table 2).

Table 2. Changes in strength indicators and speed-strength abilities of track and field athletes during the OMC, *N* = 23

OMC days	Statistical indicators							
	Hand dynamometry, kg				Long jump from a standing position, cm			
	$\bar{x}$	*S*	*m*	*p*	$\bar{x}$	*S*	*m*	*p*
1	35.58	2.97	0.62	< 0.05	228.6	9.51	1.98	
4	36.56	2.93	0.61	< 0.01	230.8	7.99	1.67	< 0.05
7	38.51	2.71	0.57	< 0.05	240.4	9.54	1.99	< 0.05
11	39.86	2.77	0.58	< 0.05	246.6	8.59	1.79	< 0.05
13	39.08	2.59	0.54	> 0.05	244.6	8.13	1.70	< 0.05
14	38.47	2.27	0.47	< 0.05	242.3	9.71	2.02	< 0.05
17	39.80	2.50	0.52	< 0.01	244.8	8.67	1.81	< 0.05
22	39.24	2.48	0.52	> 0.05	243.7	8.32	1.73	< 0.05
24	38.12	1.87	0.39	< 0.05	239.0	9.69	2.02	< 0.05
28	35.73	2.28	0.48	< 0.05	234.7	9.26	1.93	< 0.05

Source: created by the author

The lowest values were observed on the 1st day of the cycle – 35.58 ± 0.62 kg. By the 4th day, the manifestation of strength increases to 36.56 ± 0.61 kg. Its significant growth took place on the 7th day to 38.51 ± 0.57 kg and continued until the 11th day – 39.86 ± 0.58 kg. During the period of ovulation (13-14 days), the indicators decreased slightly, respectively – 39.08 ± 0.54 kg and 38.47 ± 0.47 kg, but on the 17th and 22nd days of the cycle, an increase was recorded again in the level of strength (39.80 ± 0.52 kg and 39.24 ± 0.52 kg). However, already on the 24th day, the indicator of hand muscle strength decreased to 35.73 ± 0.48 kg. Therefore, the indicators of the strength of young multi-athletes during the OMC changed unevenly: they gradually increased in the menstrual and at the beginning of the postovulatory phase; sharply increased at the beginning of the postmenstrual phase and significantly decreased before menstruation.

The study of the dynamics of the speed and strength capabilities of track and field athletes during the OMC made

it possible to identify common features in the dynamics of the dynamometry indicators and the results in the "Long jump from a standing position" test. The lowest test results are characteristic of the menstrual phase. In the post-menstrual period, they reach their maximum. Some decrease in indicators of speed-strength abilities was observed in the ovulatory phase, which increased again in the postovulatory phase (17th and 22nd days). In the premenstrual period, the results of the jump significantly deteriorated to the level characteristic of the menstrual phase. Analysing the dynamics of the results of the "Long jump from a standing position" test, it should be noted that it improved from the 1st day of menstruation and on the 4th day was 230.8 ± 1.67 cm. Further improvement of the indicator to 240.4 ± 1.99 cm was registered on the 7th and up to 246.6 ± 1.79 cm on the 11th day of the cycle. In the ovulatory phase, the indicators decreased – on the 13th day to 244.6 ± 1.70 cm, on the 14th day to 242.3 ± 2.02 cm. By the 17th day, the results reached high values for the second time in the cycle – 244.8 ± 1.81 cm, which are kept until the 22nd day. By the 24th day, they significantly deteriorated to 239.0 ± 2.02 cm and even more on the 28th day – 234.7 ± 1.93 cm.

To characterise the speed capabilities of track and field athletes, the tests "Running 30 m from a walk" and "Running 60 m from a high start" were used. Since running at this distance refers to short-term maximum power exercises and its energy supply is determined by the amount of creatine phosphate in the muscles, the obtained results were used as indirect indicators of the analactate anaerobic power of sportswomen (Shakhlina, 2020). The results of the study of the dynamics of the "Running 30 m from a walk" test during the OMC indicate their gradual increase, starting from the end of the menstrual phase (4th day) to the 11th day of the cycle: 3.65 ± 0.02 s and 3.38 ± 0.02 s, respectively. Some reduction of the indicator took place in the ovulatory phase (3.41 ± 0.01 s). High results were demonstrated for the second time during the cycle by athletes in the postovulatory phase: 17th day – 3.23 ± 0.01 s; 22nd day – 3.35 ± 0.01 s. By the 24th day, the indicators of 30 m run decreased (3.44 ± 0.02 s), and in the premenstrual phase (28th day) – significantly worsened (3.65 ± 0.02 s) (Table 3).

Table 3. Changes in indicators of speed abilities of female track and field athletes during the OMC, $N = 23$

OMC days	Statistical indicators							
	Running 30 m from a walk				Running 60 m from a high start			
	$\bar{x}$	S	m	p	$\bar{x}$	S	m	p
1	3.73	0.10	0.02		8.39	0.08	0.02	
4	3.65	0.08	0.02	< 0.05	8.36	0.09	0.02	> 0.05
7	3.54	0.07	0.01	< 0.05	8.26	0.10	0.08	< 0.05
11	3.38	0.08	0.02	< 0.01	8.03	0.12	0.02	< 0.01
13	3.40	0.07	0.02	> 0.05	8.04	0.14	0.03	> 0.05
14	3.41	0.07	0.01	> 0.05	8.10	0.13	0.03	> 0.05
17	3.23	0.06	0.01	< 0.01	8.03	0.12	0.03	> 0.05
22	3.35	0.07	0.01	< 0.05	8.04	0.12	0.03	< 0.05
24	3.44	0.07	0.02	< 0.05	8.12	0.11	0.08	< 0.05
28	3.65	0.08	0.02	< 0.05	8.35	0.08	0.02	< 0.05

Source: created by the author

Indicators changed almost in the same way during the OMC in the "Running 60 m from a high start" test. Thus, the lowest results were observed in the menstrual phase (8.39 ± 0.02 s). During the postmenstrual phase, they gradually increased: 4th day – 8.36 ± 0.02 s; 7th day – 8.26 ± 0.08 s; 11th day – 8.03 ± 0.02 s. Some decrease in indicators occurred in the ovulatory phase (8.10 ± 0.03 s). A secondary improvement of the results in the 60 m run was observed in the postovulatory phase (8.03 ± 0.12 s), which was replaced by a significant deterioration in the premenstrual period of the cycle (8.35 ± 0.02 s). It was not established the complete identity between the changes in the results in the 30 and 60 m run during the OMC, which could be expected. This fact can be explained by the fact that during the 30 m run, the decisive factor is the manifestation of absolute speed abilities, and during the 60 m run, the level of development of speed endurance exerts an influence. If a single run of 60 m does not yet require its manifestation, then a different situation arises under the condition of 3 repetitions, which was the case in the study.

The level of manifestation of high-speed endurance depends, first of all, on the efficiency of glycolytic processes. To improve this mechanism of energy generation, high-intensity physical activity lasting 20-60 s is used (Zemtsova, 2019). In this regard, it is necessary to analyse the data received from the study of the dynamics of results in running 150 and 300 m. The dynamics of the results of the 150 m run during the OMC (Table 4) is almost identical to the change in the indicators in the 60 m run. From the 1st and 4th days of the cycle, the results almost do not change and improve to 21.20 ± 0.10 s only by the 7th day.

Table 4. Changes in indicators of speed endurance of female track and field athletes during the OMC, $N = 23$

OMC days	Statistical values							
	150 m run				300 m run			
	$\bar{x}$	S	m	p	$\bar{x}$	S	m	p
1	21.58	0.47	0.10		47.10	0.80	0.17	

Table 4, Continued

OMC days	Statistical values							
	150 m run				300 m run			
	$\bar{x}$	*S*	*m*	*p*	$\bar{x}$	*S*	*m*	*p*
4	21.46	0.49	0.10	> 0.05	46.96	0.97	0.20	< 0.05
7	21.20	0.50	0.10	< 0.05	46.01	0.84	0.17	< 0.01
11	20.62	0.55	0.12	< 0.01	45.44	0.75	0.16	< 0.01
13	20.81	0.50	0.10	> 0.05	45.75	0.79	0.16	< 0.05
14	20.92	0.47	0.10	< 0.05	45.97	0.76	0.16	< 0.05
17	20.74	0.50	0.11	< 0.01	45.38	0.79	0.16	< 0.05
22	20.61	0.55	0.12	< 0.05	45.82	0.71	0.15	< 0.05
24	20.80	0.64	0.13	< 0.05	45.98	0.74	0.15	> 0.05
28	21.27	0.45	0.09	< 0.05	47.23	0.80	0.17	< 0.01

Source: created by the author

Their significant increase to 20.62 ± 0.12 s was observed on the 11th day. Then, on the 13th day, the distance running time deteriorated to 20.81 ± 0.10 s. Repeated improvement of the indicator to 20.74 ± 0.12 s occurred on the 17th day, and its stabilisation – on the 22nd day of OMC. On the 28th day of the cycle, there was a significant deterioration of the results in the 150 m run. The dynamics of the results in the "300 m run" test show that the worst of them were observed in the menstrual and pre-menstrual phases: 1st day of OMC – 47.10 ± 0.17 s; 28th day – 47.23 ± 0.17 s. The best indicators were recorded in the postovulatory period – 45.38 ± 0.16 s. But, already on the 22nd day of the cycle, there was a tendency to decrease the result of running 300 m – 45.82 ± 0.15 s. The data of the conducted research indicate the presence of phase changes of general physical work capacity and other indicators of motor capabilities during OMC. It was also established that the dynamics of each of these indicators have their own characteristics, which are characteristic of one or another phase of the cycle. These features are associated with changes in the functional state of organs and systems, on which the level of manifestation of physical qualities of female athletes depends.

Data from special literature indicate that the dynamics of physical work capacity (the basis of which is the aerobic capacity of the body) depends on the dynamics of the number of erythrocytes caused by changes in the hormonal state (McNulty *et al.*, 2020; Kissov *et al.*, 2022). G. Cristina-Souza *et al.* (2019) indicated that during menstruation, the number of erythrocytes decreases by 1 million on average, and on the 10th day of the cycle, this indicator returns to normal. The same authors note that along with changes in the number of erythrocytes, the dynamics of the haemoglobin content in the blood are observed. Thus, the data obtained on the increase in the level of the general physical work ability of sportswomen in the postmenstrual and postovulatory phases confirm the results of the research of other authors, such as S. Emmonds *et al.* (2019), G. Artemyeva *et al.* (2020) and O. Lysenko *et al.* (2021).

Other factors determined the dynamics of strength, speed and speed-strength indicators that were discovered, which, unlike physical work capacity, begin to increase after the 1st day, and especially by the 7th day of OMC. Then, before the onset of menstruation, these indicators of physical fitness deteriorate. A relatively high level of the investigated indicators of strength, speed and speed-strength abilities in the postmenstrual and postovulatory phases is ensured by an increase in the content of corticosteroids in the blood due to an increase in the oestrogen saturation of the female body. In addition, the high level of manifestation of these indicators of physical fitness in the specified phases of the OMC is ensured due to the increase in the concentration of androgens (male sex hormones), which increase the synthesis of proteins in the muscles, as noted by O. Heyward *et al.* (2020) and L. Shakhlina *et al.* (2021). The results of the research confirm these theoretical propositions, as well as the scientific investigations of E. Vrublevskiy & M. Kozhedub (2018) and O. Shishkina & I. Beygul (2023).

As already noted above, the level of speed endurance of female track and field athletes in different phases of the OMC was determined using the "150 m run" and "300 m run" tests. The duration of this high-intensity muscular activity is 20-50 s, and its energy supply is due to the anaerobic capabilities of the body. According to I. Zemtsova (2019) and G. Klymenko & M. Filippov (2023), one of the most important components of anaerobic energy production is reserves of energy substances and the ability to compensate for shifts in the internal environment of the body – the buffer capacity of blood and tissues. Glycogen and glucose serve as energy sources in the process of anaerobic energy generation, and haemoglobin is the most powerful buffer system. The author believes it is possible to use the above facts to discuss the dynamics of speed endurance established in female track and field athletes during the OMC. A low level of high-speed endurance at the beginning of menstruation can be explained by a decrease in the content of glycogen and haemoglobin.

The gradual increase in the number of erythrocytes, the content of glycogen and haemoglobin caused a corresponding increase in the level of high-speed endurance in the postmenstrual phase of OMC. It should be added that the data obtained regarding the study of changes in speed endurance indicators coincide with the results of D. Tsys *et al.* (2023). Therefore, during the OMC, the level of manifestation of the motor capabilities of sportswomen changes in accordance with the phases of the cycle, each of which is characterised by one or another state of the menstrual function and the body as a whole. Taking this provision into account in the process of building a training process will increase its effectiveness in terms of ensuring positive dynamics of the motor capabilities of female multi-sport athletes without increasing the volume and intensity of physical activity.

Conclusions

The level of manifestation of various motor capabilities in sportswomen during the OMC is not constant and changes in accordance with the phases of the cycle. The lowest level of manifestation of physical work capacity, strength, speed, speed-strength abilities and speed endurance in the cycle is observed in the menstrual phase. Thus, the lowest value characterising work capacity was observed on the 1st day of the cycle – 3.37 ± 0.5 m/s. The manifestation of strength according to dynamometry indicators was also the lowest on the 1st day of the OMC – 35.58 ± 0.62 kg. The same common features were found in the indicator of speed-strength abilities, which were determined by the results of the "Long jump from a standing position" test (the worst result on the 1st day of menstruation was 228.6 ± 9.5 cm). The dynamics of the results in the 30 and 60 m running indicators also indicate the lowest values at the beginning of the cycle (3.73 ± 0.1 s and 8.39 ± 0.08 s, respectively). Changes in the results of the 150 m run are almost identical to the changes in the 60 m run. The worst results are observed in the first four days of the OMC (21.58 ± 0.47 s – 21.46 ± 0.49 s).

The highest level of manifestation of motor capabilities in the cycle is characteristic of the postmenstrual and postovulatory phase, towards the end of which there is a decrease in speed endurance. Physical performance indicators reached their highest values on the 11th day of the cycle (3.91 ± 0.38 m/s), then decreased slightly during the ovulation phase (13-14 days) and increased again in the postovulatory phase of the OMC (3.95 ± 0.38 m/s). A significant increase in strength was recorded in the first week of the OMC (7th day – 38.51 ± 2.71 kg). During the ovulation period, the indicators decreased slightly and then increased again (17th day of the cycle – 39.8 ± 2.5 kg; 22nd day – 39.24 ± 2.48 kg). Speed-strength abilities indicators also increased to the OMC level (246.6 ± 8.59 m/s). In the ovulatory phase, their decrease was observed, and on the 17th day, a repeated increase in the results was recorded (244.8 ± 8.67 m/s). Positive dynamics of speed ability indicators were observed from the 4th to the 11th day of the cycle (30 m run – 3.65 ± 0.02 s and 3.38 ± 0.08 s, respectively; 60 m run – 8.36 ± 0.1 s and 8.03 ± 0.12 s). Some of their decrease occurred in the ovulatory phase with a further increase on the 17th day of the OMC (30 m run – 3.23 ± 0.06 s; 60 m run – 8.03 ± 0.12 s). The manifestation of speed endurance had identical changes: their improvement occurred from the 4th to the 11th day of the postmenstrual phase (150 m run – 21.20 ± 0.50 s; 300 m run – 45.44 ± 0.75 s). In the ovulatory phase, the manifestation of speed endurance worsened, and a further increase in results occurred on the 17th day of the OMC.

A slight decrease in physical performance, strength and speed abilities against the background of a deterioration in the ability to display speed-strength capabilities and special endurance was recorded in the ovulatory phase of the OMC. A decrease in all indicators of motor capabilities in track and field athletes is characteristic of the premenstrual phase. The levels of manifestation of physical work capacity, strength, speed and speed-strength qualities, as well as special endurance during individual phases of the OMC, vary heterochronically. Taking into account the results of the study, in the author's opinion, will allow for optimising the construction of the training process of multi-athletes girls, and such optimisation can be a direction for further research.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Anderson, A.J., & Babcock, M.A. (2008). Effects of the menstrual cycle on expiratory resistance, during whole body exercise in females. *Journal of Sports Science and Medicine*, 7, 475-479.
[2] Artemyeva, G., Latvynska, I., & Moshenska, T. (2020). Construction a comprehensive health training program for women in the first period of adulthood. *Slobozhanskyi Herald of Science and Sport*, 6(80), 58-64. doi: 10.15391/snsv.2020-6.009.
[3] Bugaevsky, K. (2021). Studying the peculiarities of the process of sexual maturation of young female athletes in a number of game sports. *Sports Games*, 1(9), 9-14. doi: 10.15391/si.2021-1.01.
[4] Bugaevsky, K. (2023). Premenstrual syndrome: Peculiarities of manifestation in female athletes of different age groups in a number of sports. *Journal of Endocrinology and Disorders*, 7(3), 534-537. doi: 10.31579/2640-1045/146.
[5] Carmichael, M.A., Thomson, R.L., Moran, L.I., & Wycherley, T.P. (2021). The impact of menstrual cycle phase of athletes performance: A narrative review. *International Journal of Environmental Research and Public Health*, 18(4), article number 1667. doi: 10.3390/ijerph18041667.
[6] Cristina-Souza, G., Santos-Mariano, A.C., Souza-Rodrigues, C.C., Osiecki, R., Silva, S.F., Lima-Silva, A.E., & De Oliveira, F.R. (2019). Menstrual cycle alters training strain, monotony, and technical training length in young. *Journal of Sports Sciences*, 37(16), 1824-1830. doi: 10.1080/02640414.2019.1597826.
[7] Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki/.
[8] Diadechko, I.Ye. (2018). *Improvement of the training process of qualified handball players taking into account specific features of the body*. (PhD thesis, Prydniprovsk State Academy of Physical Culture and Sport, Dnipro, Ukraine).
[9] Emmonds, S., Heyword, O., & Jones, B. (2019). The challenge of applying and undertaking research in female sport. *Sports Medicine – Open*, 5, article number 51. doi: 10.1186/s40798-019-0224-x.
[10] Heyward, O., Nicholson, B., Emmonds, S., Roe, G., & Jones, B. (2020). Physical preparation in female rugby codes: An investigation of current practices. *Frontiers in Sports and Active Living*, 2, article number 584194. doi: 10.3389/fspor.2020.584194.
[11] Kissov, J., Jacobsen, K.I., Gunnarsson, T.P., Jessen, S., & Hostup, M. (2022). Effects of follicular and luteal phase – based menstrual cycle resistance training on muscle strength and mass. *Sport Medicine*, 52, 2813-2819. doi: 10.1007/s40279-022-01679-y.

[12] Klymenko, G., & Filippov, M. (2023). Functional and psychophysiological changes in the condition of female students under the influence of a special organization of the physical education process. *Scientific Journal of Drahomanov Ukrainian State University. Series 15. Scientific and Pedagogical Problems of Physical Culture (Physical Culture and Sports)*, 3K(162), 179-183. doi: 10.31392/NPU-nc.series15.2023.3K(162).36.
[13] Krutsevich, T., Vorobyov, M., & Bezverhnya, H. (2011). *Control in the physical education of children, adolescents and youth*. Kyiv: Olympic Literature.
[14] Lysenko, O., Hasanova, S., Shynkaruk, O., Fedorchuk, S., & Kolosova, O. (2021). Manifestation of special working capacity of high-class female-boxers. *Sports Medicine, Physical Therapy and Occupational Therapy*, 2, 23-29. doi: 10.32652/spmed.2021.2.23-29.
[15] McNulty, K.L., Elliot-Sale, K.J., Dolan, E., Swinton, P.A., Ansdell, P., Goodall, S., Thomas, K., & Hicks, K.M. (2020). The effects of menstrual cycle phase on exercise performance in eumenorrheic women: A systematic review and meta-analysis. *Sport Medicine*, 50, 1813-1827. doi: 10.1007/s40279-020-01319-3.
[16] Roda, O., Kalytka, S., & Voytovych, M. (2018). Comparative characteristic of functional capabilities and physical performance of men and women specializing in middle-distance running. *Sports Medicine and Physical Rehabilitation*, 2, 15-22. doi: 10.32652/spmed.2018.2.15-22.
[17] Shakhlina, L. (2020). Medical and biological basis of sports training in sports of high achievers. *Theory and Methods of Physical Education and Sports*, 2, 95-104. doi: 10.32652/tmfvs.2020.2.95-104.
[18] Shakhlina, L., Chystiakova, M., & Avinov, V. (2021). Characteristics of special working capacity in highly skilled female athletes in judo during different phases of the menstrual cycle. *Sports Medicine, Physical Therapy and Occupational Therapy*, 2, 39-44. doi: 10.32652/spmed.2022.2.39-44.
[19] Shishkina, O., & Beygul, I. (2023). The influence of physical culture and health classes on the psychophysical condition of women of the first mature age. *Sports Bulletin of the Dnieper Region*, 3, 90-98. doi: 10.32540/2071-1476-2023-3-090.
[20] Tsys, D., Khlus, N., & Tsys, N. (2020). Differentiated physical training of female football players at the general preparatory stage of the preparatory period. *Sports Games*, 4(18), 106-115. doi: 10.15391/si.2020-4.10.
[21] Vrublevskiy, E., & Koshedub, M. (2018). The level of specific motor properties in the individual phases of the menstrual cycle a mong young sport women practicing sprints. *Rocznik Lubisky*, 44(2), 105-115.
[22] Vrublevskiy, E., Kozhedub, M., & Sevdalev, S. (2018). Individualization of the training process of female runners of different distances depending on the biorhythms of their body. *Fundamentals of the Structure of the Training Process in Cyclic Sports*, 2, 13-21.
[23] Yevpak, M. (2018). *Optimizing the process of competitive activity of female athletes who specialize in water polo*. (PhD thesis, National University of Ukraine on Physical Education and Sport, Kyiv, Ukraine).
[24] Zemtsova, I. (2019). *Sports physiology*. Kyiv: Olympic Literature.

Динаміка показників рухових можливостей юних легкоатлеток у різні фази овaріально-менструального циклу

Борис Пангелов

Кандидат педагогічних наук, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0003-3590-9428

Анотація. Результати узагальнення досвіду підготовки юних легкоатлеток свідчить про те, що врахування біологічних особливостей жіночого організму в спортивній практиці полягає переважно в застосуванні меншого обсягу тренувального навантаження. Водночас не враховуються циклічні зміни рівня проявлення фізичних якостей, які обумовлені фазами овaріально-менструального циклу. Тому метою дослідження було вивчення динамічних показників рухових можливостей юних легкоатлеток-багатоборок протягом овaріально-менструального циклу. Для реалізації встановленої мети були використані такі методи дослідження: аналіз, систематизація та узагальнення даних літературних джерел із досліджуваної проблематики; педагогічні (констатувальний експеримент, тестування); соціологічні (анкетування); методи математичної статистики. У дослідженні взяли участь 23 легкоатлетки віком 17-18 років. Рівень рухових можливостей досліджуваних визначався у дні, які відповідають певній фазі менструального циклу. Визначалася динаміка показників фізичної роботоздатності, швидкісних, силових, швидкісно-силових здібностей, а також - швидкісної витривалості. Було з'ясовано, що рівень прояву зазначених показників у спортсменок протягом овaріально-менструального циклу не є постійним, змінюється у відповідності з фазами циклу і має гетерохронний характер. Найнижчий рівень прояву фізичної роботоздатності, сили, швидкісно-силових здібностей, швидкості і швидкісної витривалості спостерігався у передменструальну та менструальну фазу овaріально-менструального циклу, що обумовлює необхідність зменшення обсягу тренувального навантаження в останньому (четвертому) тижні циклу. Найвищий у циклі рівень проявлення рухових можливостей дівчат-легкоатлеток є характерним для постменструальної та постовуляторної фази, що дозволяє планувати максимальне фізичне навантаження у цей період

Ключові слова: біологічні особливості; жіночий організм; дівчата-багатоборки; фізична роботоздатність; фізичні здібності

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 05.08.2024. Revised: 08.11.2024. Accepted: 12.12.2024

UDC 373.5.016:796.011.3]:616-056.2-055.25-053.6

DOI: 10.69587/tppcs/2.2024.27

Optimising the physical condition of senior school-age girls using new types of motor activity (on the example of "Rugby-7")

Nataliia Panhelova*

Doctor of Physical Education and Sport, Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0002-4846-3907

Tetiana Kravchenko

PhD in Pedagogy, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0002-6041-3101

Vladyslav Ruban

PhD in Physical Education and Sport, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0003-3771-5117

Abstract. The process of physical education of high school students includes model training programmes that include both traditional and innovative types of motor activity. In particular, the variable programme "Rugby-7" is presented, but the content and direction of sectional classes differs from physical education lessons, which necessitated the purpose of the work: to justify and develop the organisational and methodological principles of classes with the priority use of "Rugby-7" in the process of extracurricular (sectional) work and to determine their impact on the morphofunctional state and physical fitness of girls of high school (16-17) age. The anthropometric method was used to assess the physical development. The harmony of the physique was determined using the index method. The functional state of the cardiorespiratory system was determined by pulsometry, tonometry, spirometry. The aerobic capacity was studied using the Robinson index. Assessment of physical fitness took place in the pedagogical testing process. The programme "Rugby-7" for sectional classes with girls of high school age has been developed. Organisational and methodological features of sectional classes with priority use of "Rugby-7" were highlighted in the developed programme, which include: purpose, tasks, principles and implementation (complexity, continuity, variability), content, control standards. The effectiveness of the proposed programme was tested in the process of a formative experiment. At the end of its implementation, a re-examination was carried out to determine the indicators of girls morphofunctional state and physical fitness. A comparative analysis of physical development indicators and functional state of girls before and after the experiment showed their positive dynamics. A comparison of the results of physical fitness allowed to claim a general improvement in indicators. The greatest rates of growth were recorded in the manifestation of speed and strength, coordination abilities, and speed. The obtained data proved the effectiveness of the developed programme of extracurricular activities and can be applied by physical education teachers in extracurricular work

Keywords: 16-17-year-old schoolgirls; programme of extracurricular activities; sport games; motor qualities; morphofunctional state

Introduction

Taking into account the challenges of the last three years (2020-2023: COVID-19 pandemic, the full-scale invasion of Ukraine), the issue of maintaining and improving the physical and mental health of children, adolescents and

Suggested Citation: Panhelova, N., Kravchenko, T., & Ruban, V. (2024). Optimising the physical condition of senior school-age girls using new types of motor activity (on the example of "Rugby-7"). *Theory and Practice of Physical Culture and Sports*, 3(2), 27-35. doi: 10.69587/tppcs/2.2024.27.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

young people is an urgent one. In the system of physical education, a special place belongs to mobile and sports games. Among the modern sports that appeared in the last decade (the so-called "non-Olympic sports"), women's rugby stands out, which has been intensively developing recently: not only "big" rugby, but also its 7×7 variants, beach rugby, etc. Taking into account the fact that there has been a tendency for women to engage in strictly "masculine" and extreme sports, the active introduction of the game of rugby into the practice of physical education of girls of high school age allows to count on mass interest in this game.

Data from the World Health Organization (2021) indicates that insufficient level of physical activity is one of the main factors that limits the quality and length of human life. The confirmation of the presence of significant problems and the objective need for significant changes in the system of school physical education is the low level of physical fitness and the deterioration of the health of a large part of the students. According to Ya. Sorokata (2021), effective implementation of physical education programmes for secondary school students requires the implementation of appropriate scientific and methodological developments in practice. N. Belikova & I. Shnyt (2019), O. Rymar *et al.* (2020) and O. Nesen (2023) emphasised that one of the problems of the school physical education system is the imperfection of physical education. Work on physical education at school is characterised by a wide variety of forms, both in-class and extra-curricular.

As O. Rymar *et al.* (2020) emphasised, extracurricular forms of physical education and sports are aimed at improving motor skills and abilities, increasing the level of physical fitness, as well as sports achievements of students. It is noted in the O. Nesen (2023) researching, that within the framework of the New Ukrainian School reform, approaches to the teaching of physical culture disciplines in general secondary education institutions were changed (introduction of competence-oriented physical education, formative assessment, new types of motor activity, etc). The data of N. Belikova & I. Shnyt (2019) and A. Petrova (2021) testified creation of programmes which include both traditional and modern types of physical activity (crossfit, squash, korfball, pétanque, etc.) for students of basic and specialised schools. The authors of these programmes, A. Boliak *et al.* (2022) and O. Pedan *et al.* (2022) highlighted that, for the most part, these programmes are intended to be introduced into the content part of physical education lessons.

According to T. Krutsevich *et al.* (2023), physical education lessons compensate for only 15-20% of the amount of motor activity necessary for the child's body. Approximately 50% of students have no sustained interest in physical education lessons. In this regard, there is a need to improve the educational process by including new types of motor activity. The effective use of rugby tools in the process of sports and mass work at school is hindered by the lack of a well-founded and developed content for organising and conducting extracurricular sectional classes. Therefore, the purpose of the study was to substantiate and develop the organisational and methodological principles of classes with the priority use of "Rugby-7" in the process of extracurricular (sectional) work and to determine their impact on the physical fitness of girls aged 16-17.

Materials and Methods

The following research methods were used to achieve the research goal: theoretical analysis and generalisation of data from scientific and methodological literature, pedagogical methods (experiments, testing), medical and biological methods (anthropometry, pulsometry, tonometry, spirometry, index method) and methods of mathematical statistics. The analysis of scientific and methodological literature made it possible to develop the programme "Rugby-7" for sectional classes with girls of high school age. The anthropometric method was used to assess the physical development of the studied contingent, and the harmony of the physique was determined using the index method (deviation of the actual body weight from the appropriate one), namely the Quetelet index was used. The functional state of the cardiorespiratory system of girls aged 16-17 was determined by medical and biological methods (pulsometry, tonometry, spirometry). The Robinson index was used to study the body's aerobic capacity, which determines the functioning state of the cardiovascular system. To determine the level of endurance 12 minutes Cooper test was applied. Assessment of physical fitness took place in the process of pedagogical testing in the conditions of pedagogical experiments (declarative, formative). The interpretation of the actual research material was carried out by statistical methods on a personal computer using the STATISTICA 6.0 package of applied statistics of automated data processing systems, as well as the EXCEL spreadsheet editor for MAC-2015.

19 girls ($N = 19$), aged 16-17, who attended sectional "Rugby-7" classes at the Pereiaslav secondary school of grades I-III No. 3 participated in the study. Testing of the subjects took place with the written consent of the parents. The research was conducted in accordance with the rules of the Declaration of Helsinki (2013), and all research participants were informed of the purpose of this interaction and how the data obtained would be used. The pedagogical experiment lasted for one academic year (September 2022-May 2023) in the working conditions of the "Rugby-7" school section of Pereiaslav Secondary School No. 3 (Kyiv Region, Ukraine). The research, which was aimed at solving the established tasks, was conditionally divided into three stages. The first stage was conducting an ascertaining experiment, determining the initial level of the morpho-functional state and physical fitness of the studied contingent (September-October, 2022). The second stage has been a development of the "Rugby-7" programme sectional classes, conducting a formative experiment, control testing (October 2022-April 2023). The third stage was a mathematical processing of the obtained results, their interpretation, formulation of conclusions (April-May, 2023).

Results and Discussion

Content, organisation and methodical basis of the "Rugby-7" extracurricular classes programme

There has been an increase in the interest of women in purely "male" sports, which caused the active introduction of the game of rugby into the system of extracurricular work with girls of high school age. That is due the fact that rugby can be used as a physical training tool, as from the technics of the "Rugby-7" is not difficult. No special ammunition, inventory, etc. is required. It can be done without a goal and played with any ball. The game of

rugby is gaining more and more popularity in the world as a means not only of sports, but also of recreational activity (Mandiuk, 2021). In some countries, rugby is part of the physical education programmes for students. N. Kholidari (2017), revealing the content of physical education in elite schools in Great Britain, noted that such sports as athletics, rowing, football, golf, cricket and rugby are very widely used, and the predominant method of organising classes is sports and games. Game sports, particularly rugby, are especially popular. Perhaps this is due to the fact that it was in the college of the English town of Rugby that this game was started more than 100 years ago. According to many scientists, playing rugby is an effective means of physical education, which has a complex effect on the personality of students.

According to Z. Kozina & Y. Zaichenko (2022), in the process of game activity there is a need to implement a large number of technical methods and tactical elements. All this happens in conditions of rapid change of game situations against the background of great emotionality. In addition, it is necessary to perceive and analyse information quickly, make the right decisions, that is, to show cognitive abilities. The authors emphasised that sports games are one of the main content components of the school physical education programme. The "Rugby-7" lesson is introduced into the practice of physical education lessons in grades 10-11 as a variable module (Boliak *et al*., 2022). However, the presented module "Rugby, Rugby-7" in the physical education programme for a specialised school does not fully correspond to the specifics of sectional classes, which prompted authors to develop the organisational and methodological principles of "Rugby-7" classes with girls 16-17 years old outside of school.

The purpose of the "Rugby-7" programme is the formation of a versatile, harmoniously developed personality, ready for active creative self-realisation in the space of universal culture. The use of rugby equipment is appropriate for strengthening and preserving one's own health, fostering responsibility and professional self-determination in accordance with individual abilities in the organisation of a healthy lifestyle. ***The goal*** of the programme achieved through solving the following tasks:

1. Formation of a healthy lifestyle by means of rugby.
2. Development of basic physical qualities, formation of vital motor abilities and skills.
3. Strengthening and preservation of health, improvement of physique and education of a harmoniously developed personality, aimed at long-term preservation of a high level of general working capacity.
4. Education of positive personality qualities, collective interaction and cooperation in educational and competitive activities.

Principles of programme implementation. The principle of complexity implied a close relationship between all aspects of the educational process (physical, technical-tactical, integral, psychological and theoretical training, educational work, pedagogical control). The principle of continuity determined the sequence of presentation of the programme material by stages of training to ensure the continuity of tasks, means and methods of training, volumes of training and competitive loads, growth of indicators of physical and technical-tactical readiness in the multi-year educational process. The principle of variability provided for the variability of programme material for practical classes, which is characterised by a variety of educational and training tools and workloads aimed at solving pedagogical tasks, depending on the stage of multi-year training and individual characteristics of students. Rugby tools allowed to successfully solve the entire set of tasks listed above, created prerequisites for the formation of survival skills in extreme situations, which emphasises their applied value (especially in the conditions of martial law in Ukraine). Thematic planning of the "Rugby-7" programme for girls aged 16-17 is described below.

Rugby based physical education knowledge. Theoretical training. Individual plan of educational and training classes. Studying the experience of teams of the game in rugby. The theory of rugby. Game strategy. *Main content lines*. Drawing up an individual lesson plan taking into account the characteristics of those who work. Referee gestures, rules of the game. Orientate yourself on the court, perform the functions of players from standard positions and in open play in defence. Build game tactics depending on game conditions. Adhere to the optimal alternation of workload and rest. Analyse indicators of physical condition. Regulate physical load during physical exercises. Tell about the rules of the game in "Rugby-7". Name and distinguish gestures of judges. Tell and understand the location of players from standard positions and in open play in defence.

Ways of motor activity. Perform individual technical actions: improvement of skills and abilities in possession of the ball and other technical techniques of rugby. Perform group tactical interactions: improve previously learned options for group interaction, depending on the conditions on the sports field. Perform team tactical actions in defence and in attack: improve the execution of previously learned team interactions, both in open play and depending on standard provisions. *Main content lines*. Improving the skills and abilities of performing individual technical actions with the ball, coordinated combinations of hand movements with the execution of basic steps (elements). Improvement of abilities and skills of performing group tactical interactions in attack and defence. Improvement of abilities and skills of performing team tactical actions in attack and defence. Describe the individual technique of performing various kicks on the ball, catching and passing the ball, movement without the ball. Master the technique of the studied exercises. Identify mistakes while performing an exercise, be able to analyse and correct them. Perform coordinated combinations of hand movements with the execution of basic steps (elements). Master the technique of studied tactical actions. Demonstrate the technique of performing learned tactical actions in defence and attack.

Physical improvement. Sports and health activities with general development orientation: "Rugby-7" game. Security requirements. Have the skills to play "Rugby-7". Exercises of general development and special focus: safety requirements. Athletics exercises. Sports games using a rugby ball (handball, basketball, soccer). *Main content lines*. Compliance with safety rules during "Rugby-7" classes. To perform exercises for the development of physical qualities, to navigate in space, to perform technical and tactical interactions in game activities. Compliance with safety rules during athletics classes. Performing athletics exercises:

walking with a change in speed and stride length; different types of walking – on toes, rolling from heel to toe, springy step, with jumps, alternating walking and running; running with a change in speed and direction of movement, also precisely at the teacher's signal; back forward, step by step, "shuttle" run 3×10 m; running at 60 m, 100 m, at medium distances of 400-800 m in the mode of repeated – interval method; a steady 6-minute run. Compliance with safety rules during sports games. Application of sports games for the development of speed, coordination, strength, orientation in space: stance and movement; moving to the right, to the left side in incremental steps, with the back forward; with a change of direction at the teacher's signal; with jumps and turns at the teacher's signal; passing the ball in pairs (from the side, from below) while standing still and in motion; transfers in columns with movements; two-way games using a rugby ball.

Observe safety rules during "Rugby-7" classes. Perform technical exercises from the sports game of "Rugby-7". Interact in pairs, threes, groups when performing exercises and game actions. Take an active part in games. Model the technique of game actions and techniques, depending on the game situation and the conditions that arise in the process of game activity. Follow the rules of the game. Communicate and interact with peers during the game. Show benevolence, mutual understanding, to treat one's emotions objectively. Use rugby game actions to develop physical qualities and as a means of active recreation. Perform exercises to develop endurance, coordination, strength and speed. Identify possible lags in indicators of physical development and physical fitness. Follow the standards of physical training. Follow the rules of breathing when performing exercises. Control the load according to the heart rate. Organise and conduct independent classes, compile their content and plan in the system of physical education classes. Actively participate in games and referee. Model the technique of game actions and techniques, depending on the game situation and the conditions that arise in the process of game activity. Follow the rules of fair play. Communicate and interact with peers during the game. Respect your opponent, control your emotions. Use game actions of sports games for the development of physical qualities, and as a means of active recreation.

Control exercises on rugby technique for students (16-17 years old). Passing the ball on the spot – 7-8 times. Passing the ball in motion – 7-8 times. Catching the ball after kicking – 7-8 times. Kick the ball with your hands for accuracy – 6-7 times. "Slalom" – 18-21 times. *Means of dexterity development*: performing movements of different intensity, changing the direction of movement by 90° according to a sound or visual signal (repeatedly); receiving and passing the ball in different ways. Moving along the sports field with low, moderate, high intensity, in groups of three "fan", in "extreme". Pass from the right "extreme" to the "central", receiving the "central" and passing the ball to the left "extreme" and back; moving along the field, in groups of three "fan", the distance between athletes is from 2 to 7 m; passing the ball and "running" for a partner, receiving the ball; in pairs, passing the ball in different ways, from different positions, changing places. The first student performs a pass on the spot and moves to the place of the receiver, the second student performs the reception of the ball and moves to the place of another, etc. Pupils perform ten receptions and passes of the ball. The exercise is performed in series; multiple execution of a technical element; execution of several technical elements in a row; mobile games: "Third extra", "Sparrows and crows", "Running with proceeds", "Two camps", "Shoot the ball", "Running in teams", "Squads" along the lines with and without the ball" and others; sports games using a rugby ball (handball, basketball, soccer).

Means of endurance development: fartlek. Alternating running segments with maximum, high, moderate and low intensity; receiving and passing the ball in groups, repeatedly in motion. Different formations are used: in rows, opposite columns, shaped formations (triangle, square, star, circle); 6-minute run; execution of several team technical-tactical actions with increased intensity in a row; educational and training games with a longer duration; moving games: "Race with elimination", "Onslaught", "Be able to catch up"; sports games using a rugby ball (handball, basketball, football).

Means of strength development: performance of strength exercises by the circular training method; execution of passes of the stuffed ball in different ways; performance of strength exercises with a partner, in pairs; mobile games: "Rugby on your knees", "One by one", "Gladiators" and others; sports games using a weighted ball for rugby (handball, basketball). *Means of speed development*: running 10-30 m; running at maximum intensity with running around landmarks; low-intensity running, with a further start of 10 m (left, right) at the signal; repeated running of distances from 10 to 60 m with feints; educational and training games with a reduced composition and reduced time; mobile games: "Falling stick", "Onslaught", "Run with proceeds", "Call the number" and others; sports games using a rugby ball (handball, basketball, football).

The influence of the "Rugby-7" programme on the physical condition of girls aged 16-17 years

The effectiveness of the proposed "Rugby-7" programme was tested in the process of conducting a formative experiment. At the end of its implementation, a repeat examination was conducted to determine the morphofunctional state and indicators of physical fitness. The physical development assessment was based on the parameters of length, body weight, the proportions of the development of individual parts of the body, as well as the degree of development of the functional capacities of the body, first of all cardiovascular and respiratory systems. As G. Giorgi *et al.* (2020) and T. Liu (2022) noted, these systems depend on the differentiation and maturity of the cellular elements of organs and tissues, functional capabilities of the nervous system and endocrine apparatus. Historically, physical development has been assessed mainly by external morphological characteristics (Table 1).

Table 1. Average statistical values of indicators of physical development of girls aged 16-17

Quantity	Body length, cm	Body weight, kg	Quetelet index, g/cm
N = 19	169.39 ± 1.88	59.79 ± 2.11	310 ± 1.51

Source: created by the authors

Analysing parameters of physical development, it was found that 58% of girls had an average level of physical development, their body weight was normal; 37% of girls had an index below the average level of physical development, they had a body weight deficit; the remaining 5% had a higher-than-average level of physical development, their proper body weight exceeded the actual one. Obtained data confirms the results of investigation by M.C. Pascoe *et al.* (2020) and Y. Geng *et al.* (2023). This proves about availability of common tendencies in physical development of girls 16-17 years old in European region. The data received are somewhat inconsistent with the results obtained by Y. Geng *et al.* (2023). According to their data, the arithmetic mean of body length is 164.51 ± 1.75 cm, body weight is 55.63 ± 2.35 kg, the Quetelet index is 317 ± 2.15 g/cm.

One of the components of physical development is the functional capabilities of the body, which are determined by the activity of the cardiovascular and respiratory systems. Heart rate, systolic and diastolic arterial blood pressure and vital lung capacity were measured to evaluate the activity of the cardiorespiratory system. The rate of heart rate in an untrained person is in the range of 70-85 beats per minute (bpm). Analysing the obtained results of the rate of heart rate, it was evident that this rate was within the normal range for most girls (Table 2).

Table 2. Average statistical values of functional indicators of the cardiovascular system of the studied girls

Age	*N*	Heart rate at rest, bpm^{-1}		Systolic blood pressure, mm Hg		Diastolic blood pressure, mm Hg	
		$\bar{X}$	*S*	$\bar{X}$	*S*	$\bar{X}$	*S*
16-17	19	78.28	2.58	113.11	1.66	73.06	1.66

Note: $\bar{X}$ – arithmetic mean; *S* – mean square deviation
Source: created by the authors

There were some statistical differences with the data obtained by T. Krutsevich *et al.* (2019) and C.A. Webster *et al.* (2021). Data obtained by T. Krutsevich *et al.* (2019) show that resting heart rate in high school age girls is 83.22 ± 3.21 bpm, systolic blood pressure is 118.21 ± 3.71 mm Hg, diastolic arterial pressure – 76.51 ± 2.83 mm Hg. The author noted that the functional state of the cardiovascular system of teenagers and young people is not only the main indicator of health, it is of exceptional importance in the body's adaptation to physical exertion and is one of the main indicators of the body's functional capabilities. At the same level of exercise, the heart rate of women is higher than that of men. The scientist emphasised that this is due to a lower concentration of haemoglobin in the blood of women who have reached sexual maturity. The degree of relative tachycardia of women ranges from 10 to 20 bpm. C.A. Webster *et al.* (2021) conducted research on the functional state of schoolchildren who, due to quarantine restrictions during the COVID-19 pandemic, were on distance learning (physical education lessons were conducted online). The obtained results indicate deterioration of indicators of the functional state of the cardiovascular system of girls aged 15-17. An 8-12% increase in heart rate during absolute and relative rest was observed. As for the blood pressure indicators, they had minor fluctuations from the norm. The analysis of the obtained data showed that blood pressure is within the physiological norm, which should be 110-120/60-85 mm Hg. The vital capacity of the lungs of the observed girls was in the range of 2,500-2,700 mm, which corresponded to the average values of this age group of girls (Table 3). Obtained data as for functional condition of cardiorespiratory system of pupils of high school age confirm the results of research by W. Thompson (2018) and M. Grasdalsmoen *et al.* (2020).

Table 3. Average statistical values of the functional indicators of the respiratory system of the subjects

Age	*N*	The vital capacity of the lungs, ml		Robinson's index, conventional units	
		$\bar{X}$	*S*	$\bar{X}$	*S*
16-17	19	2,492.22	144.41	88.48	3.61

Source: created by the authors

Using the Robinson index, as a characteristic of a person's aerobic capabilities, it was determined that 16% of schoolgirls had a high level, 31% had an average level, and 53% of girls had an above-average level. No deviations in the regulation of the cardiovascular system were detected (Fig. 1).

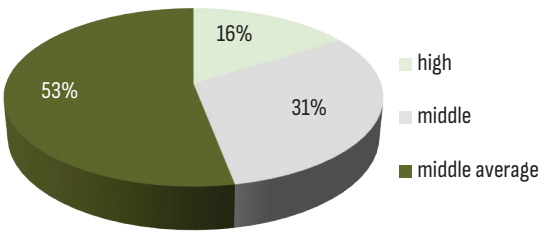

Figure 1. Indicators of the Robinson index level of girls aged 16-17
Source: created by the authors

A comparative analysis of the values of the results of the manifestation of individual motor abilities according to the results of the pedagogical testing of schoolgirls (Table 4) allows to state that in schoolgirls who are engaged in "Rugby-7" in extracurricular time, there is a positive dynamic of the results in the manifestation of motor abilities in the age aspect (compared to the beginning of the course occupations). The assessment of general endurance according to Cooper test showed that none of the girls has a low level of physical fitness. However, 31.25% of girls have a lower-than-average level, average – 50%, higher-than-average – 12.5% and high – 6.25% of the subjects.

Table 4. Average statistical indicators of pedagogical tests at the beginning and at the end of the observation course for girls aged 16-17

Test	Results	
	At the beginning	At the end
Running 30 m, s	6.59 ± 0.33	6.32 ± 0.20
Running 1,500 m, min	9.65 ± 1.83	9.53 ± 1.64
Long jump from a standing position, cm	187.22 ± 10.07	198.00 ± 10.90
"Shuttle" run 3×10 m, s	10.38 ± 0.26	10.07 ± 0.23
Flexion and extension of the arms in a supine position, repetitions	10.70 ± 3.40	13.00 ± 2.29
Cooper test, m	1,900 ± 250	2,100 ± 303
Leaning forward from a sitting position on the floor, cm	15.13 ± 2.01	17.34 ± 2.45

Source: created by the authors

Authors of the study considered it expedient to compare the data obtained regarding the physical fitness of 16-17-year-old girls with the results of other authors' research. M. Perehinets (2018), researching the physical condition of girls of high school age in various types of educational institutions, noted that the lack of physical activity affects physical fitness indicators. Only 36.7% of girls have a high level of competence, and 30.4% have an average level of competence. The results of indicators of development of speed, coordination and speed-power abilities were lower in comparison with authors' data. The exception is the "running 1,500 m" test, which was significantly higher (8 min 6 s ± 0.51) than in the group of girls studied by the authors of the study (9 min 53 s ± 1.64).

The obtained data confirm the results of research by T. Krutsevich *et al.* (2023), which noted that the analysis of indicators of physical fitness of high school students does not meet the requirements of modern society. According to the Ministry of Education and Science of Ukraine, 65.01% of students in the 2018-2019 academic year had an insufficient level of physical fitness, namely: 15.2% had a high level, 19.7% – sufficient, 12.3% – average and 52.8% – low. The authors noted that the modular programme for grades 10-11 contains 37 modules that can be used both in academic and extracurricular (sectional) classes. This is an innovative approach that will contribute to increasing the motivation of high school students to engage in physical culture and sports, which, in turn, will optimise their level of physical fitness. N. Moskalenko *et al.* (2020), analysing the methods of implementation of each key competence in the process of physical education of schoolchildren within the framework of the New Ukrainian School reform, also noted that the level of physical fitness of modern students does not correspond to the appropriate indicators. The authors believe that an integrative approach to the formation of key competencies in the process of physical education will allow to comprehensively solve the problem of increasing the level of development of physical abilities of students.

The received data to some extent confirm the results of the study by V. Vakhniak (2022) regarding the inadequate level of physical fitness of girls of high school age. The researcher noted that the cancellation of the assessment for the dynamics of the development of physical qualities and indicative educational standards had a negative impact on motor activity, physical fitness and, as a result, significantly reduced the level of physical health of students. The authors emphasise that the model curriculum "Physical culture 10-11 grades" has a significant number of modules, but the programmes for most of them need significant revision. The distribution of the obtained results of physical fitness according to the rating tables in percentages is given in Table 5.

Table 5. Distribution of the obtained indicators of physical fitness of girls aged 16-17 at the beginning of the experiment according to evaluation tables, %

Test / Level	High	Sufficient	Average	Low
Running 30 m	46.68%	16.66%	36.66%	–
Running 1,500 m	45.01%	20.00%	34.99%	–
Standing long jump	16.65%	58.35%	15.61%	9.39%
"Shuttle" run 3×10 m	8.33%	16.65%	58.35%	16.67%
Leaning forward from a sitting position	9.41%	18.32%	38.34%	33.93%

Source: created by the authors

At the end of the study, pedagogical testing was conducted again in order to compare with the results obtained at the beginning of the study and to determine whether there was an improvement in the level of physical fitness of high school girls. The average statistical values of the results of pedagogical testing of schoolgirls who played "Rugby-7" have improved and have reliable differences in such motor tests as "running 30 m", "shuttle run 3×10 m" and "long jump from a standing position" ($p < 0.05$). In particular, a significant improvement of the results by 8.7% was recorded in the indicators of speed abilities (running 30 m). Indicators of such a component of coordination abilities as the ability to estimate space-time parameters of movement also had positive dynamics, the rate of growth was 7.6%. Indicators of speed-power abilities improved by 5.8%. Table 6 shows the results of pedagogical testing at the end of the experiment.

Table 6. Distribution of the obtained indicators of physical fitness of girls aged 16-17 years after the experiment, %

Test / Level	High	Sufficient	Average	Low
Running 30 m	76.66%	16.66%	6.68%	–
Running 1,500 m	75.01%	16.66%	8.33%	–
Standing long jump	39.98%	47.69%	12.33%	–
"Shuttle" run 3×10 m	26.61%	58.31%	10.31%	4.77%
Leaning forward from a sitting position	16.51%	66.68%	9.36%	7.45%

Source: created by the authors

It can be stated that there have been positive changes in the distribution of the obtained indicators according to the levels of physical fitness of the studied contingent. At the beginning of the experiment, according to the evaluation tables, a high level of manifestation of speed abilities was recorded in 46.68% of the subjects, sufficient – 16.66%, average – 36.64%. At the end of the experiment, a high level of speed development was already recorded in 76.66%, sufficient in 16.64%, and average only in 6.68% of the contingent. Similar trends were recorded in dynamic endurance indicators: at the beginning of the experiment, a high level was observed in 45.01% of girls, a sufficient level in 20.00%, and an average level in 34.99%. At the end of the experiment, 75.01% of female students achieved a high level, a sufficient level was observed in 16.66%, and an average level of endurance was recorded in 8.33% of girls.

A high level of development of speed and strength abilities at the beginning of the experiment was recorded in 16.65% of girls, a sufficient level in 58.35%, an average level in 15.61% and a low level in 9.39% of the researched ones. After the end of the experiment, there was an improvement in the level of manifestation of this ability (high level 39.98%, sufficient 47.69%, average 12.33, low level was not detected. The distribution of indicators by the level of development of coordination abilities at the beginning of the experiment was as follows: high level – 8.33%, sufficient – 16.65%, average – 58.35%, low – 16.67%. After the end of the experiment, positive dynamics in the development of dexterity were also observed (high level 26.61%, sufficient 58.31%, average 10.31%, low 4.77%). There were also positive changes in the indicators of the development of spinal flexibility (leaning forward from a sitting position). At the beginning of the experiment, the following data were obtained: high level of development – 9.41%, sufficient – 18.32%, average – 38.34%, low – 33.93%. After the end of the experiment, the level of flexibility improved significantly (a high level of manifestation was recorded in 16.51% of girls, sufficient in 66.68%, average in 9.36%, low in 7.45%). Therefore, a comparison of the results of the motor tests of high school girls playing "Rugby-7" at the beginning and at the end of the experiment allows to claim a general improvement in the indicators, but the greatest growth rates were recorded in the manifestation of dexterity, speed and speed-power abilities.

Conclusions

The analysis of special literature devoted to the problem of the effectiveness of using "Rugby-7" classes with girls of high school age shows that these classes are a new and effective type of physical exercise, which is gaining more and more popularity both abroad and in Ukraine. However, despite this, in the special literature there are only episodic data on the organisation and methods of conducting health-oriented classes using rugby equipment, which necessitated the development of the "Rugby-7" programme for sectional classes, which included: the goal, tasks, principles of programme implementation, its thematic planning, expected results, control standards. The developed programme was implemented into extracurricular work of physical education with girls 16-17 years old.

During the research of the parameters of the physical condition of girls aged 16-17 under the influence of the "Rugby-7" course, the positive dynamics of some indicators were found. Thus, the indicators of the harmony of the physique indicate that 12.5% of the girls had normalised their body weight, which significantly reduced the number of subjects who were overweight. The condition of the body's functional systems also improved, especially the cardiovascular system (heart rate at rest). If at the beginning of the experiment the average arithmetic value of this indicator was 78.3 bpm^{-1}, then after the experiment this indicator decreased to 76.7 bpm. Repeated assessment of dynamic endurance according to Cooper test showed that 31.3% of the studied girls showed an improvement in indicators.

Conducting extracurricular "Rugby-7" classes contributed to a statistically significant increase in indicators of the morphofunctional state and physical fitness of high school-aged girls. A low level of physical fitness was not recorded, 7.6% of girls had a lower-than-average level, an average

level was recorded in 22.0%, an above average level in 26.6% of schoolgirls, and a high level was found in 43.7% of the subjects. Prospects for further research will be to determine the impact of the "Rugby-7" physical culture and health programme on the level of physical health of high school girls.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Belikova, N., & Shnit, I. (2019). Increasing the level of motor activity and health promotion of high school students during aqua aerobics training. *Youth Scientific Journal Lesya Ukrainka Eastern European National University*, 35, 80-85.

[2] Boliak, A., Hladkovskyi, R., Hloba, M., Derevianko, V., Dykyi, O., Kolomoiets, H., & Rebryna, A. (2022). *Physical education. 10-11 grades. Standard level. Curriculum for institutions of general secondary education institutions*. Retrieved from https://surl.li/yxhmpj.

[3] Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/.

[4] Geng, Y., Trachuk, S., Ma, X.M., Shi, Y.J., & Zeng, X. (2023). Physiological features of musculoskeletal system formation of adolescents under the influence of directed physical training. *Physical Activity and Health*, 7(1), 1-12. doi: 10.5334/paah.217.

[5] Giorgi, G., Leon-Perez, J.M., Pignata, S., Topa, G., & Mucci, N. (2020). Addressing risks: Mental health, work-related stress, and occupational disease management to enhance well-being 2019. *BioMed Research International*, 2020, article number 1863153. doi: 10.1155/2020/1863153.

[6] Grasdalsmoen, M., Eriksen, H.R., Lønning, K.J., & Sivertsen, B. (2020). Physical exercise, mental health problems, and suicide attempts in university students. *BMC Psychiatry*, 20, article number 175. doi: 10.1186/s12888-020-02583-3.

[7] Kholidari, N. (2017). Features of physical education in "public schools" – the elite boarding schools of Great Britain. *Pedagogical Sciences*, 77(1), 118-122.

[8] Kozina, Z., & Zaichenko, Y. (2022). Integral development of coordination and cognitive abilities of basketball players in groups of initial training. *Health Saving Technologies, Rehabilitation and Physical Therapy*, 3(1), 43-47. doi: 10.58962/HSTRPT.2022.3.1.43-47.

[9] Krutsevich, T., Panhelova, N., & Moskalenko, N. (2023). Physical education in educational institutions: Current state and realities of today. *Sports Bulletin of the Dnieper Region*, 1, 67-77. doi: 10.32540/2071-1476-2023-1-067.

[10] Krutsevich, T., Pengelova, N., & Trachuk, S. (2019). Model-target characteristics of physical fitness of the systems of programming sports and recreational activities witch adolescents. *Journal of Physical Education and Sports*, 19(1), 242-248. doi: 10.7752/jpes.2019.s1036.

[11] Liu, T. (2022). Home-school cooperative education: Reflections on the double reduction policy. *International Journal of Education and Humanities*, 4(3), 238-243. doi: 10.54097/ijeh. v4i3.1815.

[12] Mandiuk, A. (2021). *Theoretical and methodological foundations of the formation of schoolchildren's free time culture using various forms of motor activity*. (Doctoral dissertation, Lviv State I. Boberskyi University of Physical Culture, Lviv, Ukraine).

[13] Moskalenko, N., Sorokolit, N., & Turchyk, I. (2020). Key competencies in the physical education of schoolchildren within the framework of the "New Ukrainian School" reform. *Scientific Journal of Drahomanov Ukrainian State University. Series 15. Scientific and Pedagogical Problems of Physical Culture (Physical Culture and Sports)*, 5K(113), 223-228.

[14] Nesen, O. (2023). Selection of variable modules for classes during one academic quarter for students of grades 5-6, in accordance with the requirements of the modular program. In *Topical issues of physical education, sports, healthy lifestyle and quality of life of different strata of the population: Collection of theses of I all-Ukrainian science and practice conference* (pp. 82-85). Kharkiv: National Aerospace University "Kharkiv Aviation Institute".

[15] Pascoe, M.C., Hetrick, S.E., & Parker, A.G. (2020). The impact of stress on students in secondary school and higher education. *International Journal of Adolescence and Youth*, 25(1), 104-112. doi: 10.1080/02673843.2019.1596823.

[16] Pedan, O., Kolomoiets, H., Boliak, A., Rebryna, A., Derevianko, V., Stetsenko, V., Ostapenko, O., Lakiza, O., & Kosyk, V. (2022). *Model educational program "Physical culture. 5-6 grades" for institutions of general secondary education*. Retrieved from https://mon.gov.ua/storage/app/media/zagalna%20serednya/Navchalni.prohramy/2021/14.07/Model.navch.prohr.5-9.klas.NUSH-poetap.z.2022/Fiz.kult.5-6.kl.Pedan.ta.in.22.08.2022.pdf.

[17] Perehinets, M. (2018). *Organization of the process of physical education of high school students in educational institutions of various types*. (PhD dissertation, National University of Physical Education and Sports of Ukraine, Kyiv, Ukraine).

[18] Petrova, A. (2021). *The effectiveness of the application of the variable module "Crossfit" in the physical education of high school students*. (PhD dissertation, State Academy of Physical Culture, Kharkiv, Ukraine).

[19] Rymar, O., Solovey, A., Sorokolit, N., Shevtsiv, U., & Matviiv, V. (2020). Tools for children fitness in the physical education of primary school pupils. *Society. Integration. Education*, 3, 540-551. doi: 10.17770/sie2020vol3.4852.

[20] Sorokata, Ya. (2021). Modern lessons of physical culture according to the New Ukrainian School. In *Research and innovation in the field of social sciences and humanities: Collection of materials of the first all-Ukrainian scientific and practical internet conference* (pp. 312-314). Melitopol: Tavria State Agrotechnological University.

[21] Thompson, W. (2018). Worldwide survey of fitness trends for 2019. *ACSM's Health & Fitness Journal*, 22, 10-17. doi: 10.1249/FIT.0000000000000438.
[22] Vakhniak, V. (2022). Physical culture in the conditions of the New Ukrainian School. In *IV international scientific and theoretical conference "Theory and practice of modern science"* (pp. 177-179). Kraków: European Scientific Platform.
[23] Webster, C.A., D'Agostino, E., Urtel, M., McMullen, J., Culp, B., Egan Loiacono, C.A., & Killian, C. (2021). Physical education in the COVID era: Considerations for online program delivery using the comprehensive school physical activity program framework. *Journal of Teaching in Physical Education*, 40(2), 327-336. doi: 10.1123/jtpe.2020-0182.
[24] World Health Organization. (2021). *Promoting physical activity through schools*. Geneva: World Health Organization.

Оптимізація фізичного стану дівчат старшого шкільного віку засобами нових видів рухової активності (на прикладі «Регбі-7»)

Наталія Пангелова

Доктор наук з фізичного виховання і спорту, професор
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0002-4846-3907

Тетяна Кравченко

Кандидат педагогічних наук, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0002-6041-3101

Владислав Рубан

Кандидат наук з фізичного виховання і спорту, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0003-3771-5117

Анотація. У процес фізичного виховання старшокласників впровадженні модельні навчальні програми, які включають як традиційні, так й інноваційні види рухової активності. Зокрема представлена варіативна програма «Регбі-7», але зміст і спрямованість секційних занять відрізняється від уроків фізичної культури, що обумовило мету роботи: обґрунтувати й розробити організаційно-методичні засади занять із пріоритетним використанням «Регбі-7» у процесі позакласної (секційної) роботи та визначити їх вплив на морфофункціональний стан і фізичну підготовленість дівчат старшого шкільного віку (16-17 років). Для оцінки фізичного розвитку використано метод антропометрії. Гармонійність тілобудови визначалася за допомогою методу індексів. Функціональний стан кардіореспіраторної системи визначався пульсометрією, тонометрією, спірометрією. Аеробні можливості досліджені за допомогою індексу Робінсона. Оцінка фізичної підготовленості відбувалась у процесі педагогічного тестування. Розроблено програму «Регбі-7» для секційних занять із дівчатами старшого шкільного віку. Організаційно-методичні особливості секційних занять із пріоритетним використанням «Регбі-7» були висвітлені в розробленій програмі, яка включає: мету, завдання, принципи її реалізації (комплексності, наступності, варіативності), зміст, контрольні нормативи. Ефективність запропонованої програми перевірена в процесі формувального експерименту. У кінці його проведення було здійснено повторне обстеження для визначення показників морфофункціонального стану і фізичної підготовленості дівчат. Порівняльний аналіз показників фізичного розвитку й функціонального стану дівчат до та після експерименту свідчить про їх позитивну динаміку. Порівняння результатів фізичної підготовленості дозволило стверджувати про загальне покращення показників. Найбільші темпи приросту зафіксовано в прояві швидкісно-силових, координаційних здібностей та швидкості. Отримані дані засвідчили ефективність розробленої програми позаурочних занять і можуть бути застосовані вчителями фізичної культури в позаурочній роботі

Ключові слова: учениці 16-17 років; програма позаурочних занять; спортивні ігри; рухові якості; морфофункціональний стан

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 28.06.2024. Revised: 22.10.2024. Accepted: 12.12.2024

UDC 796.332-053.6

DOI: 10.69587/tppcs/2.2024.36

Morpho-functional conditioning of the effectiveness of defensive actions of young football players at the stages of preliminari and specialised basic training

Volodymyr Stepanenko*

PhD in Physical Education and Sport, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0003-1653-2426

Victor Pogrebniy

Senior Lecturer
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0001-6374-5817

Andrii Kapelyan

Postgraduate Student
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0009-0004-0986-5163

Abstract. The need for a sufficient level of functional training and the influence of individual morphological features on the effectiveness of tactical actions is urgent. Since the assimilation and improvement of tactical activity takes place at the stages of preliminary and specialised basic training (11-13 and 13-15 years old), the determination of the morpho-functional conditioning of the effectiveness of defensive actions by young football players will allow improving the process of their tactical training. The purpose of the study was to determine the relationship between morpho-functional features and the effectiveness of defensive actions by young football players at the stages of preliminary and specialised basic training. The level of functional capabilities was determined by indirect methods: aerobic – by heart rate indicators after performing a standard 5-minute exercise; anaerobic – according to jump ergometry indicators. In all groups, reliable relationships were established between the length of the body in the standing position and the efficiency coefficient of the head game in defence. High values of the correlation coefficients between the indicators of the length of the lower limbs and the coefficient of efficiency of interceptions (except for 12-year-olds) were revealed. The presence of statistically significant relationships between all characteristics of the effectiveness of actions in defence and the aerobic capabilities of young athletes was established. It was found that at the age of 14, absolute anaerobic phosphagen capacity indicators are significantly correlated with efficiency coefficients of interceptions, defensive headers and counterattacks. It was determined that the effectiveness of actions in protection is related to the ability to maintain a high power of jumping work, which characterises anaerobic capacity. The established dependencies of the effectiveness of defensive actions on the studied morphological features and functional characteristics should be used by coaches of children's and youth football teams when determining the propensity of young football players to perform certain tactical functions, team composition and rational application of training of different (aerobic and anaerobic) orientations

Keywords: aerobic capacity; anaerobic capabilities; age changes; correlation analysis; morphological features

Suggested Citation: Stepanenko, V., Pogrebniy, V., & Kapelyan, A. (2024). Morpho-functional conditioning of the effectiveness of defensive actions of young football players at the stages of preliminari and specialised basic training. *Theory and Practice of Physical Culture and Sports*, 3(2), 36-44. doi: 10.69587/tppcs/2.2024.36.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

Introduction

The commercialisation of modern sports, in particular football, caused a significant increase in competition in achieving high sports results. This provision determines the need to constantly search for scientifically based ways of improving the system of training the sports reserve. The system-forming factor of the effective competitive activity of football players is the sports result, which is determined by the components of provision and implementation. The components of ensuring effective competitive activity are the morphofunctional and psychophysiological capabilities of the body of football players (Sarmento *et al.*, 2018). They are implemented at the level of technical and tactical skill, physical and mental preparedness (King, 2018).

According to S. Barrett *et al.* (2018), improving the technical and tactical skill of football players is a complex multifactorial process, and due to the fact that the specifics of the conditions of the modern game require each player to alternately perform defensive and attacking actions, the effectiveness of the game in defence and attack has equal importance for the final result. However, R. Oliveira *et al.* (2022) noted that, despite the increasing role of group methods of play in defence, such as pressing, counter selection, numerical advantage in parts of the field, when studying the features of technical and tactical activity and the factors that determine its effectiveness, priority is given to the attacking actions of football players, and assessment of their effectiveness is carried out by registration of accurate and inaccurate actions followed by calculation of the corresponding coefficients.

Such attention is caused mainly by the commercial component, due to the spectacle of attacking actions, as J.L. Delgado & J.A. Mendez Villanueva (2018) noticed. But it is necessary to pay attention to the fact that it is impossible to attribute the incomplete selection of the ball, when the opponent's attack is interrupted, but the ball remained under his control, to accurately performed or inaccurately performed defensive actions. Thus, the use of generally accepted efficiency coefficients in this case is not correct. This necessitates the use of a balanced assessment of defensive actions in competitive activities. This approach consists in evaluating defensive tactical actions on a special scoring scale that takes into account the results of the defensive action that was performed. At the same time, the zone and situation in which this or that game action is performed is taken into account.

T. Modric *et al.* (2021) highlighted the need for a high level of functional characteristics (aerobic and anaerobic capabilities) for high-quality performance of tactical actions by high-class football players. A.H. Roberts *et al.* (2019) established that the presence of certain morphological features in qualified football players (length of the body and lower limbs, body mass and hip girth) selectively determines the effectiveness of certain tactical actions (heading in defence, interceptions and ball selection). In addition, G. Lisenchuk & V. Tyshchenko (2019) suggested that due to morpho-functional differences, the specificity of interdependencies in qualified and young football players may have different conditioning. Therefore, the significance of the impact of individual functional features and morphological features on the effectiveness of defensive actions by young football players needs additional study.

According to V. Nikolaienko *et al.* (2021), it is the stages of preliminary and specialised basic training that are the beginning of training and the improvement of tactical actions of young football players continues, and any miscalculations in the training and selection process (along with the orientation towards the performance of certain game functions and team composition) lead to a decrease in the quality of training reserve. Thus, mastering modern methods of conducting the game in defence requires high individual playing skills of the players, which also confirms the importance of improving the process of learning defensive tactical actions, taking into account the special features of young athletes. The above made it necessary to carry out specialised studies aimed at determining the specificity of the relationships between morpho-functional features and indicators of the effectiveness of defensive tactical actions of young football players at the stages of preliminary and specialised basic training.

Materials and Methods

The method of analysis of scientific and methodological literature was used in order to study the state of the research problem. The method of pedagogical control is used to assess the level of tactical skill when performing defensive actions during competitions. The coefficients of the efficiency of tackles, interceptions, head play in defence, opposition to passes, driving, shots, and the integral coefficient of the efficiency of defensive actions were determined. The evaluation scale of protective actions is presented in the work of V. Stepanenko & V. Pogrebnyi (2022). At the same time, the zone and situation in which this or that game action is performed is taken into account. Efficiency coefficients (EC) were also calculated by the formula of V. Stepanenko & V. Pogrebnyi (2022).

Morphological characteristics (body weight, kg; hip circumference, cm; body length in standing position, cm; length of lower limbs, cm) were determined in accordance with generally accepted methods of anthropometric measurements. Aerobic capacity was determined using an indirect method. Subjects climbed a bench 35 cm high for 5 minutes at a pace of 25 times per minute. At the end of the work, the heart rate was measured for the last 30 seconds of work. Then the *MOC* (maximum oxygen consumption) was calculated according to the following formula:

$$MOC = 1.29 \times \sqrt{\frac{h \times p \times n \times 1.3 \times e^{-0.000884 \times t}}{F-60}}, \qquad (1)$$

where h – the bench height; n – the number of ascents per minute; e – the base of the natural logarithm; f – heart rate per minute; p – body mass; t – age. Anaerobic capacity was determined by the jumping ergometry method on the contact area. Subjects performed three maximal upward jumps with sufficient rest pauses. An electronic millisecond meter recorded the time of the unsupported phase of the jump (the best indicator was taken into account). After a rest pause, the subjects performed a 60-second series of upward jumps with a frequency of 1 jump per 2 seconds. With the help of a millisecond meter, the total time of the resistance-free phase was recorded in each of the 10-second segments of jumping work, which made it possible to

determine the dynamics of the change in anaerobic power during the test. From the 60-second jumping test, the average indicators of anaerobic power of the first and last 10 seconds of jumping work were used to calculate the correlation coefficients. The height of the jump was calculated according to the formula:

$$h = \frac{9.8 \times \left(\frac{T}{2}\right)^2}{2}, \quad (2)$$

where h – the height of the jump, m; 9.8 – speed of free fall, m/s^2; T – the time of the jump, s. The power of the jump was calculated according to the formula:

$$N = (hm/(t/2))/0.102, \quad (3)$$

where N – power, W; h – jump height, m; m – mass, kg; t – jump time, s. The absolute anaerobic phosphagen power, the power of each 10-second segment of work in the 60-second jump test, and the index of the decrease in anaerobic power were calculated according to the following formula:

$$ACRE = \frac{W1 - W6}{W1} \times 100\%, \quad (4)$$

where $ACRE$ – anaerobic capacity reduction index, conditions unit; $W1$ – power of the first 10-second segment of work, W; $W6$ – power of the sixth 10-second segment of work, W. Digital data obtained in the study were processed using traditional methods of descriptive statistics. Determination of the probability of differences between parameters was carried out according to the Student's criterion, according to the formula for independent samples with unequal variances. Evaluation of the relationship between the studied parameters and indicators of the effectiveness of defensive tactical actions in the process of competitive activity, as well as the significance (determinism) of individual parameters was carried out using a multivariate correlation-regression analysis with the calculation of paired correlation coefficients and subsequent calculation of the multiple correlation coefficient. The values of r and p for the studied groups were as follows: $p \le 0.05$ with $r \ge 0.54$; $p < 0.001$ with $r \ge 0.76$ – 11 years; $p \le 0.05$ with $r \ge 0.48$; $p \le 0.001$ with $r \ge 0.72$ – 12 years; $p \le 0.05$ with $r \ge 0.54$; $p \le 0.001$ with $r \ge 0.76$ – 13 years; $p \le 0.05$ with $r \ge 0.45$; $p \le 0.001$ with $r \ge 0.69$ – 14 years; $p \le 0.05$ with $r \ge 0.49$; $p \le 0.001$ with $r \ge 0.74$ – 15 years. The method of finding determinants is presented in the special literature (Antomonov *et al.*, 2021). Statistical processing of the results was carried out using MS EXCEL, STATISTICA 6.0.

The confirmatory experiment was conducted during two competitive mesocycles of the children's and youth football league of the Kyiv Region of the 2023 season. Football players aged 11-13 years (stage of preliminary basic training) and 13-15 years old (stage of specialised basic training) took part in the study, who studied at the football department of the lyceum of the Shchaslyve Village of the capital's village council of the Boryspil District, Ukraine. Consent for the study was obtained from the parents of the children, and they were informed about the purpose and methods of using the obtained data. Anonymity of research participants and compliance with ethical standards were ensured (Declaration of Helsinki, 2013). The age of the group of 11-year-old football players was 11 ± 0.3 years, 12 years – 12 ± 0.1 years, 13 years – 13 ± 0.2 years, 14 years – 14 ± 0.1 years, and 15 years – 15 ± 0.1 years old. The total number of research participants was 82 ($N = 82$).

Results and Discussion

It is necessary to note the uneven development of the morphological features of the body of young football players at the stages of preliminary and specialised basic training (11-13 and 13-15 years, respectively). Irregularity of development is due to the onset of puberty in this age period. Standing height increases significantly from 12 to 13 and from 13 to 14 years ($p \le 0.05$), and leg length increases significantly from 12 to 13, from 13 to 14 and from 14 to 15 years ($p \le 0.05$) (Fig. 1).

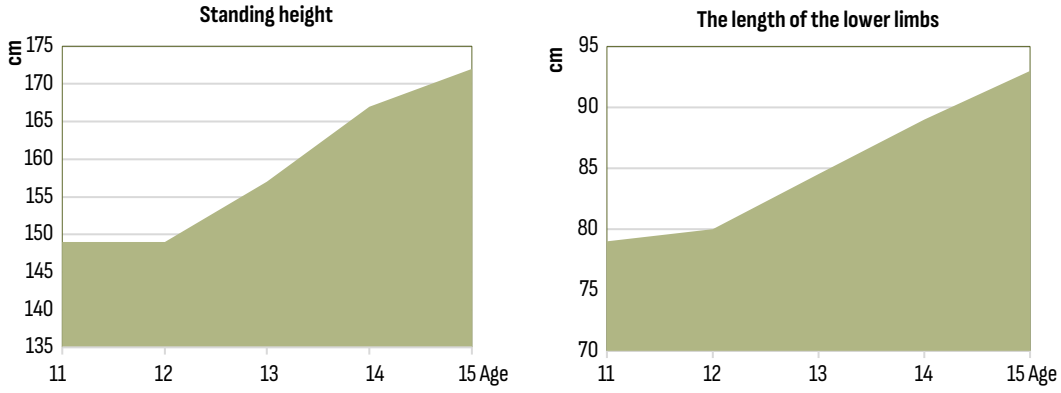

Figure 1. Indicators of height, standing and length of lower limbs of young football players, $\bar{x}$
Source: created by the authors

The above data allowed to establish two periods of significant growth in body length and lower limbs from 12 to 13 and from 13 to 14 years. Body mass and hip girth indicators have a similar tendency to increase: slight – from 11 to 12 years, jump-like increase – from 12 to 13 years, and most likely – from 13 to 14 years ($p \le 0.05$) (Fig. 2).

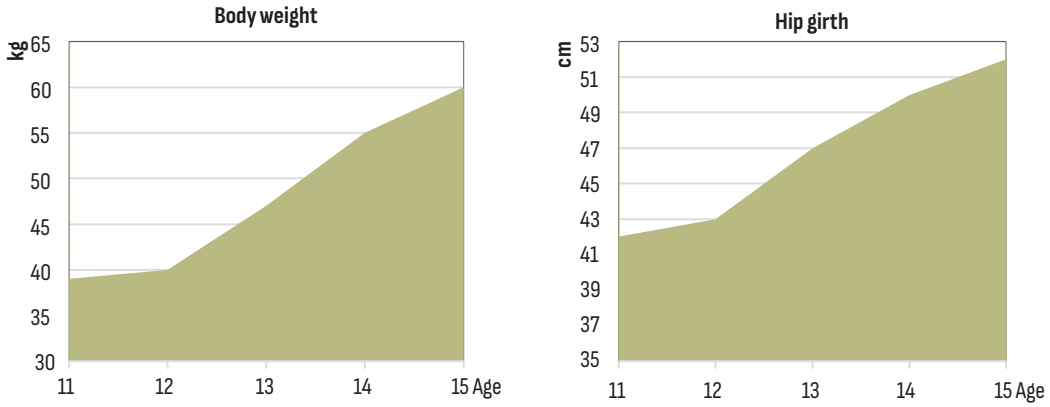

Figure 2. Indicators of body weight and hip girth of young football players, $\bar{x}$

Source: created by the authors

The obtained data allowed to generalise the following: the most reliable growth of the studied morphological features occurs from 12 to 13 and from 13 to 14 years. The analysis of age-related changes in the development of functional features allowed to establish the greatest increase in aerobic capacity (according to MOC indicators) in the period from 13 to 14 years ($p \leq 0.05$) (Fig. 3). A significant increase in anaerobic phosphagen capacity occurs from 12 to 13 and from 13 to 14 years ($p \leq 0.05$). Indicators of relative anaerobic phosphagen power significantly increase from 11 to 12, from 13 to 14 and from 14 to 15 years ($p \leq 0.05$) (Fig. 4).

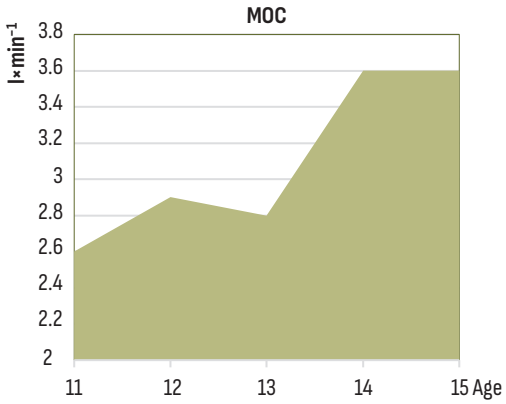

Figure 3. Indicators of MOC of young football players, $\bar{x}$

Source: created by the authors

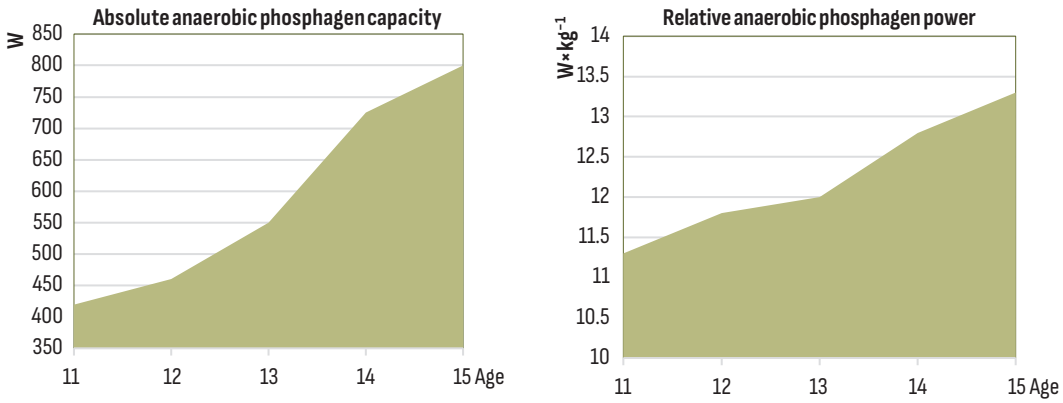

Figure 4. Indicators of absolute and relative anaerobic phosphagen capacity of young football players, $\bar{x}$

Source: created by the authors

Research has established that the effectiveness of protective measures increases slightly with age. Only at the age of 14, the integral EC of defensive actions, EC of interceptions and head games in defence are likely to increase ($p \le 0.05$). The significant growth of the specified characteristics coincides with significant increases at this age in such morphological features as body length and length of the lower limbs. Correlation analysis of the studied characteristics made it possible to establish that body mass has a relationship with the EC of head play in defence only in 11-year-old football players ($r = 0.56$, $p \le 0.05$). Indicators of hip circumference correlate with the EC of selections in 15-year-old athletes ($r = 0.58$, $p \le 0.05$). All age groups are characterised by reliable connections between body length and EC of head play in defence. In 13- and 14-year-olds, body length indicators significantly coincide with EC intercepts ($r = 0.54$, $r = 0.56$, $p \le 0.05$, respectively). All groups of subjects (except 12-year-olds) are characterised by the presence of high correlation coefficients between indicators of the length of the lower limbs and EC intercepts (Table 1).

Table 1. Correlation relationships between morphological features and indicators of the effectiveness of protective actions

Age	Indexes	EC			
		selections	interceptions	head games in defence	opposition
11	Body weight	0.31	0.43	0.56	0.05
	Standing height	0.38	0.49	0.61	0.07
	The length of the lower limbs	0.33	0.55	0.56	0.24
12	Standing height	−0.02	0.37	0.49	−0.23
13	Standing height	0.04	0.54	0.55	0.17
	The length of the lower limbs	0.13	0.58	0.39	0.28
14	Standing height	−0.06	0.56	0.58	−0.08
	The length of the lower limbs	0.29	0.52	0.38	0.31
15	Hip girth	0.58	0.34	0.32	0.15
	Standing height	−0.63	0.47	0.49	−0.19
	The length of the lower limbs	0.09	0.53	0.28	0.04

Source: created by the authors

Determining the playing functions of young football players and the composition of teams must be carried out in accordance with the established dependencies of the effectiveness of defensive actions on the investigated morphological features. To perform the functions of central defenders and midfielders, young players with high indicators of body length and lower limbs should be set up, due to the fact that, first of all, the middle part of the football field is characterised by interceptions and head play in defence, and the specified morphological characteristics, according to the obtained results, determine their effectiveness. Since the ball is most often collected on the flanks, young football players with shorter body length and lower limbs, but with a larger hip girth, should be oriented to perform the functions of full backs and midfielders.

Studies have shown that in almost all groups of subjects (except for the group of 12-year-old football players) there are statistically significant relationships between the characteristics of the effectiveness of defensive actions and aerobic capabilities. Therefore, a high level of development of general endurance determines the effective performance of protective actions. Indicators of absolute anaerobic phosphagen power of 11-year-old athletes are positively correlated with EC of interceptions and head play in defence ($r = 0.58$ and $r = 0.64$, $p \le 0.05$, respectively) (Table 2).

Table 2. Correlation relationships between functional characteristics and indicators of the efficiency of defensive actions, 11 and 12 years old

Age	Indexes	EC			
		selections	interceptions	head games in defence	opposition
11	MOC	0.67	0.72	0.76	0.69
	Absolute anaerobic phosphagen power	0.48	0.58	0.64	0.22
	Relative anaerobic phosphagen capacity	0.43	0.32	0.36	0.55
	Anaerobic power (1-10 s of work)	0.50	0.59	0.67	0.25
	Anaerobic power (51-60 s of work)	0.46	0.57	0.63	0.21
	Anaerobic power reduction index	−0.48	−0.36	−0.59	−0.39
12	Anaerobic power reduction index	−0.33	−0.28	−0.35	−0.58

Source: created by the authors

In 13-year-old players, interdependencies are observed only with EC of interceptions and with EC of head play in defence ($r = 0.54$, $r = 0.56$, $p \le 0.05$, respectively). Positive correlations of 14-year-old athletes were found regarding the absolute anaerobic phosphagen power, on the one hand, and EC of interceptions ($r = 0.54$, $p \le 0.05$), EC of head play in defence ($r = 0.50$, $p \le 0.05$), EC counteraction ($r = 0.58$, $p \le 0.05$), on the other hand. However, in 15-year-old young football players, this indicator correlates only with the EC of tackles and interceptions ($r = 0.69$, $r = 0.50$, $p \le 0.05$, in accordance).

Relative anaerobic phosphagen power in eleven-year-old football players is positively correlated with EC of oppositions ($r = 0.55$, $p \leq 0.05$). However, in 12- and 13-year-old football players, there is no significant correlation of this characteristic with indicators of the effectiveness of defensive actions. It was also established that there is a significant relationship between the relative anaerobic phosphagen capacity and all indicators of the effectiveness of defensive actions in 14-year-old athletes. But for 15-year-old players, this indicator correlates with the EC of selections and countermeasures ($r = 0.52$ and $r = 0.51$, $p \leq 0.05$, in accordance) (Table 3).

Table 3. Correlation relationships between functional characteristics and indicators of the effectiveness of defensive actions, 13, 14, and 15 years old

Age	Indexes	EC			
		selections	interceptions	head games in defence	opposition
13	MOC	0.42	0.78	0.63	0.55
	Absolute anaerobic phosphagen power	0.14	0.54	0.56	0.21
	Anaerobic power (51-60 s of work)	0.27	0.57	0.54	0.36
	Anaerobic power reduction index	−0.55	−0.58	−0.35	−0.58
14	MOC	0.52	0.52	0.36	0.58
	Absolute anaerobic phosphagen power	0.44	0.54	0.50	0.58
	Relative anaerobic phosphagen capacity	0.55	0.53	0.51	0.59
	Anaerobic power (1-10 s of work)	0.55	0.31	0.39	0.58
	Anaerobic power (51-60 s of work)	0.20	0.38	0.48	0.70
	Anaerobic power reduction index	−0.69	−0.47	−0.40	−0.72
15	MOC	0.45	0.55	0.57	0.52
	Absolute anaerobic phosphagen power	0.69	0.50	−0.30	0.33
	Relative anaerobic phosphagen capacity	0.52	0.27	−0.36	0.51
	Anaerobic power (1-10 s of work)	0.49	0.21	−0.33	0.02
	Anaerobic power (51-60 s of work)	0.39	0.52	0.51	0.28

Source: created by the authors

In 11-year-old athletes, correlational dependences of the first and last 10 seconds of jumping work with EC interceptions and head play in defence were revealed. With regard to 13-year-olds, indicators of the power of their work in the first 10 seconds do not have a relationship with all characteristics of the efficiency of defensive actions, and the last 10 seconds of jumping work are correlated with the EC of interceptions and head play in defence ($r = 0.57$ and $r = 0.54$, $p \leq 0.05$, respectively). In 14-year-old football players, the power of the first 10 seconds of work correlates with the EC of tackles and counterattacks ($r = 0.55$ and $r = 0.58$, $p \leq 0.05$, respectively), and the power of the last 10 seconds of work correlates with the EC of head play in defence and counteraction ($r = 0.48$, $p \leq 0.05$, $r = 0.70$, $p \leq 0.001$, in accordance).

The indicator of the power of the first 10 seconds of work in 15-year-old players has correlations with the EC of tackles ($r = 0.49$, $p \leq 0.05$), and the power of the last 10 seconds of work – with the EC of interceptions and head play in defence ($r = 0.52$, $r = 0.51$, $p \leq 0.05$, in accordance). It should be noted that the higher the power of the last 10 seconds of jumping work, the better are almost all indicators of the effectiveness of defensive actions of young football players. The index of decrease in jumping power is inversely proportionally correlated with all indicators of the effectiveness of defensive actions in 13- and 14-year-old athletes; the exception is the EC of head games in defence. As for 11-year-old players, the indicator of the decrease in their anaerobic power is negatively correlated with the EC of head play in defence ($r = -0.59$, $p \leq 0.05$). However, in 12-year-old athletes, this indicator correlates with the EC of countermeasures ($r = -0.58$, $p \leq 0.05$), and in 15-year-old athletes, only a weak connection of this component is observed with all indicators of the effectiveness of defensive actions.

The analysis of scientific and methodical literature shows that the improvement of children's football occurs due to the increase in requirements for all aspects of the training of young athletes (including tactical), as noted by A. Dulibskyi (2021). It has been established that only an optimal level of tactical preparation can ensure the achievement of high sports results (Ulderink *et al.*, 2017). Since the effectiveness of offensive and defensive actions is equal to achieving victory over the opponent, giving preference to attacking actions in terms of game organisation is not a rational approach. However, the majority of the attention of scientists and practitioners is directed to the search for ways to improve the attacking tactical actions of both qualified and young football players, as written by J.R. Tarragó *et al.* (2019).

In a general sense, the term "football tactics", as E. Valcárcel (2020) wrote, means the team's ability to use all its playing capabilities (technical, physical, psychological) with the greatest efficiency to achieve victory over a given specific opponent. It should be noted that the manifestation of physical capabilities is conditioned by the morpho-functional features of the human body. Taking into account the analysed theoretical data, one of the directions for improving tactical preparedness is the determination of the morpho-functional features of football players, which determine the quality of the performance of defensive tactical actions. According to trainers R. Schomann *et al.* (2014), for practicing sports within the framework of multi-year improvement, adolescence is considered the most favourable for basic and specialised training. Therefore, miscalculations made at the specified stages of preparation will exclude opportunities to make up for what was lost in the future. Agreeing with this statement, the authors conducted

research at the stages of preliminary and specialised basic training. M. Krespi *et al.* (2019) noted that when determining the characteristics that determine the effectiveness of defensive actions, both in young and in qualified football players, only the selection of the ball and its interception are taken into account. While monitoring the effectiveness of defensive actions, this article used a balanced assessment and covered the registration of countermeasures (driving, passes, strikes), which made it possible to expand the range of information received and increase its informativeness.

Specialists like K. Johnston & J. Baker (2020) paid considerable attention to morphological features, because in sports games, weight and height data are of great importance for the performance of certain game functions. Such indicators as the height and weight of an athlete are largely determined by heredity (body length – by 90-95%, body weight by 72-76%). The results of the research on the morphofunctional state of young football players carried out, in accordance with the set goal, are partially confirmed by the data of the literature. According to D. Bujnovky *et al.* (2019), the greatest increase in the length of the body in the standing position and the length of the lower limbs in young football players occurs from 11 to 12 and from 13 to 14 years. The same study showed a slight increase in the specified signs from 11 to 12 years, and a significant increase from 12 to 13, and from 13 to 14 years. Also, the largest increase in body weight and hip girth, which falls on this age period, has been established. According to A. Terzis (2020), in highly qualified football players, the efficiency of head play in defence is determined by the length of the body in a standing position, and the efficiency of interceptions is determined by the length of the lower limbs. The authors observed the same specificity of addictions in young football players based on the analysis of the data of this study, which indicates the high informativeness of these indicators in the process of orientation towards the performance of certain game functions.

N. Jayanthi *et al.* (2022) noted that the ability of athletes to perform long-term non-specific physical activity is determined by the level of the body's aerobic capacity (due to MOC) and is positively influenced by the improvement of specific components of playing skill. The correlation analysis performed by the authors confirmed the need for high indicators of MOC characteristics for the effective performance of protective actions. However, the data obtained in this study had a certain specificity. In particular, high correlation activity between the integral and separate EC of defensive actions and MOC indicators was found in all age groups, with the exception of 12-year-old football players. It was also established that with age the number of correlations decreases and their numerical values decrease. This indirectly indicates that with age and an increase in the level of special training, the role of anaerobic sources of energy supply increases. But according to the results of these studies, aerobic energy production and general endurance are leading to the effective performance of defensive actions by young football players.

In sports, effective competitive activity is also ensured by the ability to productively perform anaerobic work, as written by P. Kunz *et al.* (2019). The data obtained by the authors partially confirm this statement, but also indicate that at this age stage of the training of football players, anaerobic processes of energy supply are not exclusively decisive for effective defensive activity. Thus, only in young players aged 11 and 14, the strongest relationship between the indicators of absolute and relative anaerobic phosphagen capacity with individual indicators and integral EC of defensive actions was found. In 12-, 13-, and 15-year-old athletes, correlations of this indicator with individual EC of defensive actions are episodic. Also, a significantly higher correlation activity of the anaerobic power indicators of the last 10 seconds of work in the test and the index of its decrease than the first 10 seconds of jumping work was established. This indicates the importance of the capacity of anaerobic pathways of energy supply for the successful performance of protective actions. Therefore, this study demonstrated the predominant importance of aerobic energy production for the effective performance of defensive actions, but indirectly showed that as the level of playing skill increases and the intensity of competitive loads increases, the importance of anaerobic sources of energy supply will increase.

Conclusions

The conducted research made it possible to determine the specificity of the morpho-functional conditioning of the effectiveness of the defensive actions of young football players at the stages of preliminary and specialised basic training. The analysis of the age characteristics of the indicators of the effectiveness of defensive actions demonstrates the gradual formation of tactical skills in young football players in the period from 11 to 15 years. The investigated morphological features significantly increase from 12 to 13 and from 13 to 14 years ($p \leq 0.05$). The greatest increase in aerobic capacity (MOC) was noted from 13 to 14 years ($p \leq 0.05$). A significant increase in the indicators of anaerobic phosphagen power occurs from 12 to 13 and from 13 to 14 years ($p \leq 0.05$), and the indicators of relative anaerobic phosphagen power increase reliably from 11 to 12, from 13 to 14 and from 14 to 15 years ($p \leq 0.05$).

The established dependences of the effectiveness of defensive actions on the investigated morphological features must be used when determining the game functions of young football players and team selection. Thus, young football players with relatively high indicators of body length and lower limbs should be oriented to perform the functions of central defenders and midfielders due to the fact that it is in the middle part of the football field that interceptions and head plays in defence are most often performed, and the indicated morphological characteristics in young football players 11-15 years old, as confirmed in the course of research, determine their effectiveness. Young football players with relatively lower indicators of body length and lower limbs, and with a relatively larger hip girth, should be oriented to perform the functions of wing players due to the fact that on the wings, such a defensive action as ball retrieval is most often performed.

Reliable dependencies between aerobic and anaerobic capabilities, on the one hand, and the effectiveness of protective actions, on the other, determine the need for a balanced combination of aerobic and anaerobic exercises in the process of sports training. It can be argued that the ability of young athletes to maintain a high power of jumping work, which characterises the level of anaerobic capacity, is

related to their effective performance of protective actions. Prospects for further research are determined by the need to improve the system of complex control, taking into account the morpho-functional conditioning of the effectiveness of defensive tactical actions of young football players.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Antomonov, M., Korobeynikov, G., Khmelnitskaya, I., & Kharkovlyuk-Balakina, N. (2021). *Mathematical methods for processing and modelling the results of experimental studies*. Kyiv: Olympic Literature.
[2] Barrett, S., McLaren, S., Spears, I., Ward, P., & Weston, M. (2018). The influence of playing position and contextual factors on soccer players' match differential ratings of perceived exertion: A preliminary investigation. *Sports*, 6(1), article number 13. doi: 10.3390/sports6010013.
[3] Bujnovky, D., Maly, T., Ford, K.R., Sugimoto, D., Kunzmann, E., Hank, M., & Zahalka, F. (2019). Physical fitness characteristics of high-level youth football players: Influence of playing position. *Sports*, 7(2), article number 46. doi: 10.3390/sports7020046.
[4] Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/.
[5] Delgado, J.L., & Mendez Villanueva, J.A. (2018). *Tactical periodization – a proven successful training model*. London: Soccertutor.com Ltd.
[6] Dulibskyi, A. (2021). Organization of sports selection in the system of youth and professional English football. *Scientific Journal of Drahomanov Ukrainian State University. Series 15. Scientific and Pedagogical Problems of Physical Culture (Physical Culture and Sports)*, 6(137), 60-65. doi: 10.31392/NPU-nc.series15.2021.6(137).14.
[7] Jayanthi, N., Schley, S., Cumming, S.P., Myer, G.D., Saffel, H., Hartwig, T., & Gabbett, T.J. (2022). Developmental training model for the sport specialized youth athlete: A dynamic strategy for individualizing load-response during maturation. *Sports Health*, 14(1), 142-153. doi: 10.1177/19417381211056088.
[8] Johnston, K., & Baker, J. (2020). Waste reduction strategies: Factors affecting talent wastage and the efficacy of talent selection in sport. *Frontiers in Psychology*, 10, article number 2925. doi: 10.3389/fpsyg.2019.02925.
[9] King, P.J. (2018). *Expansive football. A game model: Positional play based game model for coaches*. New York: Independently Published.
[10] Krespi, M., Sporis, G., & Popovic, S. (2019). Exponential versus linear tapering in junior elite soccer players: Effects on physical match performance according to playing positions. *Montenegrin Journal of Sports Science and Medicine*, 8(1), 17-22. doi: 10.26773/mjssm.190303.
[11] Kunz, P., Engel, F.A., Holmberg, H.-C., & Sperlich, B. (2019). A meta-comparison of the effects of high-intensity interval training to those of small-sided games and other training protocols on parameters related to the physiology and performance of youth soccer players. *Sports Medicine – Open*, 5, article number 7. doi: 10.1186/s40798-019-0180-5.
[12] Lisenchuk, G., & Tyshchenko, V. (2019). Innovative technology in computer testing of psychomotor in team sports. *Science in Olympic Sport*, 1, 36-41. doi: 10.32652/olympic2019.1_5.
[13] Modric, T., Versic, S., & Sekulic, D. (2021). Relations of the weekly external training load indicators and running performances in professional soccer matches. *Sport Mont*, 19(1), 31-37. doi: 10.26773/smj.210202.
[14] Nikolaienko, V., Maksymchuk, B., Donets, I., Oksom, P., Verbyn, N., Shemchuk, V., & Maksymchuk, I. (2021). Cycles of training sessions and competitions of youth football players. *Revista Românească pentru Educație Multidimensională*, 13(2), 423-441. doi: 10.18662/rrem/13.2/429.
[15] Oliveira, R., Martins, A., Moreno-Villanueva, A., Brito, J.P., Nalha, M., Rico-Gonzalez, M., & Clemente, F.M. (2022). Reference values for external and internal training intensity monitoring in professional male soccer players: A systematic review. *International Journal of Sports Science & Coaching*, 17(6), 1506-1530. doi: 10.1177/17479541211072966.
[16] Roberts, A.H., Greenwood, D.A., Stanley, M., Humberstone, C., Iredale, F., & Raynor, A. (2019). Coach knowledge in talent identification: A systematic review and meta-synthesis. *Journal of Science and Medicine in Sport*, 22(10), 1163-1172. doi: 10.1016/j.jsams.2019.05.008.
[17] Sarmento, H., Clemente, F.M., Araújo, D., Davids, K., McRobert, A., & Figueiredo, A. (2018). What performance analysts need to know about research trends in association football (2012-2016): A systematic review. *Sports Medicine*, 48, 799-836. doi: 10.1007/s40279-017-0836-6.
[18] Schomann, P., Bode, G., & Vieth, N. (2014). *Children's football: Training with concept 1*. Münster: Philippka.
[19] Stepanenko, V., & Pogrebnyi, V. (2022). Age features of indicators of efficiency of defensive tactical actions of young football players of 11-15 years. *Scientific Journal of Drahomanov Ukrainian State University. Series 15. Scientific and Pedagogical Problems of Physical Culture (Physical Culture and Sports)*, 6(151), 150-154. doi: 10.31392/NPU-nc.series15.2022.6(151).32.
[20] Tarragó, J.R., Massafred-Marimón, M., Seirullo, F., & Cos, F. (2019). Training in team sports: Structured training in the FCB. *Apunts Educación Física y Deportes*, 137, 103-114. doi: 10.5672/apunts.2014-0983.es.(2019/3).137.08.
[21] Terzis, A. (2020). *Diego Simeone defending tactics – tactical analysis and sessions from Atlético Madrid's 4-4-2*. London: Soccertutor.com Ltd.

[22] Ulderink, A., Mariman, H., & Berger, H. (2017). *Dutch academy football coaching (U14-15) – functional training & tactical practices from top Dutch coaches*. London: Soccertutor.com Ltd.
[23] Valcárcel, E. (2020). *Spanish football federation coaching program U9-12*. London: Soccertutor.com Ltd.

Морфофункціональна обумовленість ефективності захисних дій юних футболістів на етапах попередньої та спеціалізованої базової підготовки

Володимир Степаненко

Кандидат наук з фізичного виховання і спорту, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0003-1653-2426

Віктор Погребний

Старший викладач
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0001-6374-5817

Андрій Капелян

Аспірант
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0009-0004-0986-5163

Анотація. Актуальною є необхідність достатнього рівня функціональної підготовленості та впливу окремих морфологічних ознак на ефективність тактичних дій. Оскільки засвоєння та удосконалення тактичної діяльності відбувається на етапах попередньої та спеціалізованої базової підготовки (11-13 та 13-15 років), визначення морфофункціональної обумовленості ефективності виконання захисних дій юними футболістами дозволить вдосконалити процес їх тактичної підготовки. Мета дослідження – визначити взаємозв'язок морфофункціональних особливостей з ефективністю виконання захисних дій юними футболістами на етапах попередньої та спеціалізованої базової підготовки. Рівень функціональних можливостей визначено непрямими методами: аеробні – за показниками частоти серцевих скорочень після виконання стандартного 5-хвилинного навантаження; анаеробні – за показниками стрибкової ергометрії. У всіх групах встановлено достовірні зв'язки між довжиною тіла в положення стоячи та коефіцієнтом ефективності гри головою у захисті. Виявлено високі значення коефіцієнтів кореляції між показниками довжини нижніх кінцівок та коефіцієнтом ефективності перехоплень (окрім 12-річних). Встановлено наявність статистично значущих взаємозв'язків між усіма характеристиками ефективності дій у захисті та аеробними можливостями юних спортсменів. Виявлено, що у віці 14 років показники абсолютної анаеробної фосфагенної потужності значуще корелюють із коефіцієнтами ефективності перехоплень, гри головою в захисті та протидій. Визначено, що ефективність дій у захисті пов'язана зі спроможністю підтримувати високу потужність стрибкової роботи, яка характеризує анаеробну ємність. Встановлені залежності ефективності захисних дій від досліджуваних морфологічних ознак і функціональних характеристик мають використовуватися тренерами дитячо-юнацьких футбольних команд при визначенні схильності юних футболістів на виконання певних тактичних функцій, комплектуванні команд та раціональному застосуванні тренувань різної (аеробної й анаеробної) спрямованості

Ключові слова: аеробні можливості; анаеробні можливості; вікові зміни; кореляційний аналіз; морфологічні ознаки

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 11.07.2024. Revised: 01.11.2024. Accepted: 12.12.2024

UDC 796.046.6

DOI: 10.69587/tppcs/2.2024.45

Muscle strength training plan optimisation for weightlifters

Taras Dutko*

Honoured Master of Sport, Honoured Worker of Physical Culture and Sport, Associate Professor
Ukrainian State University of Science and Technology
49000, 2 Lazarian Str., Dnipro, Ukraine
https://orcid.org/0000-0002-1390-7889

Abstract. Improvement of muscle strength is a critical aspect for weightlifting athletes, as it directly affects the performance of key competitive exercises, such as the snatch and clean and jerk, which are crucial for achieving high performance in this sport. The study aimed to develop and substantiate an optimised training plan for increasing muscle strength in weightlifters and compare its effectiveness with a standard programme. The research methodology included analysis of existing training plans, development of an adaptive plan based on modern principles of periodisation, and experimental comparison of the dynamics of strength indicators in two groups of athletes. Statistical analysis methods were used to assess the reliability of the results. The results demonstrated that the group that trained according to the optimised plan showed a more significant increase in strength performance in the snatch (15%), clean and jerk (14%) and bench press (12%) compared to the standard programme (7%, 8% and 6% respectively). In addition, the athletes who used the optimised plan demonstrated a steady increase in performance throughout the training cycle, while the group with the standard programme saw a significant decrease in progress after the third month. The study also determined that the number of injuries in the group with the optimised plan was significantly lower due to the control of exercise technique and the proper organisation of recovery periods. The study confirmed that the use of an adaptive approach that incorporates the individual characteristics of athletes and the variability of loads contributes to a more pronounced progress in the development of muscle strength. The practical significance of the study is determined by the possibility of implementing the proposed methodology to improve the effectiveness of the training process in weightlifting, for athletes of different levels of training

Keywords: snatch; clean and jerk; press; physical activity; adaptive periodisation

Introduction

To achieve high sporting results in weightlifting, it is necessary to ensure the systematic development of muscle strength using structured programmes that account for the specifics of competitive movements, individual characteristics of athletes and the body's adaptation to high physical exertion. Effective training planning contributes to optimal strength development, reduces the risk of injury and increases athletes' competitiveness. However, despite the existence of standard programmes their effectiveness may vary depending on the individual characteristics of athletes. This necessitates the development of optimised training plans based on modern scientific approaches and considering innovative techniques. Muscle strength development is a complex process that involves neuromuscular adaptation, the development of muscle hypertrophy and the optimisation of motor skills. Traditional training programmes for weightlifters are mostly based on the principles of progressive overload, periodisation and integration of general and specialised physical training. However, there are differences in the choice of intensity, frequency and volume of loads, which can affect the final result. Modern research also emphasises the importance of individualising training, highlighting the physiological, biomechanical and psycho-emotional characteristics of athletes. For instance, approaches such as block periodisation or non-linear periodisation were noted to provide positive results in other sports, but their implementation in weightlifting requires further study.

At the international level, various sports organisations, such as the International Weightlifting Federation and the International Olympic Committee, are actively promoting the development of training methodology. The International Weightlifting Federation offers recommendations on the use of innovative approaches, such as the use of load monitoring technologies, force sensors and platforms for analysing athletes' movements. Such tools can track performance and adapt training plans depending on the athlete's physical

Suggested Citation: Dutko, T. (2024). Muscle strength training plan optimisation for weightlifters. *Theory and Practice of Physical Culture and Sports*, 3(2), 45-54. doi: 10.69587/tppcs/2.2024.45.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

condition. In addition, international scientific conferences, such as the Congress of the European Federation of Sport and Health Science, provide a platform for the exchange of best practices in training programme planning. These events discuss the latest research in physiology, biomechanics and sports medicine, which can form the basis for improving training programmes. At the current stage of development of sports science, biofeedback technologies are gaining popularity, allowing real-time assessment of exercise performance. Another promising area is the introduction of virtual reality technologies to simulate competitive conditions, which increases the psychological preparedness of athletes. Modern approaches also address the importance of an interdisciplinary approach, where training programmes are developed with the participation of coaches, physiologists, nutritionists and sports psychologists.

T.J. Suchomel *et al.* (2018) emphasised the importance of muscle strength in sports activities and the need to incorporate specific aspects into training programmes. The study noted that an individualised approach to training planning, addressing the specific needs of the athlete, is a key factor in achieving maximum results. According to P. Androulakis-Korakakis *et al.* (2021), the minimum effective training load is an important aspect of increasing the maximum strength (1RM – one repetition maximum, one-rep max) in athletes with training experience. This systematic assessment determined the smallest amount of training stimuli required to achieve significant results, making it extremely relevant for creating effective and cost-efficient programmes. P. Androulakis-Korakakis *et al.* (2021) expanded the understanding of the minimum effective load by investigating its effect on powerlifters. They concluded that the use of reasonable load dosages can achieve significant progress in strength performance even with limited training time.

I. Sandau & U. Granacher (2023) analysed how optimal lever force and velocity profiles can maximise performance in weightlifting exercises. The study emphasised the importance of properly adjusting these parameters to improve the efficiency of weightlifting. This study emphasised that it is important to consider the relationship between strength and speed to achieve the best results in strength exercises. D.-C. Yeom *et al.* (2023) analysed the effects of low-load, high-repetition training on maximal muscle strength and muscle tissue damage in elite weightlifters. The researchers determined that this methodology allows for achieving significant results in strength indicators while minimising the risk of injury, which is especially important for high-level competitions. H. Arazi *et al.* (2021) investigated how different series configurations in resistance training affect strength adaptation and muscle performance in powerlifters. The study concluded that varying the duration of rest between sets and the number of repetitions can significantly affect strength and power levels. V.M. Zatsiorsky *et al.* (2020) systematised the basics of the science of strength training, emphasising the key principles for building successful programmes. The study emphasised the importance of periodisation, accounting for the specifics of movements and biomechanical characteristics of athletes. It provided a theoretical basis for optimising training plans.

Despite significant progress in the study of training methods, gaps remain in the adaptation of existing standard programmes to the individual needs of athletes and the integration of innovative approaches into the structure of training plans. The study aimed to optimise a training plan for improving muscle strength in weightlifters based on modern methods and compare its effectiveness with existing standard programmes. The objectives of the study were to analyse the effectiveness of training programmes in weightlifting, to develop an optimised plan accounting for innovative approaches and individual characteristics of athletes, and to conduct a comparative analysis of muscle strength indicators between groups that trained according to standard and optimised plans to determine their effectiveness.

Materials and Methods

Data from open sources, including the official training plan of the Weightlifting Federation of Ukraine (Oleshko *et al.*, 2018) and the results of scientific publications on the topic of optimisation of training programmes, were analysed. Based on the data from Table 1, scientifically based criteria for training periodisation, strength development techniques, and optimisation of technical aspects were used to develop the optimised plan, based on the individual needs of athletes.

Table 1. Structure of a standard weightlifting training plan

Training component	Content	Frequency	Aim
Warm-up	Dynamic stretching, light aerobic exercises (running, jumping, swinging)	Daily, 10-15 minutes	Preparing muscles and joints for exercise
Basic exercises	Jerk, push, their variations	3-4 training sessions/week	Developing technique and strength indicators
Auxiliary exercises	Squats, deadlift, bench press, waist press, back exercises	2-3 training sessions/week	Development of core strength, support of motor chains
Specialised exercises	Speed exercises (jumps, kettlebell swings, plyometric exercises)	1-2 training sessions/week	Improved speed and power performance
Work on weaknesses	Specialised exercises to address individual technical or physical weaknesses (e.g., correction of jerk technique)	2-3 training sessions/week	Correction of technical and physical deficiencies
Restoration	Passive and active recovery, stretching, massage, recovery exercises	Daily, 15-30 minutes	Reduction in fatigue, prevention of injuries and overwork
Physical fitness	Exercises to develop endurance and explosive strength (jumps, sprints)	1-2 training sessions/week	Improving overall physical fitness
Psychological preparation	Development of mental state, concentration training	1-2 training sessions/week	Increase mental stability, concentration

Source: compiled by the author based on V. Oleshko *et al.* (2018)

The sources used in the development include works on neuromuscular adaptation and performance improvement in strength sports. In addition, the recommendations of leading researchers in the field of sports science were incorporated, which was used to form a theoretical model of an optimised training plan. The study was based on a comparison of muscle strength indicators in 40 male athletes aged 18-30 years with at least three years of weightlifting training experience. For 12 weeks in 2024, the indicators were recorded and subsequently compared. The participants were divided into two equal groups: the first trained according to the standard plan of the Weightlifting Federation of Ukraine, and the second – according to the optimised plan developed within the study. The sample included athletes without chronic injuries or diseases that could affect exercise performance, provided they voluntarily agreed to participate. This sampling approach ensured the homogeneity of the groups and minimised the influence of extraneous factors on the results. In addition, the study complied with ethical standards, including the principles of voluntary and informed consent of participants, confidentiality of their data, risk minimisation and safety (The Declaration of Helsinki, 2013). Integrity in the use and analysis of the results was also ensured, as well as homogeneity of the sample to minimise extraneous factors. The optimised training plan was developed addressing modern research in the field of sports science (Suchomel *et al*., 2018; Androulakis-Korakakis *et al*., 2021).

The analysis method was used to examine the structure of the standard training plan and consider its strengths and weaknesses. The effectiveness of the training plans was assessed using statistical methods such as descriptive statistics, comparison of means (*t* test) and analysis of variation (ANOVA) to identify significant differences between the groups. These methods were used to assess the effect of different approaches on athletes' muscle strength. The synthesis method was used to combine the knowledge gained to create a theoretical model of an optimised training plan that covers the individual needs of weightlifters. The methods of induction and deduction were used to draw logical conclusions about the impact of different training approaches on muscle strength growth. Induction helped to summarise the data from individual studies, while deduction assessed the effect of the optimised plan. Generalisation and systematisation were used to draw clear conclusions about the benefits of the proposed approach.

Results and Discussion

Development and structure of an optimised training plan

The optimised plan is based on the principles of periodisation, load variability, and gradual progression, and focuses on the optimal ratio of load and recovery. The training process was divided into three phases. The first phase was the preparatory phase, which lasted 4 weeks. This phase focused on general physical fitness, strengthening stabilising muscles and building endurance. The intensity was 60-70% of the 1RM. Multiple repetitions were used (4-6 sets of 12-15 repetitions). This stage was used to create a solid base for further increasing loads while minimising the risk of injury. The main phase lasted 6 weeks. The key focus was on developing maximum strength and power. The intensity varied from 75% to 90% of the 1RM. A total of 4-5 sets of 6-8 repetitions in basic exercises (squat, deadlift, bench press, clean and jerk) was done. High intensity and medium volume of training contribute to increased neuromuscular adaptation and muscle strength. The competition phase lasted for 2 weeks. The focus shifted to weightlifting-specific movements with an emphasis on technique and explosive power. The intensity was 85-95% of the 1RM, the number of sets was 3-4 with 2-4 repetitions. The final stage of training helps to maximise strength potential before competitions. Each stage of the training process has a clear scientific rationale and a defined goal, which contributes to the gradual progress in the development of muscle strength (Table 2).

Table 2. Structure of an optimised training plan to improve muscle strength in weightlifters

Training phase	Duration	Intensity (from 1RM)	Number of approaches	Number of repetitions	Basic exercises	Objectives and rationale
Preparatory phase	4 weeks	60-70%	4-6	12-15	Squat, deadlift, bench press, pull-ups, press	Development of basic endurance, strengthening of stabilising muscles, minimisation of injuries
The main phase	6 weeks	75-90%	4-5	6-8	Squat, deadlift, bench press, clean and jerk	Development of maximum strength and power, neuromuscular adaptation, and performance improvement
Competitive phase	2 weeks	85-95%	3-4	2-4	Jerk, push, and squat with a heavy load	Optimisation of technique, explosive power, and preparation for competitions
Recovery (period between phases)	2-3 times a week	Light activity	-	-	Light cardio, stretching, massage	Reducing fatigue, preventing injuries, and maintaining muscle and joint mobility

Source: compiled by the author based on T.J. Suchomel *et al*. (2018), P. Androulakis-Korakakis *et al*. (2021)

To optimise the progress, the intensity of the exercises varied depending on the training phase, ensuring the gradual increase in workload without overworking. The plan included both basic exercises for all major muscle groups and auxiliary exercises to develop problem areas (e.g., pull-ups, Romanian deadlifts, front squats). Total number of exercises: 6-8 per workout. Training frequency: 4-5 times a week. The use of different tempos, exercise variations and training methods (e.g., cluster approaches or pyramidal loading) helps to avoid plateauing in strength development. The plan included mandatory recovery days, which are critical to ensure maximum progress and prevent overuse. Active recovery days were held 2-3 times a week and included light cardio (e.g., running, cycling or swimming)

and stretching to improve flexibility and circulation, which helps reduce muscle soreness and speed recovery. The periodicity of recovery and rest helps to minimise the risk of injury, optimises adaptation to exertion and contributes to overall performance improvement. Nutritional recommendations emphasise the provision of adequate energy for recovery, as well as the importance of sleep to maximise performance and muscle regeneration. The balance between exertion and recovery is key to long-term progress and injury prevention. The plan is based on the principles of muscle adaptation to a gradual increase in load (Zatsiorsky *et al.*, 2020). The proposed structure can increase the efficiency of the training process compared to the standard plan of the Ukrainian Weightlifting Federation (n.d.). High intensity and variability of exercises in proposed plan can stimulate maximum strength gains, while sufficient rest minimises the risk of injury and fatigue.

Comparative analysis of the effectiveness of training plans

To substantiate the effectiveness of the developed optimised training plan, a detailed comparative analysis of muscle strength indicators between two groups of athletes was conducted. The first group used a standard training plan approved by the Ukrainian Weightlifting Federation (n.d.). This programme is based on traditional approaches to periodisation, which include successive phases of volume, intensity and recovery. In the preparatory phase, the intensity and volume of exercises were reduced to develop basic endurance. In the main phase, the intensity increased to develop maximum strength. The competitive phase focused on technical improvement with high intensity and short volume of exercises. The second group trained based on an optimised plan that was tailored to modern scientific approaches to the training process, individual characteristics of athletes and new methods of adaptation of loads. The comparative analysis of the two plans involved assessing the effectiveness of training loads, recovery intervals and optimising periodisation to achieve results.

In the traditional approach, there is a clear distinction between phases, allowing for a gradual increase in intensity and volume, depending on the fitness of the athletes, while the optimised plan integrates individual parameters and modern scientific recommendations, allowing for flexible adjustment of the load and recovery. An important advantage of an optimised plan is the individualisation of training, which allows for more effective consideration of the biological and physiological characteristics of each athlete. Compared to the traditional approach, where recovery periods can be standardised for everyone, the optimised plan allows for a more precise determination of the optimal recovery intervals, which ensures better adaptation and stability of results (Table 3).

Table 3. Comparison of the effectiveness of standard and optimised training plans in weightlifting

Criteria	Standard plan	Optimised plan
Average strength gain (snatch, clean and jerk, press)	7% (snatch), 8% (clean and jerk), 6% (press)	15% (snatch), 14% (clean and jerk), 12% (press)
Intensity of progress during the cycle	Decreases after the third month	Steady progress throughout the cycle
Frequency of injuries	Higher (three times as many injuries)	Lower costs thanks to adaptive monitoring
Phase structure	Distinct phases, but common to all athletes	Individually customisable phases
Incorporating restorative practices	Minimal attention to recovery, standard intervals	Structured recovery with active and passive methods

Source: compiled by the author based on Ukrainian Weightlifting Federation (n.d.)

The results of the comparison showed that the group that trained according to the standard programme demonstrated an average increase in the maximum strength indicator (1RM) by 7%. This result is in line with previous studies showing that traditional methods provide moderate progress due to the gradual increase in loads and the maintenance of the stability of the training process (Garhammer, 2020). At the same time, the second group, which trained according to the developed optimised plan, achieved an average increase in 1RM of 15%. This significant improvement confirms the effectiveness of using an individualised approach and adaptive periodisation (Comfort *et al.*, 2023). One of the key differences of the optimised plan is the use of adaptive intensity, which addresses the current physiological state of athletes. According to preliminary data, this approach minimises the risk of overwork and ensures effective recovery, which is especially relevant for high-level weightlifters (Kirichenko, 2021). In this study, intensity adaptation was carried out based on regular testing of the state of muscle strength of athletes, which ensured their readiness for a gradual increase in loads. An additional element of the optimised plan was the introduction of special techniques for controlling exercise technique, as it has been confirmed that proper technique reduces the risk of injury and promotes greater strength gains (Hermassi *et al.*, 2019). In the present study, this aspect was integrated into each phase of training, which reduced the number of injuries in the second group to a minimum. It is also worth noting that the optimised plan included structured recovery periods that alternated with phases of increased loads. This made it possible to use the principle of supercompensation more effectively (Comfort *et al.*, 2023). As a result, the athletes of the second group demonstrated better recovery indicators and a stable increase in performance throughout the training cycle. The obtained data indicate significant advantages of the optimised training plan over the standard programme of the Weightlifting Federation of Ukraine. Due to the combination of adaptive periodisation, individualisation of loads, control of technique and organisation of recovery phases, a significant increase in muscle strength in athletes of the second group was noted. These results can be used to further improve training programmes and increase the efficiency of weightlifters' training.

Factors affecting progress in muscle strength development

The development of muscle strength is a complex process that depends on many factors, including the type of training, intensity of exercise, level of training and individual characteristics. The main goal of muscle strength training is to increase the ability of muscles to perform physical activities at maximum loads, as well as to optimise neuromuscular coordination to achieve effective results. Proper exercise technique is an important aspect, as even the strongest athletes can face progression limitations if they do not follow the correct technique. To maximise progress in developing muscle strength, training programmes that include not only weightlifting but also other types of physical activity should be used. Combination training, which combines different types of exercise, such as weightlifting, plyometric and ballistic exercises, can improve results. Plyometric exercises, which involve rapid stretching and contractions of the muscles, activate the elastic mechanisms of the muscle fibres, improving their reactivity and strength. Ballistic exercises, which involve fast, explosive movements, stimulate the development of maximum strength and improve the overall power of muscle groups. At the same time, such combined training helps to develop various physiological systems, including the nervous system, which leads to more comprehensive adaptations and improved strength performance (James *et al.*, 2018). An important aspect of achieving progress is the level of training of athletes. Athletes with a higher level of initial strength can adapt more quickly to complex training programmes that include heavy loads and a variety of technical exercises. Their bodies have a greater potential for adaptation, as their muscles and nervous system already have a basic level of development that can handle more intense programmes. For beginners in weightlifting, on the contrary, it is important to start with basic training programmes that gradually build strength and technique without the risk of injury.

Tailoring training programmes is an important element in achieving maximum effectiveness. For athletes whose activities require high technical skill and stability, it is necessary to include exercises that promote balance and coordination. One of the most effective methods is to use single-arm variations of weightlifting and powerlifting to help strengthen stabilising muscles and reduce the risk of injury. This is especially relevant for athletes involved in dance or other sports where stability and balance are key to performing complex movements (Pistilli *et al.*, 2021). Despite the variety of approaches to training, to achieve maximum results, scientifically sound methods must be applied. The choice of an optimal training strategy should address the individual characteristics of each athlete, their level of fitness and the specifics of their sport. For instance, for athletes involved in weightlifting at a high level, methods aimed at maximising neuromuscular adaptations are important. Such methods can include both strength training with heavy weights and exercises to develop speed and power. The combination of these elements allows to achieve high results and maximise progress in the development of muscle strength (Duchateau *et al.*, 2021). Thus, to achieve sustainable progress in the development of muscle strength, it is necessary to combine a variety of training methods, apply an individual approach and consider the athlete's level of training. Only through a variety of training programmes that include weightlifting, plyometrics, ballistics and stabilisation exercises can optimally result in sustainable strength development.

Dynamics of progress in the development of muscle strength

The dynamics of changes in power indicators (press, snatch, clean and jerk) were analysed throughout the study period for both groups. In the group that trained according to the standard plan of the Weightlifting Federation of Ukraine, there was a gradual, but less pronounced increase in strength indicators in all exercises. The average weight increase in the snatch was 7%, in the clean and jerk – 8%, and in the press – 6%. Instead, the group that used the optimised training plan demonstrated a more significant increase in strength performance. During the study, the average increase in the snatch was 15%, in the clean and jerk – 14%, and in the press – 12%. This indicates the effectiveness of an individualised approach, the use of variable loads and adaptive periodisation. The graphs below show that the group with the optimised training plan achieved better results in all periods of the study (Fig. 1).

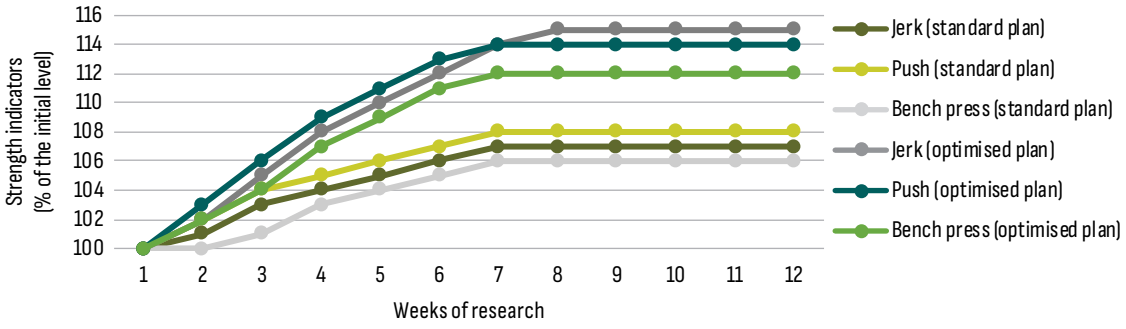

Figure 1. Dynamics of changes in strength indicators (snatch, clean and jerk, press)
Source: compiled by the author based on data analysis of Ukrainian Weightlifting Federation (n.d.)

More stable gains were achieved, without the significant drops in progress evident in the group that trained according to the standard plan. The intensity of progress in the first group began to decline after the third month, which is determined by the lack of adaptation of the training plan to the current physiological capabilities of the

athletes. In the second group, due to regular monitoring of progress and correction of loads, the growth of indicators continued until the end of the study. The contrast was particularly marked during the competition phase. The standard plan group stabilised, while the optimised plan group showed further growth, which significantly improved performance in a competitive environment. The group that trained based on the optimised plan demonstrates a stable and significant increase in all indicators, especially in the main and competitive phases. In contrast, the group with the standard plan made much slower progress, with a noticeable decrease in the rate of increase after the third month. Thus, the results confirm that the use of innovative training methods contributes to faster and more pronounced progress in the development of muscle strength.

The impact of an optimised training plan on recovery and injury prevention

The optimised training plan developed in this study demonstrated significant benefits in terms of the quality of athletes' recovery and reduction in the frequency of injuries. In the process of implementing this plan, a key aspect was the combination of adaptive intensity and structured rest phases, which reduced the physiological load on athletes and optimised their recovery after training (Laakso, 2021). An important element of the plan was to address the individual needs of the athletes when planning their workload. Regular monitoring of the athletes' condition, including assessment of their level of fatigue and risk of overload, allowed for timely adjustments to the intensity of training. This approach contributed to a significant reduction in the number of injuries in the group that trained according to the optimised plan (Huebner *et al*., 2022).

Periods of active recovery, including light exercise, stretching and recovery procedures, were integrated into the training cycle. These methods are known to improve blood circulation in the muscles and reduce muscle tension, which contributes to faster tissue regeneration (Bompa & Buzzichelli, 2022). As a result, the athletes in the optimised plan group showed fewer complaints of muscle discomfort compared to the standard programme group. The proposed plan also included specialised training days with a focus on technical training. This minimised the risk of injuries associated with poor technique in complex exercises such as the snatch and clean and jerk. Studies show that improving technical skills can significantly reduce the possibility of injury (Bernárdez-Vázquez *et al*., 2022). The individualisation of loads within the optimised plan was based on a multifactorial approach that addressed both the physiological and psycho-emotional aspects of athletes' training. This mitigates excessive stress and ensures a more balanced adaptation of the body to physical activity (Travis *et al*., 2020b).

The injury rate was three times higher in the group that trained according to the standard plan than in the group with the optimised approach. This confirms the importance of integrating modern techniques aimed at customising the training process. Recovery also included nutritional aspects, which are an important component in preventing fatigue and accelerating regeneration. The athletes' diets were adapted to match their energy expenditure, which ensured rapid replenishment of glycogen stores and increased resistance of muscle tissue to stress (Bompa & Buzzichelli, 2022). The performance of athletes in the second group shows that the structured alternation of loads and recovery contributed not only to reducing the risk of injury but also to the overall improvement of physical condition. This emphasises the need for an integrated approach to the training process that addresses physiological, technical and psychological aspects of training. The results of the study confirmed that the use of adaptive techniques can not only improve the recovery of athletes but also optimise their preparation for competitive conditions. The proposed plan can be recommended for implementation in the training process of weightlifters, as it contributes to the achievement of high results with minimal risk of injury.

Statistical confirmation of the results

To substantiate the obtained results, a statistical analysis of changes in strength indicators (press, snatch, clean and jerk) between the groups that trained according to the standard and optimised plans was conducted. The main criteria for the analysis were mean values, standard deviations, and testing the statistical significance of differences. This approach is based on the methods of monitoring and adjusting training intensity recommended by T.J. Suchomel *et al*. (2021). The mean values of the increase in maximum strength in the group that trained according to the optimised plan were significantly higher than those of the standard group. For the bench press, the average increase was 12% (±2.1) in the optimised group versus 5% (±1.9) in the standard group. In the snatch, these figures were 14% (±2.3) versus 6% (±2), and in the clean and jerk – 15% (±2.2) versus 7% (±2.1). These data confirm the advantage of an individual approach to load periodisation (Xiang *et al*., 2020). The values of standard deviations in the standard group indicate a greater variability of results, which indicates that the plan is not sufficiently tailored to the individual characteristics of athletes. An additional analysis of the distribution of strength gains among participants showed that in the optimised plan group, 85% of athletes achieved gains of more than 10%, while in the standard group, only 40% did so. This is in line with the findings of G. Slater & L. Mitchell (2019), who emphasised the importance of combining training variables to achieve consistent results in strength sports.

Descriptive statistics were used in the study for statistical analysis to calculate the mean values and standard deviations of changes in strength indicators such as the bench press, snatch and clean and jerk. To test the statistical significance of the difference between the groups in these indicators, a paired samples *t* test was used, which showed that the strength gains in the group that trained according to the optimised plan were significantly higher: for the bench press 12% (±2.1) vs. 5% (±1.9), for the snatch 14% (±2.3) vs. 6% (±2.0), and the clean and jerk 15% (±2.2) vs. 7% (±2.1). In addition, the ANOVA was used to assess the dynamics of changes in strength indicators throughout the training cycle, confirming that the group with the optimised plan showed a steady increase in results without significant declines observed in the standard group, especially after the third month.

The asymmetry of loads and the stability of results among participants was an important aspect of the analysis. Proper adaptation of loads allows not only to increase strength performance but also to reduce muscle imbalance

(Hammami *et al*., 2023). In the present study, the group with the optimised plan demonstrated a lower level of asymmetry during the performance of snatches and push-ups, which indicates a more effective impact of the programme. The analysis also demonstrated that the optimised plan contributed to a better adaptation of athletes to the loads due to the integration of recovery phases and individual control over the technique. This correlates with the recommendations of S. Kaabi *et al*. (2022) regarding the importance of an optimal combination of strength and technical aspects of the training process. Thus, the statistical analysis confirmed that the proposed optimised training plan provides a significantly greater increase in strength indicators, stability of results and adaptation of athletes to high loads compared to the standard approach. These data confirm the effectiveness of modern adaptive approaches in weightlifting.

The effectiveness of an optimised training plan: Analysis of the results

The results of the study demonstrated the significant effectiveness of the optimised training plan in comparison with the standard approach approved by the Weightlifting Federation of Ukraine. The proposed methodology, which includes adaptive periodisation, individualisation of loads, regular monitoring of athletes' condition and structured recovery phases, not only provided a significant increase in strength performance but also significantly reduced the risk of injury. The study evaluated the effectiveness of the developed optimised training plan in comparison with the results of previous scientific works.

J. Garhammer (2020) emphasised that the effectiveness of training programmes depends on a well-defined structure of periodisation and consideration of the individual characteristics of athletes. This is consistent with the results of the present study, where the optimised plan provided for a progressive change in loads, which ensured better adaptation of the body to the training process. According to P. Comfort *et al*. (2023), the integration of intensity control methods in strength training programmes helps maximise sports achievements. The developed plan used methods of gradually increasing the intensity of exercises, which, according to the data obtained, ensured a stable increase in muscle strength. This approach proved to be more effective than the standard plan of the Ukrainian Weightlifting Federation, where intensity control was less systematic.

According to T. Kirichenko (2021), the use of optimised training plans can significantly improve strength indicators in women engaged in powerlifting. The present study confirmed the effectiveness of an adaptive approach to the periodisation and volume of training for both men and women, which indicates the universality of the proposed methodology. S. Hermassi *et al*. (2019) noted that strength training, which includes a set of exercises with different intensities, has a positive effect on physical indicators such as muscle volume and maximum strength. In the context of this study, the use of methods such as variable resistance exercises demonstrated similar results, particularly in terms of improving strength and speed. The authors also confirmed that athletes' motivation is a key factor in achieving high performance. In this study, regular monitoring of progress helped to increase motivation, which had a positive impact on the results.

L. James *et al*. (2018) highlighted that the combination of weight training with plyometric exercises contributes to better adaptation of athletes to increased loads. The optimised training plan included plyometric elements at the main stages, which allowed for achieving faster results compared to traditional approaches. In an analysis of other aspects of training process optimisation, E. Pistilli *et al*. (2021) noted that the inclusion of unilateral variations of exercises in strength training contributes to the stability of athletes, especially among those involved in specific sports. Within the framework of the present study, the use of such approaches allowed to improvement of the indicators of symmetry of force in weightlifters, which confirms the effectiveness of the developed plan.

J. Duchateau *et al*. (2021) emphasised the importance of integrating strategies to maximise neuromuscular performance, such as complex exercises and periodisation. The study confirmed that such approaches provide more stable progress in the development of muscle strength. According to L. Laakso (2021), the effectiveness of the training process increases significantly when verbal communication between the coach and the athlete is optimised. This is consistent with the results obtained since the optimised plan focused on explaining the technical aspects of exercise performance, which helped to reduce the risk of injury and improve results. T.O. Bompa & C. Buzzichelli (2022) noted that proper periodisation is a key factor in achieving maximum performance in sports. This directly correlates with the findings of this study, where the structure of the optimised plan was based on periodisation, which ensured a progressive increase in loads and adaptation of the athletes' bodies.

According to M. Huebner *et al*. (2022), weightlifting masters often use a combination of training practices, including weight training and general physical fitness. The present study also demonstrated the effectiveness of integrating various techniques within a single plan, which contributed to the harmonious development of strength and endurance of athletes. R. Bernárdez-Vázquez *et al*. (2022) demonstrated that the optimisation of strength training parameters, such as volume, intensity and frequency, is an important factor in achieving muscle hypertrophy. The study also used similar principles, including volume and periodisation, which led to an increase in muscle strength. According to S.K. Travis *et al*. (2020b), the use of load phasing, particularly the reduction of intensity before peak competition (the so-called tapering), contributes to the achievement of maximum strength performance. The optimised plan of this study included a similar approach to periodisation, which ensured proper adaptation of athletes to the increase in load. According to Y. Xiang *et al*. (2020), the optimisation of multivariate models that consider dynamic strength helps to predict maximum performance during weightlifting training. The developed plan was also based on a multifactorial approach that considers the individual characteristics of athletes to ensure maximum progress.

T.J. Suchomel *et al*. (2021) emphasised the importance of monitoring and adjusting training intensity to ensure sustainable progress. Similarly, in the present study, the use of an adaptive approach to intensity avoided a plateau in muscle strength development. S. Kaabi *et al*. (2022) concluded that weightlifting training is more effective than plyometric training in improving strength, jumping and

directional changes in junior athletes. This study confirmed that the use of weightlifting exercises in training programmes has significant benefits for the development of physical qualities. According to R. Hammami *et al.* (2023), the use of unstable training contributes to the development of physical qualities and the reduction of lower limb asymmetry in younger athletes. The optimised plan also included exercises aimed at balance and stability, which allowed to achieve harmonious development of muscle strength.

J.W. Evans (2019) and B. Schoenfeld *et al.* (2021) emphasised the importance of a periodised approach to training to achieve maximum results in muscle hypertrophy and strength performance. Periodisation can effectively structure the load, preventing plateaus in progress and helping the body to adapt to increasing demands. The present study also used an adaptive periodised approach, which provided a stable increase in strength indicators compared to the standard plan of the Ukrainian Weightlifting Federation. This indicates the versatility and effectiveness of adaptive periodisation in strength training. Similar conclusions were made by S.K. Travis *et al.* (2020a), emphasising the importance of load variables such as volume, intensity and phasing to achieve maximum results. The use of a gradual increase in intensity and structured training phases in an optimised plan has significantly improved the physical performance of athletes. In addition, phasing of loads, in particular, tapering (gradual reduction of volume) before peak competitions, ensured optimal preparation of athletes for high loads, which demonstrates the effectiveness of this approach.

Compared to the standard plan, the optimised programme has proven to be more effective by integrating modern training methods. This includes the use of variable resistance, individualisation of loads and a gradual increase in intensity. Thus, the results of this study confirmed the importance of an individualised approach to strength training, which is also consistent with previous research. The use of such programmes not only improves physical performance but also minimises the risk of injury, which is an important aspect of long-term sporting success.

Conclusions

The study determined that the proposed optimised training plan has significant advantages over the standard approach used in the practice of the Ukrainian Weightlifting Federation. The plan has demonstrated high efficiency in increasing muscle strength, minimising the risk of injury and improving the quality of athletes' recovery. Adaptive periodisation and the introduction of structured recovery phases, stable and high results in athletes' strength performance were achieved due to the individualisation of loads. The average increase in strength in the bench press, snatch clean and jerk in the group that trained according to the optimised plan was 12-15%. In the standard group, this figure did not exceed 5-7%. These results demonstrate the importance of flexible adjustment of training parameters in accordance with the physiological state and needs of athletes. This approach avoids plateaus in progress, ensuring a steady increase in strength at all stages of the training cycle.

The incidence of injuries in the group that used the standard plan was three times higher than in the group that followed the optimised programme. This proves the effectiveness of introducing phases of active rest, careful monitoring of exercise techniques and the inclusion of special recovery procedures. The presence of such elements in the plan reduces the risk of overload and helps to maintain the functional integrity of muscles and joints. An analysis of the effectiveness of standard weightlifting training programmes was carried out, which showed their strengths and weaknesses. Based on modern scientific approaches, an optimised training plan was developed that considers the individual characteristics of athletes and innovative techniques such as adaptive periodisation and load variability. A comparative analysis of muscle strength indicators between the groups showed that the optimised plan is significantly more effective than the standard one, providing a significant increase in strength performance and reducing the risk of injury. Thus, the objectives of the study were successfully achieved, which confirms its scientific and practical value. The results are of practical importance for coaches and athletes. An optimised training plan ensures not only the achievement of high results but also the stability of progress, reducing the risk of overload and injury. This is an important factor in improving the overall level of training of weightlifters, especially in competitive conditions.

To further improve the proposed plan, it is worth paying attention to the study of the long-term impact of optimised plans in competitive conditions to assess their sustainability and impact on results: the integration of modern technologies, such as wrist sensors for real-time monitoring of physiological parameters, can significantly improve the accuracy of training parameters. This opens the prospect of developing automated training correction systems based on the collected data. In addition, the impact of additional factors, such as rehabilitation methods, specialised nutrition and psychological support, on the effectiveness of the training process should be assessed. Further research could also analyse the creation of multivariate models for analysing and optimising training that consider a range of interrelated variables. This will allow for even greater efficiency in weightlifting training, improving performance and reducing the risk of injury.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Androulakis-Korakakis, P., Michalopoulos, N., Fisher, J.P., Keogh, J., Loenneke, J.P., Helms, E., Wolf, M., Nuckols, G., & Steele, J. (2021). The minimum effective training dose required for 1RM strength in powerlifters. *Frontiers in Sports and Active Living*, 3, article number 713655. doi: 10.3389/fspor.2021.713655.

[2] Arazi, H., Khoshnoud, A., Asadi, A., & Tufano, J.J. (2021). The effect of resistance training set configuration on strength and muscular performance adaptations in male powerlifters. *Scientific Reports*, 11, article number 7844. doi: 10.1038/s41598-021-87372-y.

[3] Bernárdez-Vázquez, R., Raya-González, J., Castillo, D., & Beato, M. (2022). Resistance training variables for optimization of muscle hypertrophy: An umbrella review. *Frontiers in Sports and Active Living*, 4, article number 949021. doi: 10.3389/fspor.2022.949021.
[4] Bompa, T.O., & Buzzichelli, C. (2022). *Periodization of strength training for sports* (4th ed.). Champaign: Human Kinetics.
[5] Comfort, P., *et al*. (2023). National Strength and Conditioning Association position statement on weightlifting for sports performance. *The Journal of Strength & Conditioning Research*, 37(6), 1163-1190. doi: 10.1519/JSC.0000000000004476.
[6] Duchateau, J., Stragier, S., Baudry, S., & Carpentier, A. (2021). Strength training: In search of optimal strategies to maximize neuromuscular performance. *Exercise and Sport Sciences Reviews*, 49(1), 2-14. doi: 10.1249/JES.0000000000000234.
[7] Evans, J.W. (2019). Periodized resistance training for enhancing skeletal muscle hypertrophy and strength: A mini-review. *Frontiers in Physiology*, 10, article number 13. doi: 10.3389/fphys.2019.00013.
[8] Garhammer, J. (2020). Weight lifting and training. In C.L. Vaughan (Ed.), *Biomechanics of sport* (pp. 169-211). Boca Raton: CRC Press. doi: 10.4324/9781003068549.
[9] Hammami, R., Nobari, H., Hanen, W., Gene-Morales, J., Rebai, H., Colado, J.C., & Ardigò, L.P. (2023). Exploring two different equated instability resistance training programs on measures of physical fitness and lower limb asymmetry in pre-pubertal weightlifters. *BMC Sports Science, Medicine and Rehabilitation*, 15, article number 40. doi: 10.1186/s13102-023-00652-0.
[10] Hermassi, S., Chelly, M.S., Bragazzi, N.L., Shephard, R.J., & Schwesig, R. (2019). In-season weightlifting training exercise in healthy male handball players: Effects on body composition, muscle volume, maximal strength, and ball-throwing velocity. *International Journal of Environmental Research and Public Health*, 16(22), article number 4520. doi: 10.3390/ijerph16224520.
[11] Huebner, M., Faber, F., Currie, K., & Rieger, T. (2022). How do master weightlifters train? A transnational study of weightlifting training practices and concurrent training. *International Journal of Environmental Research and Public Health*, 19(5), article number 2708. doi: 10.3390/ijerph19052708.
[12] James, L.P., Haff, G.G., Kelly, V.G., Connick, M.J., Hoffman, B.W., & Beckman, E.M. (2018). The impact of strength level on adaptations to combined weightlifting, plyometric, and ballistic training. *Scandinavian Journal of Medicine & Science in Sports*, 28(5), 1494-1505. doi: 10.1111/sms.13045.
[13] Kaabi, S., Mabrouk, R.H., & Passelergue, P. (2022). Weightlifting is better than plyometric training to improve strength, counter movement jump, and change of direction skills in Tunisian elite male junior table tennis players. *The Journal of Strength & Conditioning Research*, 36(10), 2912-2919. doi: 10.1519/JSC.0000000000003972.
[14] Kirichenko, T. (2021). Optimization of strength training of females on the example of powerlifting. *Scientific Journal of Drahomanov Ukrainian State University. Series 15. Scientific and Pedagogical Problems of Physical Culture (Physical Culture and Sports)*, 12(144), 66-70. doi: 10.31392/NPU-nc.series15.2021.12(144).15.
[15] Laakso, L.A. (2021). Optimizing verbal communication in the instruction of weightlifting to weightlifting naïve athletes. *Strength & Conditioning Journal*, 43(5), 109-115. doi: 10.1519/SSC.0000000000000636.
[16] Oleshko, V., Lobko, B., & Tkachenko, K. (2018). *Weightlifting: Curriculum for children and youth sports schools, specialised children's and youth sports schools of the Olympic reserve, schools of higher sportsmanship and specialised educational institutions of sports profile*. Kyiv: Republican Scientific and Methodological Cabinet Ministry of Youth and Sports of Ukraine.
[17] Pistilli, E.E., Mitchell, M., & Florence, L. (2021). Incorporating unilateral variations of weightlifting and powerlifting movements into the training program of college-level dancers to improve stability. *Strength & Conditioning Journal*, 43(3). doi: 10.1519/SSC.0000000000000612.
[18] Sandau, I., & Granacher, U. (2023). Optimal barbell force-velocity profiles can contribute to maximize weightlifting performance. *PLOS ONE*, 18(8), article number e0290275. doi: 10.1371/journal.pone.0290275.
[19] Schoenfeld, B., Fisher, J., Grgic, J., Haun, C., Helms, E., Phillips, S., Steele, J., & Vigotsky, A. (2021). Resistance training recommendations to maximize muscle hypertrophy in an athletic population: Position stand of the IUSCA. *International Journal of Strength and Conditioning*, 1(1). doi: 10.47206/ijsc.v1i1.81.
[20] Slater, G., & Mitchell, L. (2019). Strength and power athletes. In R. Belski (Ed.), *Nutrition for sport, exercise and performance* (pp. 208-218). London: Routledge. doi: 10.4324/9781003116592.
[21] Suchomel, T.J., Nimphius, S., Bellon, C.R., & Stone, M.H. (2018). The importance of muscular strength: Training considerations. *Sports Medicine*, 48, 765-785. doi: 10.1007/s40279-018-0862-z.
[22] Suchomel, T.J., Nimphius, S., Bellon, C.R., Hornsby, W.G., & Stone, M.H. (2021). Training for muscular strength: Methods for monitoring and adjusting training intensity. *Sports Medicine*, 51, 2051-2066. doi: 10.1007/s40279-021-01488-9.
[23] The Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki/.
[24] Travis, S.K., Ishida, A., Taber, C.B., Fry, A.C., & Stone, M.H. (2020a). Emphasizing task-specific hypertrophy to enhance sequential strength and power performance. *Journal of Functional Morphology and Kinesiology*, 5(4), article number 76. doi: 10.3390/jfmk5040076.
[25] Travis, S.K., Mujika, I., Gentles, J.A., Stone, M.H., & Bazyler, C.D. (2020b). Tapering and peaking maximal strength for powerlifting performance: A review. *Sports*, 8(9), article number 125. doi: 10.3390/sports8090125.

[26] Ukrainian Weightlifting Federation. (n.d.). Retrieved from https://uwf.net.ua/.
[27] Xiang, Y., Cruz, J., Zaman, R., & Yang, J. (2020). Multi-objective optimization for two-dimensional maximum weight lifting prediction considering dynamic strength. *Engineering Optimization*, 53(2), 206-220. doi: 10.1080/0305215X.2019.1702979.
[28] Yeom, D.-C., Hwang, D.-J., Lee, W.-B., Cho, J.-Y., & Koo, J.-H. (2023). Effects of low-load, high-repetition resistance training on maximum muscle strength and muscle damage in elite weightlifters: A preliminary study. *International Journal of Molecular Sciences*, 24(23), article number 17079. doi: 10.3390/ijms242317079.
[29] Zatsiorsky, V.M., Kraemer, W.J., & Fry, A.C. (2020). *Science and practice of strength training* (3rd ed.). Champaign: Human Kinetics.

Оптимізація плану тренувань для підвищення м'язової сили у важкоатлетів

Тарас Дутко

Заслужений майстер спорту, заслужений працівник фізичної культури та спорту, доцент
Український державний університет науки і технології
49000, вул. Лазаряна, 2, м. Дніпро, Україна
https://orcid.org/0000-0002-1390-7889

Анотація. Підвищення м'язової сили є критично важливим аспектом для спортсменів важкої атлетики, оскільки рівень розвитку м'язової сили безпосередньо впливає на ефективність виконання ключових змагальних вправ, зокрема ривка та поштовха, що є визначальними для досягнення високих результатів у цьому виді спорту. Метою дослідження було розробити та обґрунтувати оптимізований тренувальний план для підвищення м'язової сили у важкоатлетів і порівняти його ефективність зі стандартною програмою. Методологія дослідження включала аналіз існуючих тренувальних планів, розробку адаптивного плану, заснованого на сучасних принципах періодизації, та експериментальне порівняння динаміки силових показників у двох групах спортсменів. Використовувалися методи статистичного аналізу для оцінки достовірності результатів. Результати роботи демонструють, що група, яка тренувалася за оптимізованим планом, показала суттєвіший приріст силових показників у ривку (15 %), поштовху (14 %) та жимі (12 %) порівняно зі стандартною програмою (7 %, 8 % і 6 % відповідно). Крім того, спортсмени, які використовували оптимізований план, продемонстрували стабільне зростання результатів протягом усього тренувального циклу, тоді як у групі зі стандартною програмою темпи прогресу суттєво знижувалися після третього місяця. Також виявлено, що кількість травм у групі з оптимізованим планом була значно меншою завдяки контролю техніки виконання вправ і належній організації періодів відновлення. Дослідження підтверджує, що застосування адаптивного підходу, який враховує індивідуальні особливості спортсменів і варіативність навантажень, сприяє більш вираженому прогресу в розвитку м'язової сили. Практичне значення роботи полягає у можливості впровадження запропонованої методики для підвищення ефективності тренувального процесу у важкій атлетиці, зокрема для спортсменів різного рівня підготовки

Ключові слова: ривок; поштовх; жим; фізичні навантаження; адаптивна періодизація

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 25.06.2024. Revised: 16.10.2024. Accepted: 12.12.2024

UDC 796.012.12

DOI: 10.69587/tppcs/2.2024.55

Active recreation in the training process transition period

Iryna Yuzkovets*

PhD in Physical Education and Sport, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0001-9372-550X

Abstract. The study aimed to determine the effectiveness of various means of active recreation for maintaining the physical fitness of athletes during the transition period of the training process. An experimental methodology that included testing the impact of four methods of active recreation, namely aerobic exercises, hydrotherapy, yoga and team games, on the physiological parameters of athletes, was used in the study. The study involved 48 athletes aged 20 to 30, who were divided into four equal groups. The measurements were made before and after the experiment under standardised conditions. The results of the study demonstrated that all methods of active recreation contributed to the improvement of physiological parameters of athletes, but aerobic exercises and yoga demonstrated the highest efficiency. Aerobic exercise resulted in a significant reduction in resting heart rate by 8% in men and 7% in women, as well as a 15% increase in lung capacity. In addition, this method demonstrated a significant improvement in endurance: the distance covered by athletes according to the Cooper test increased by 15%. Yoga contributed to a significant 17% reduction in blood lactic acid levels after exercise in both men and women and improved muscle strength and flexibility. Hydrotherapy was noted to be effective in reducing muscle tension, improving muscle tone by 20% and contributing to greater relaxation in athletes. Team games, although having a lesser impact on physiological parameters, had a positive effect on social interaction and overall motivation of athletes, and provided a moderate increase in endurance. The results obtained concluded that aerobic exercises and yoga are the most effective means of active recreation for maintaining the physiological parameters of athletes in the transition period

Keywords: physical activity; psychological rehabilitation; muscle strength; level of physical fitness; athletes

Introduction

The need to maintain the achieved level of physical fitness of athletes and the effective recovery of their physical, psychophysiological and emotional resources determines the importance of researching the means of active recreation during the transition period of training. In the sporting macro-cycle, the transition period is a key moment when a decrease in training intensity can decrease fitness, psychological demotivation and the risk of injury. Active recreation is a necessary part of recovery and sports require constant adaptation to significant physical and mental stress.

The problem in the field of sports training is the need for effective planning of the transition period of the training process to ensure the recovery of the physical and psychophysiological resources of athletes. A study of the impact of different approaches to the organisation of the transition period on the physical fitness of young female basketball players was conducted by F. D'Elia *et al.* (2019). The study compared two approaches: systematic training during the period and complete rest. The results showed that systematic training significantly improves physical fitness ($p = 0.004$), while inactivity had no significant effect ($p = 0.075$). The study did not analyse the impact of different types of active recreation on sports performance, and there are no recommendations for adapting the methods to other sports.

The impact of seasonal transitions and training strategies on athletes' physical fitness is a substantial factor in sports training. T.M. Purdom *et al.* (2020) investigated how seasonal transitions and training patterns affect aerobic capacity and body composition in first-division female football players. The study determined that during the transition period, a decrease in the volume of training led to an increase in aerobic capacity by 12.9% ($p = 0.001$), and after the spring season, this indicator reached a maximum with an increase of 16.4% ($p < 0.01$). However, in the pre-season, due to the indirect nature of the training, there was a 7% decrease ($p = 0.02$). The study does not analyse the long-term impact of training methods on physical fitness and does not offer adaptive recommendations for different sports.

Suggested Citation: Yuzkovets, I. (2024). Active recreation in the training process transition period. *Theory and Practice of Physical Culture and Sports*, 3(2), 55-63. doi: 10.69587/tppcs/2.2024.55.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

In sports training, it is necessary to determine how different methods of warming up during the transition period affect athletes' performance. M. Mckenzie *et al.* (2022) conducted a systematic review investigating the effects of land-based warm-ups on swimmers. The analysis determined that a reduction in the transition period by half improved swim times by 1.1-1.5%. Active warm-up methods increased performance by 0.6-0.9%, and a combination of active and passive warm-ups allowed for an increase of up to 3%. However, the effects at the level of the lower limbs were mixed, and for the upper limbs, mostly unfavourable. The main gap is the lack of analysis of the physiological mechanisms of these techniques, as well as the limited amount of research analysing the long-term results and adaptation of these strategies in different sports.

In the field of sports training, it is necessary to maintain the physical level of athletes and optimise their weight during the transition period of the training macrocycle. B.M. Witwit (2018) investigated the use of the cross-training method to maintain these indicators in young wrestlers. The results showed that the cross-training programme allowed to maintain the level of physical fitness and stabilise weight, avoiding its significant increase, which is typical for traditional rest during this period. However, the study revealed gaps, such as the lack of a detailed analysis of the long-term impact of cross-training on sports performance and insufficient study of the possibility of adapting the programme to other sports and age groups.

In the field of sports tracking, it is necessary to determine how personal information tools can improve physical activity monitoring for recreational athletes. M. Pandey *et al.* (2019) investigated the use of tracking technologies by recreational athletes such as runners, football players, basketball players, and tennis players. The study determined that participants actively used trackers to measure basic indicators (distance, steps, speed), but faced limitations in monitoring specific sports techniques. The main gap is the lack of support for complex metrics such as racket speed or shot accuracy, as well as the lack of tools for analysing team interaction and social support in team sports.

In sports training, it is necessary to determine the effectiveness of active recovery to improve the physical performance of athletes. R.O.Jr. Ortiz (2019) conducted a systematic review of studies on the use of active recovery among professional, collegiate and competitive athletes. The results showed that active recovery sessions lasting 6-10 minutes contributed to improved athletic performance, such as increased lactic acid removal and improved specific athletic outcomes. However, the methodological diversity of the studies makes it difficult to draw definitive conclusions on the effectiveness of recovery approaches. The main gap is the lack of standardised markers to measure the intensity and duration of active recovery, as well as insufficient analysis of the psychological aspects of the impact of these methods on athletes' recovery.

This study aimed to determine the effectiveness of various means of active recreation for maintaining the physical fitness of athletes during the transition period of the training process. The objectives of the study are to conduct an experimental study with the division of athletes into groups, each of which uses a separate means of active recreation, and to measure physiological parameters before and after the transition period; to analyse the impact of the selected means of active recreation on the physiological parameters of athletes and to determine the most effective methods for maintaining fitness.

Materials and Methods

The study is experimental and was conducted in the format of practical testing of the impact of various methods of active recreation on the physiological parameters of athletes. The study was conducted over five weeks and included an experiment for evaluation of the effectiveness of various methods of active recreation for athletes involved in anaerobic sports. The study involved 48 athletes ($N = 48$) who were divided into four equal groups of 12 people each ($n = 12$). Each Group consisted of 6 men and 6 women, which ensured an even distribution by gender, allowing for gender specifics to be considered when analysing the results. The study participants had different levels of experience in their respective sports, but all of them met the requirements for prior physical fitness. The sample was carefully selected from athletes aged 20 to 30 years with at least three years of training experience in their disciplines and an appropriate level of physical fitness confirmed by previous tests. To ensure the homogeneity of the sample, athletes specialising in sprinting, weightlifting and wrestling were recruited, which covered the specifics of anaerobic sports. Before the study, all participants provided written consent to participate in the experiment after receiving a detailed explanation of the purpose, procedures and possible risks of the study. The ethical principles of the study were based on The Declaration of Helsinki (2013). The experiment was approved by the local ethics committee.

Low-intensity aerobic exercise – Group A. This Group performed light jogging or brisk walking for 30 minutes three times a week. The exercises were done in the morning in the fresh air, which provided an additional positive effect on the body due to natural oxygenation. The pace of running was controlled by the trainers to avoid overloading and corresponded to a level at which participants could maintain a conversation without significant effort. Hydrotherapy – Group B. This Group used contrast baths with a temperature regime of 38-16°C. Each session lasted 20 minutes and consisted of five cycles of alternating warm and cold water. The procedures were carried out three times a week in a specialised sports centre under the supervision of medical staff. Yoga and stretching – Group C. Participants in this Group performed a set of exercises for flexibility and breathing relaxation lasting 40 minutes three times a week. The sessions included basic yoga asanas, breathing exercises (pranayama) and dynamic stretching. Classes were held in a room with a minimum number of external stimuli. Team games – Group D. This Group participated in informal sports games, such as volleyball or basketball, lasting 60 minutes twice a week. The main goal was to combine physical activity with elements of social interaction. The groups played in open areas.

Heart rate was measured using certified heart monitors with the function of automatic recording. The procedure was performed at rest at 7:00 a.m., before breakfast, to avoid the influence of external factors such as physical activity or emotional stress. The participants of the experiment were in a sitting position, in a quiet environment with

a minimum noise level. The heart rate was recorded three times over three days to avoid random fluctuations caused by stress or other temporary changes. The procedure consisted of several stages. The participants performed a control exercise in the form of a 3-minute sprint on a treadmill at an intensity of 85% of their maximum heart rate. This intensity ensured the achievement of a state of moderate anaerobic stress, which stimulated the formation of lactic acid. After completion of the exercise, 5 minutes later, capillary blood was taken from the finger using a standard lancet. The obtained sample was immediately analysed using a portable lactate meter, which provides an accuracy of up to 0.1 mmol/l for determining the concentration of lactic acid in the blood.

The measurement of vital capacity of the lungs was assessed using a portable spirometer, which accurately determined the volume of air that an athlete can inhale and exhale at maximum effort. The procedure included three main stages. The participant inhaled deeply to the maximum and then exhaled as fully as possible into the spirometer mouthpiece. This procedure was repeated three times with an interval of two minutes between each attempt. The best value from the three attempts was used for analysis, which reflected the athlete's maximum ventilatory capacity. The data was collected under standardised conditions to ensure maximum accuracy, including control of temperature, humidity and time of measurement. Each parameter was measured several times, and the averages were used to analyse the effectiveness of active recreation methods.

Two methods were used to measure muscle strength and endurance: a hand dynamometer to measure hand strength and the Cooper test to measure overall physical endurance. There were several stages in the process. Participants performed the measurements in a standing position, holding the dynamometer in their working hand, with the other arm hanging along their body. Each participant had three attempts to squeeze the dynamometer with maximum force, with an interval of one minute. The highest value of the three attempts, which best reflected the athlete's maximum capabilities, was used for analysis. All collected data were processed using statistical tools to determine average values, percentage changes and trends, which allowed for a detailed evaluation of the results. This was used to conclude the impact of different methods of active recreation on the physiological and psycho-emotional parameters of athletes, to identify the most effective approaches and to formulate practical recommendations for their implementation in the training process. The choice of active recreation methods was based on modern recommendations for the recovery of athletes, considering the specifics of anaerobic sports.

Results

Theoretical substantiation of active recreation in the transition period

Anaerobic athletes consider the transition period in their training programme to be an important step in helping their bodies recover from a long season of competition. This period is crucial for preventing psychological and physical burnout, and it also sets the stage for further performance improvement. It usually lasts from three to four weeks, after which the intensity of training gradually decreases. The purpose of the transition period is to restore the body. Athletes involved in anaerobic sports such as weightlifting, sprinting, boxing or wrestling have to expend a lot of energy on their muscles, heart and nervous system. Due to the constant intensity of training during competitions, the body is constantly under stress, which can lead to fatigue, metabolic disorders and even a reduced immune system. During this time, the main task is to stabilise physiological processes and reduce the level of stress so that the body can restore the resources it has spent. Restoring the body's energy balance is an important part of the transition period. Intense training during the competition period reduces muscle glycogen stores. Glycogen is the main source of energy for anaerobic work. A healthy diet during the transition period is crucial, as it helps to restore glycogen stores, provides the body with the necessary micro and macronutrients and promotes overall recovery (Kuybida *et al.*, 2022; Palladina & Kaliga, 2024).

The transition period also helps to reduce the psycho-emotional burden. Due to strict training and competition schedules and the need to achieve results, athletes often experience a lot of stress. During this period, psychological rehabilitation includes relaxation activities such as meditation, walking outdoors or participating in informal sports activities, which can help reduce anxiety and improve overall tone. Active recreation is another important aspect of transition. Active recreation is not too intense exercise that helps to maintain general physical condition without overloading. It is different from complete rest. Swimming, yoga, aerobic exercise, cycling and playing sports are some of the most common types of active recreation among anaerobic athletes. These activities not only improve physical fitness but also positively impact the mental health of athletes, rendering the training process harder (Kanaujia *et al.*, 2022). Basic fitness maintenance is important during the transition period. Athletes should perform exercises that help maintain muscle tone and flexibility, even though the intensity of training is significantly reduced. For instance, stretching and mobility exercises can help reduce muscle strain and injury during the preparation period before training. All athletes have different fitness levels, ages, experiences and health conditions when planning their transition. Younger athletes face more recovery activities during this period, while experienced athletes often use this transition period to address weaknesses in their training, such as tactics or techniques.

Monitoring physiological parameters is important during the transition period. Regular measurements of blood pressure, lung capacity, blood lactic acid levels and heart rate allow coaches and athletes to assess how well recovery training is working and make the necessary adjustments to their training programme. Thus, the transition period is an important part of training for athletes involved in anaerobic sports. If it is well organised, it reduces the risk of injury and facilitates the recovery of physical and psychophysiological resources. The transition period serves as a basis for further sporting achievements and as a time of rest if the right combination of physical activity, treatment and psychological rehabilitation is used. Moderation, gradualness and compliance with the physiological capabilities of the athlete are the main requirements for active recreation. After a competitive period, metabolic products, such as lactic acid, accumulate, leading to muscle pain and poor

performance. The body works excessively during prolonged training, which leads to depletion of energy resources, microtrauma to the muscles and disruption of the water-salt balance. Intense physical activity removes these products, improves tissue oxygenation and restores energy reserves, which are important factors for maintaining ideal fitness (Skalski *et al*., 2024).

The main groups of active recreation methods are primarily low-intensity aerobic exercises, such as running, walking or swimming. These exercises improve blood circulation and accelerate the recovery of the heart by putting a moderate load on it. Aerobic exercise also stabilises the nervous system, reduces stress levels and improves overall tone. Swimming, for example, is one of the most common forms of outdoor activity because it works on the soft joints and affects the entire body. Water-based exercises can also be used for its calming effect, which improves the mood of athletes. Yoga and stretching are another important part of active recreation. They relieve muscle tension, improve joint flexibility and reduce injuries. Yoga and stretching are often the last part of a workout. Yoga not only helps recover physically but also emotionally relax. Yoga is also seen as an effective way to strengthen the muscular corset and increase resistance to stress. Heavy sports such as martial arts and weightlifting require it. Hydrotherapy has a special place among the various forms of active recreation. Exercises with water, such as contrast showers, sea salt baths or hydro massage, improve blood circulation and reduce muscle pain. In addition, hydrotherapy calms the nervous system, which is highly relevant for the body's recovery after exercise. Hydrotherapy also accelerates tissue regeneration, reduces inflammation and increases the elasticity of muscle fibres. It is widely used in rehabilitation programmes for athletes who have been injured.

Participation in team games is another active recreation method. For instance, sports such as football, basketball or volleyball help maintain emotional balance by combining physical activity with social interaction. Athletes benefit from these activities because they keep them fit and have a positive psychological impact. Team games create an environment of support and cooperation, which increases the desire to train and reduces anxiety (Rzeszutko-Bełzowska *et al*., 2023). Modern athletes are increasingly using innovative methods of active recreation in addition to traditional methods. For instance, the use of specialised simulators that reproduce different types of physical activity allows for precise dosing of the load for each athlete. Virtual reality (VR) contributes to the development of interactive environments for rehabilitation training. These innovations diversify and improve recreation. Individuality is an important part of active recreation. When choosing recovery activities, each athlete should account for physiological characteristics, fitness level and personal preferences. For example, sprinters need to train to restore plyometric power, while wrestlers need to relieve tension from large muscle groups. An individualised approach maximises the effectiveness of recovery and prevents harmful effects such as overexertion and loss of motivation.

Active recreation should also include activities that contribute to the psychological rehabilitation of athletes. Athletes can experience poor emotional health due to the constant pressure and stress of performing well. Athletes feel more motivated to train and can restore their emotional balance through meditation, breathing exercises or walking in nature. This not only facilitates quick recovery but also creates optimal conditions for the next stage of training. To determine exactly how beneficial active recreation is, it is necessary to take regular measurements of physiological parameters. These include blood pressure, lung capacity, heart rate, and blood lactic acid levels (Jaiyeoba, 2021). These metrics can be used to assess the athlete's condition and optimise the recovery programme to maximise results. Such measurements facilitate the adaptation of the strategy and guarantee full recovery. Different methods of active recreation have a specific impact on the physiological and psycho-emotional state of athletes, ensuring recovery after intense physical activity. It is important to evaluate their effectiveness based on objective indicators, such as heart rate, lactic acid level, muscle tone, and subjective parameters, such as motivation and mood. Table 1 presents a comparative analysis of the impact of the main methods of active recreation on the condition of athletes, which can be used to summarise their advantages and identify the most effective approaches depending on specific recovery tasks.

Table 1. Effectiveness of active recreation methods for the recovery of athletes

The method of active recreation	Physiological effect	Psychological effect	Recommended performance indicator
Aerobic exercises	Reduced lactic acid levels by 15%	Reduced anxiety by 10%	Heart rate
Hydrotherapy	Improve muscle tone by 20%	Increased relaxation by 25%	The level of muscle tension
Stretching and yoga	Increase in flexibility by 18%	Improved mood by 15%	Flexibility of the joints
Team games	Support for overall endurance	Increase in social interaction	Reduced fatigue levels
Innovative technologies	Precise load dosing (up to 98%)	Motivational effect (20% improvement)	Evaluating the performance of a virtual environment

Source: compiled by the author based on W. Tokarski & G.F. Zarotis (2020)

Each of the active recreation methods has a unique impact on athletes' recovery. Aerobic exercise is a versatile method that is suitable for a wide range of athletes due to its positive impact on the cardiovascular system. Hydrotherapy is effective in relieving muscle tension and promoting relaxation (Gojkovic *et al*., 2019) while stretching and yoga provide flexibility and reduce the risk of injury. Team games are particularly useful for maintaining psychological balance and social interaction, and innovative technologies can tailor rehabilitation programmes to the needs of individual athletes. Summarising the results, it is possible to state that the combined use of these methods allows for a comprehensive recovery and maintenance of fitness.

Experimental study of the impact of active recreation

At the beginning of the experiment, the male athletes had an average resting heart rate of 58 to 62 beats per minute (bpm), which is normal for people who train well. Female athletes had a resting heart rate of 62-66 bpm. These indicators showed that the participants were sufficiently trained and ready to take part in the experiment. During further comparisons, these initial heart rate values were used to assess the impact of various forms of active recreation on the state of the cardiovascular system of athletes after the transition period. In addition, to assess the functional state of the respiratory system, the average values of the vital capacity were addressed. The average values for male athletes aged 20-30 years were 4.5-5.5 l and for women of the same age group – 3.5-4.5 l. This highest value served as an indicator of the functional state of the respiratory system of athletes.

Lactic acid levels were measured to assess the level of muscle fatigue after intense exercise and the body's ability to recover. This indicator is key for athletes involved in anaerobic sports, as lactic acid is a metabolic product that accumulates in the muscles during short-term intense exercise, which is typical for such disciplines. At the stage of initial measurements, the average lactic acid level in men was 7.5-8.2 mmol/l after exercise, and in women 6.8-7.4 mmol/l after exercise. These values are typical for trained athletes involved in anaerobic sports. They reflect the level of muscle fatigue caused by intense physical activity and the body's ability to produce and utilise lactic acid.

At the beginning of the experiment, muscle strength and endurance were also measured. The average strength values for men were 48-52 kg and for women 34-38 kg, which corresponds to standard values for trained individuals. The Cooper test, which is a universal method for assessing physical and aerobic endurance in athletes, was used to evaluate endurance. The test was conducted in a regular outdoor stadium with a flat 400 m track. To prepare for the main load, the participants performed a 5-minute warm-up, which included light jogging and dynamic stretching. After that, the athletes ran the maximum distance for 12 minutes. The coaches counted the distance in metres, m. At the beginning of the experiment, the men covered an average of 2,700-2,900 m, and the women 2,300-2,500 m. These results correspond to the average endurance level of anaerobic athletes.

All measurements were taken at the same time and under the same conditions to prevent the influence of external factors such as weather and athletes' energy levels. The results provided the basis for further analysis of the changes caused by the impact of different methods of active recreation. In addition, they made it possible to compare how effective different methods are in improving physical performance. After five weeks of using different methods of active recreation, significant changes in physiological parameters were recorded in the participants. The results showed that each method had a different level of impact on heart rate, lung capacity, blood lactic acid levels, muscle strength and endurance.

Resting heart rate decreased in all groups, indicating an improvement in the cardiovascular system. In Group A (aerobic exercise), the rates decreased from 60 to 55 bpm for men and from 64 to 59 bpm for women. In Group B (hydrotherapy), heart rate decreased from 61 to 57 bpm in men and from 65 to 61 bpm in women. In Group C, there was a decrease from 60 to 56 bpm in men and from 63 to 59 bpm in women. The smallest decrease was observed in Group D, from 61 to 58 bpm in men and from 64 to 61 bpm in women. Lung capacity improved in all groups, demonstrating an increase in the efficiency of the respiratory system. In Group A, lung capacity increased from 5.0 to 5.6 l in men and from 4.0 to 4.5 l in women. In Group B, there was an increase from 5.1 to 5.5 l in men and from 4.0 to 4.3 l in women. In Group C, lung capacity increased from 5.0 to 5.75 l in men and from 4.0 to 4.6 l in women. In Group D, the values increased from 5.0 to 5.5 l in men and from 3.9 to 4.3 l in women.

In Group A, lactic acid values in men decreased from 7.8 mmol/l to 6.4 mmol/l. In women, the values decreased from 7.1 mmol/l (within the range of 6.8-7.4 mmol/l) to 5.8 mmol/l. In Group B, lactic acid levels in men decreased from 7.9 mmol/l to 6.7 mmol/l. In women, the figures decreased from 7.2 mmol/l to 6.1 mmol/l. In Group C, lactic acid levels in men decreased from 7.8 mmol/l to 6.5 mmol/l. In women, the figures decreased from 7.0 mmol/l to 5.8 mmol/l. In Group D, lactic acid levels in men decreased from 8.0 mmol/l to 7.0 mmol/l. In women, the figures decreased from 7.3 mmol/l to 6.4 mmol/l. Muscle strength also improved in all groups. In Group A, the scores increased from 50 to 55 kg for men and from 36 to 40 kg for women. In Group B, strength increased from 50 to 54 kg for men and from 35 to 38 kg for women. In Group C, the increase was the largest – from 49 to 55 kg for men and from 35 to 39 kg for women. In Group D, strength increased from 50 to 53 kg in men and from 36 to 38 kg in women.

Endurance, as measured by the Cooper test, increased most significantly in Group A – from 2,800 to 3,220 m for men and from 2,400 to 2,760 m for women. In Group B, the increase was from 2,780 to 3,050 m for men and from 2,380 to 2,620 m for women. In Group C, endurance increased from 2,790 to 3,150 m for men and from 2,390 to 2,700 m for women. The smallest increase was observed in Group D, from 2,800 to 3,050 m for men and from 2,400 to 2,620 m for women. Therefore, changes in physiological parameters after five weeks of active recreation in % are shown in Table 2.

Table 2. Changes in physiological parameters after five weeks of active recreation

Parameter	Initial indicators (average values)	Group A (aerobic exercise)	Group B (hydrotherapy)	Group C (yoga and stretching)	Group D (team games)
Heart rate, bpm	M: 75 F: 78	M: 8% ↓ F: 7% ↓	M: 6% ↓ F: 5% ↓	M: 7% ↓ F: 6% ↓	M: 5% ↓ F: 4% ↓
Lung capacity, l	M: 4.8 F: 3.8	M: 12% ↑ F: 12% ↑	M: 8% ↑ F: 8% ↑	M: 15% ↑ F: 15% ↑	M: 10% ↑ F: 10% ↑
Lactic acid, mmol/l	M: 6.2 F: 5.8	M: –18% ↓ F: –18% ↓	M: –15% ↓ F: –15% ↓	M: –17% ↓ F: –17% ↓	M: –12% ↓ F: –12% ↓

Table 2, Continued

Parameter	Initial indicators (average values)	Group A (aerobic exercise)	Group B (hydrotherapy)	Group C (yoga and stretching)	Group D (team games)
Muscle strength, kg	M: 60 F: 40	M: 10% ↑ F: 10% ↑	M: 8% ↑ F: 8% ↑	M: 12% ↑ F: 12% ↑	M: 7% ↑ F: 7% ↑
Endurance, m (Cooper's test)	M: 2,400 F: 2,200	M: 15% ↑ F: 15% ↑	M: 10% ↑ F: 10% ↑	M: 13% ↑ F: 13% ↑	M: 9% ↑ F: 9% ↑

Source: compiled by the author

The results of the study showed that all methods of active recreation had a positive effect on the physical characteristics of athletes engaged in anaerobic sports; however, the effectiveness of each method differed significantly. Groups A (aerobic exercise) and C (yoga and stretching) showed the greatest improvements. These groups showed increased muscle strength and endurance, a significant increase in lung capacity, a decrease in blood lactic acid levels, and a significant decrease in resting heart rate. This indicates that these methods are effective in restoring the cardiovascular, respiratory and muscular systems of athletes during the transition period.

Hydrotherapy (Group B) also improved the physical condition of the athletes for a long time, especially by reducing the level of lactic acid in the blood and increasing muscle tone. This method showed a relaxation effect, which is necessary for overall recovery; however, its effect on lung capacity and endurance was less noticeable compared to aerobic exercise and yoga. Group D, or team games, showed the least improvement. Although this method helped to maintain general physical condition and allowed people to socialise, it was not effective in reducing lactic acid levels and improving other physiological parameters.

Depending on the needs of each athlete, hydrotherapy and team games can be recommended as complementary or alternative recovery methods. The results also highlight how important it is to use an individual approach to selecting recovery methods that take into account the physical and emotional needs of each athlete. In general, the study confirmed that each of the active recreation methods is effective for athletes' recovery after a break between training sessions. The groups that used aerobic exercise and yoga showed the best results, which demonstrates how versatile they are and how they affect the physical and emotional state of athletes. Thus, for maintaining fitness during the transition period, aerobic exercise and yoga with stretching were the best types of active recreation that provided a comprehensive improvement in physiological conditions. Hydrotherapy also showed great potential, especially for improving tissue regeneration and reducing muscle tension.

Discussion

Recovery from physical activity is an integral part of the training process for athletes involved in intense physical disciplines. The use of effective methods of active recreation helps to reduce muscle fatigue, improve physiological performance and provide optimal conditions for subsequent training. D. Boullosa *et al.* (2020) addressed factors that influence the training and physical performance of recreational endurance runners, including training methods, monitoring of physiological parameters and prediction of results. The main similarities with the present study are in the approach to the analysis of physiological parameters of athletes, in particular, heart rate, endurance performance and the effectiveness of training methods. Both studies demonstrate the importance of an individual approach to the choice of methods and the consideration of the influence of physiological and psychological factors on training results. The main differences relate to the target Group and types of physical activity. The current study focuses on anaerobic athletes undergoing a transitional period of training, evaluating the impact of various active recreation methods such as yoga, aerobic exercise, hydrotherapy and team games. Instead, D. Boullosa *et al.* (2020) highlighted endurance runners participating in recreational competitions, and the main topics are the distribution of training intensity (e.g., HIIT) and the adaptation of training periodisation. It is worth noting that D. Boullosa *et al.* (2020) addressed theoretical aspects, such as the development of training and adaptation models, while the present study has an experimental component focused on short-term physiological changes in response to specific methods of active recreation. A prospect for combining the approaches is to include a long-term analysis of the effects of the methods used in the context of endurance, which could complement the findings of D. Boullosa *et al.* (2020) on training strategies.

A study by F. D'Elia *et al.* (2019) highlighted the impact of transition on athletes' performance using two groups of young female basketball players (U16 and U20). The focus was on assessing changes in physical performance depending on training approaches: systematic training during the transition period (U16 group) and no training at all (U20 group). Both studies address the transition period, but F. D'Elia *et al.* (2019) emphasised the impact of the lack of organised training and the importance of systematic work to maintain and improve physical performance. F. D'Elia *et al.* (2019) demonstrated that the U16 Group that continued training showed significant improvements in performance ($p = 0.004$), while the U20 Group with a significant decrease in activity showed no significant changes ($p = 0.075$). In this study, the emphasis is on active recreation (aerobic exercise, yoga, hydrotherapy, team games) to improve physiological parameters. Both studies confirm the importance of active activities during the transition period to avoid detraining. The study by F. D'Elia *et al.* (2019) analysed female basketball players specialising in game sports, while the present study examined athletes involved in anaerobic disciplines. The methodology of F. D'Elia *et al.* (2019) focused on testing coordination and speed skills, while the present study assesses heart rate, lung capacity, lactic acid levels, muscle strength and endurance.

S.L. Halson (2020) analysed different recovery methods for athletes, including hydrotherapy, active recreation, compression garments, massage and stretching. The focus is on practical recommendations for elite athletes and

potential mechanisms that influence physiological and mental recovery. The main similarity is that both studies emphasised the importance of adapted recovery strategies. S.L. Halson (2020) emphasised an individualised approach to recovery, considering the sport, training intensity and external factors, while the present study focuses on the evaluation of specific active recreation methods such as aerobic exercise, yoga, hydrotherapy and team games. Both approaches demonstrate that the right choice of methods can significantly improve physiological performance, reduce fatigue and ensure readiness for subsequent exercise. S.L. Halson (2020) discussed hydrotherapy (including cold baths and contrast water therapy) in detail and found it useful for recovery from high-intensity exercise. S.L. Halson (2020) also emphasised the importance of compression garments, which were not considered in this study. In addition, S.L. Halson (2020) emphasised such aspects as sleep and nutrition that are critical to overall recovery but are not analysed in this study.

The study conducted by I. Ketut-Yoda *et al.* (2024) and the present study has common goals aimed at evaluating the effectiveness of different recovery methods for athletes. Both studies emphasise the importance of structured recreation programmes in reducing fatigue and improving athletes' physiological state. I. Ketut-Yoda *et al.* (2024) discussed methods such as water therapy (hot-cold baths), curcumin supplementation and high-intensity interval training, while the present study focuses on aerobic exercise, hydrotherapy, yoga and team games. A common aspect is the emphasis on physiological parameters that reflect the effectiveness of recovery methods. I. Ketut-Yoda *et al.* (2024) emphasised the reduction of muscle fatigue and inflammation, as well as improvements in power and endurance. Both studies recognise the multidimensional nature of recovery. I. Ketut-Yoda *et al.* (2024) used a predominantly observational method, analysing the available data on different recovery techniques. In addition, they addressed the use of additives (curcumin). Furthermore, I. Ketut-Yoda *et al.* (2024) addressed a broader approach, covering athletes from different sports disciplines, while the present study focuses on anaerobic sports.

R. Braun-Trocchio *et al.* (2022) and the present study demonstrated different approaches to the study of athletes' recovery strategies. R. Braun-Trocchio *et al.* (2022) investigated the effectiveness of recovery strategies among endurance athletes, focusing on the physiological and psychological aspects of recovery, such as hydration, sleep, nutrition, and massage. Their study also highlighted gender differences in the use of these strategies, determining that women were more likely to use active recovery techniques, such as foam rolling and compression garments. The present study focused on the effectiveness of specific active recreation tools for maintaining fitness during the transition period of the training process. The similarities lie in the importance of recovery strategies for athletes, especially in the context of increasing training efficiency and reducing the risk of injury. Both studies emphasised the importance of personalised approaches to recovery, although R. Braun-Trocchio *et al.* (2022) emphasised the multidimensionality of recovery, including social and behavioural aspects. R. Braun-Trocchio *et al.* (2022) conducted surveys and statistical analysis of recovery practices, while the present study is based on an experimental approach involving athletes in the practical use of recreational methods.

S. Li *et al.* (2024) focused on the effectiveness of recovery strategies for endurance athletes, including passive, active and proactive approaches, using various techniques such as cryotherapy, compression garments and massage. The authors noted the ambiguity of the research findings and suggest improvements in methodology to reach more consistent conclusions. For instance, although cryotherapy and compression garments have shown positive effects in some cases, neither strategy is fully effective for all recovery parameters. It is also noted that the results are largely dependent on the characteristics of the Group of athletes and the experimental conditions. The similarities between the studies lie in the emphasis on the importance of recovery in endurance athletes and the conclusions about the ambiguity of the effects of recovery strategies. The study by S. Li *et al.* (2024) is an overview study, while the present study conducted a more practical analysis focusing on specific aspects such as lactate levels, heart rate, and muscle soreness. S. Li *et al.* (2024) covered a wider range of approaches, including active and proactive recovery, while the other study is more focused on passive methods.

P. Edholm *et al.* (2024) highlighted recovery strategies for winter sports athletes preparing for the Olympic Games. The focus was on personalised recovery methods such as sleep management, nutrition, cold treatment interventions, compression garments, and psychological support. The study emphasised the importance of addressing the unique physiological and psychological needs of athletes competing in low temperatures. The study also noted the limited evidence base for the effectiveness of certain methods, such as saunas or stretching, which are used without sufficient scientific evidence. P. Edholm *et al.* (2024) focused more on recovery in low temperatures and the impact of winter sports on the physiological state of athletes, while the present study is more general, covering various aspects of endurance sports. In addition, P. Edholm *et al.* (2024) integrated elements of cognitive recovery and mental health into their findings, which are less detailed in the present study. Both studies emphasised the importance of an individualised approach to recovery, but each address different aspects depending on the specifics of the sports studied.

Maintenance of fitness, reduction of fatigue and improvement of the body's adaptive abilities depend on effective recovery from physical activity. Scientists discovered that aerobic exercise, hydrotherapy, yoga and team games significantly improve the physical and mental well-being of athletes. An integrated approach that incorporates the individual characteristics and peculiarities of each sport facilitates recovery, increases training efficiency and reduces the risk of overload. This underscores the importance of using evidence-based methods to maximise performance in sports.

Conclusions

Low-intensity aerobic exercises showed the best results by all criteria. This indicates a significant improvement in the state of the cardiovascular system among athletes of Group A: the heart rate decreased by 8% in men and 7% in women. In addition, lung capacity increased by 12%, indicating an improvement in the functional capacity of the respiratory system. The level of lactic acid in the blood

decreased by 18% in both men and women, which is an important indicator of effective muscle recovery after intense anaerobic exercise. In addition, there was a 10% increase in muscle strength and a 15% increase in endurance according to the Cooper test. This information supports the idea that aerobic exercise is a versatile and challenging strategy that improves the physical and mental state of athletes. Yoga and stretching (Group C) were also effective, with heart rates decreasing by 7% in men and 6% in women. This was particularly evident in the 15% improvement in lung capacity. Lactic acid levels in Group C decreased by 17%, almost as much as in the aerobic exercise group. In addition, this Group increased endurance by 13% and muscle strength by 12%. This shows a significant improvement in overall physical condition. Yoga, which combines physical exercises with breathing and relaxation techniques, significantly improves the mental state of the athletes. Thus, yoga is an effective means of holistic recovery that includes physiological, mental and emotional components.

Hydrotherapy (Group B) significantly improved the athletes' recovery, especially in terms of reducing muscle tension and increasing overall muscle tone. Group B participants showed an 8% increase in muscle strength and a 10% increase in endurance. At the same time, the level of lactic acid in the blood decreased by 15%, indicating that the recovery process after exercise is accelerated. The main method of hydrotherapy was contrast baths. They improve blood circulation and reduce inflammation in the muscles, which contributes to a quick recovery. Athletes who need to reduce muscle pain and improve local circulation can benefit from hydrotherapy. Aerobic exercise and yoga were noted to be more effective than hydrotherapy. Team games brought significant social and emotional benefits, even though they had the least impact on physical performance. Group D participants showed a 7% increase in muscle strength and a 9% increase in endurance. In addition, the level of lactic acid in the blood decreased by 12%. Athletes who need emotional support and seek to balance physical activity with social elements may find this method particularly useful.

The main limitation is the relatively small sample of participants, which may affect the generalisability of the results. In addition, the study was conducted for only five weeks, which does not assess the long-term effect of active recreation methods. The study did not consider the individual dietary habits of the participants, which could also affect the results. Future research could focus on the effectiveness of combined methods of active recreation. In addition, it is advisable to study the impact of these methods on the psycho-emotional state in comparison with physical indicators.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Boullosa, D., Esteve-Lanao, J., Casado, A., Peyré-Tartaruga, L.A., Gomes da Rosa, R., & Del Coso, J. (2020). Factors affecting training and physical performance in recreational endurance runners. *Sports*, 8(3), article number 35. doi: 10.3390/sports8030035.

[2] Braun-Trocchio, R., Graybeal, A.J., Kreutzer, A., Warfield, E., Renteria, J., Harrison, K., Williams, A., Moss, K., & Shah, M. (2022). Recovery strategies in endurance athletes. *Journal of Functional Morphology and Kinesiology*, 7(1), article number 22. doi: 10.3390/jfmk7010022.

[3] D'Elia, F., D'Isanto, T., & Altavilla, G. (2019). Training and performance in the transition period. *Journal of Human Sport and Exercise*, 14(2), 258-262. doi: 10.14198/jhse.2019.14.Proc2.15.

[4] Edholm, P., Ørtenblad, N., Holmberg, H.-C., & Sperlich, B. (2019). Optimizing recovery strategies for winter athletes: Insights for Milano-Cortina 2026 Olympic Games. *Sport Sciences for Health*, 20, 1169-1182. doi: 10.1007/s11332-024-01245-1.

[5] Gojkovic, Z., Ivancevic, T., & Jovanovic, B. (2019). Biomechanical model of swimming rehabilitation after hip and knee surgery. *Journal of Biomechanics*, 94, 165-169. doi: 10.1016/j.jbiomech.2019.07.035.

[6] Halson, S.L. (2020). Recovery techniques for athletes. *Sports Science Exchange*, 26(120).

[7] Jaiyeoba, O.M. (2021). Psychological consequences of sport injury on mental well-being of elite athletes in Ibadan, Nigeria. *Journal of Positive Psychology and Counselling*, 8, 166-180.

[8] Kanaujia, S., Saraswati, P., Anshu, A., Singh, N., Singh, S., Kataria, N., & Yadav, P. (2023). Effect of yoga and mindfulness on psychological correlates in young athletes: A meta-analysis. *Journal of Ayurveda and Integrative Medicine*, 14(3), article number 100725. doi: 10.1016/j.jaim.2023.100725.

[9] Ketut-Yoda, I., Tisna, G.D., Suwiwa, I.G.S., Kusuma, K.C.A., & Junior, N.K.M. (2024). Recovery methods to reduce fatigue among athletes: A systematic review and future directions. *Journal Sport Area*, 9(2), 217-234. doi: 10.25299/sportarea.2024.vol9(2).16928.

[10] Kuybida, V.V., Lopatynska, V.V., & Kokhanets, P.P. (2022). Microbiota of humans and animals: Influence of physicalactivity and diet. *Scientia et Societus*, 1(2), 108-117. doi: 10.31470/2786-6327/2022/2/108-117.

[11] Li, S., Kempe, M., Brink, M., & Lemmink, K.A.P.M. (2024). Effectiveness of recovery strategies after training and competition in endurance athletes: An umbrella review. *Sports Medicine – Open*, 10, article number 55. doi: 10.1186/s40798-024-00724-6.

[12] Mckenzie, M., McKean, M., Doyle, D., Hogarth, L., & Burkett, B. (2022). Swimming performance, physiology, and post-activation performance enhancement following dryland transition phase warmup: A systematic review. *PLoS ONE*, 17. doi: 10.1371/journal.pone.0273248.

[13] Ortiz, R.O.Jr., Elder, A.J.S., Elder, C.L., & Dawes, J.J. (2019). A systematic review on the effectiveness of active recovery interventions on athletic performance of professional-, collegiate-, and competitive-level adult athletes. *Journal of Strength and Conditioning Research*, 33(8), 2275-2287. doi: 10.1519/JSC.0000000000002589.
[14] Palladina, O., & Kaliga, A. (2024). Microbiome of athletes: Its features and diversity: A literature review. *International Journal of Medicine and Medical Research*, 10(1), 56-63. doi: 10.61751/ijmmr/1.2024.56.
[15] Pandey, M., Nebeling, M., Park, S.Y., & Oney, S. (2019). Exploring tracking needs and practices of recreational athletes. In *13th EAI international conference on pervasive computing technologies for healthcare*. Trento: EAI. doi: 10.4108/eai.20-5-2019.2283726.
[16] Purdom, T.M., Levers, K.S., McPherson, C.S., Giles, J., & Brown, L. (2020). A longitudinal prospective study: The effect of annual seasonal transition and coaching influence on aerobic capacity and body composition in division I female soccer players. *Sports*, 8(8), article number 107. doi: 10.3390/sports8080107.
[17] Rzeszutko-Bełzowska, A., Przydział, M., Pezdan-Śliż, I., Cięszczyk, P., Humińska-Lisowska, K., Stastny, P., Skrzęta, M., Lulińska, A., Prończuk, M., & Mendyka, W. (2023). Assessment of physical capacity level in recreational athletes. *Journal of Kinesiology and Exercise Sciences*, 33(104). doi: 10.5604/01.3001.0053.9342.
[18] Skalski, D.W., Tsyhanovska, N., & Kreft, P. (2024). Improving backstroke swimming technique by using unconventional objects. *Rehabilitation and Recreation*, 18(3), 231-238. doi: 10.32782/2522-1795.2024.18.3.21.
[19] The Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki/.
[20] Tokarski, W., & Zarotis, G.F. (2020). The effect of recreational sports on human health. *IOSR Journal of Sports and Physical Education*, 7(3), 25-33. doi: 10.9790/6737-07032533.
[21] Witwit, B.M. (2018). Training strategy for the transition period using cross method to maintain physical level and bodyweight of a junior wrestler. *Journal of Sports Science and Arts*, 6(6), 73-96. doi: 10.21608/eijssa.2018.72875.

Засоби активної рекреації в перехідний період тренувального процесу

Ірина Юзковець

Кандидат наук з фізичного виховання і спорту, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0001-9372-550X

Анотація. Метою дослідження було визначити ефективність різних засобів активної рекреації для підтримки фізичної форми спортсменів під час перехідного періоду тренувального процесу. У рамках дослідження використовувалася експериментальна методологія, яка включала тестування впливу чотирьох методів активної рекреації: аеробних вправ, гідротерапії, йоги та командних ігор, на фізіологічні параметри спортсменів. У дослідженні брали участь 48 спортсменів віком від 20 до 30 років, які були поділені на чотири рівноцінні групи. Вимірювання проводилися до початку експерименту та після його завершення в стандартизованих умовах. Результати дослідження показали, що всі методи активної рекреації сприяли покращенню фізіологічних параметрів спортсменів, однак найвищу ефективність продемонстрували аеробні вправи та йога. Аеробні вправи забезпечили значне зниження частоти серцевих скорочень у стані спокою на 8 % у чоловіків і 7 % у жінок, а також підвищення життєвої ємності легень на 15 %. Крім того, цей метод продемонстрував суттєве покращення витривалості: відстань, подолана спортсменами за тестом Купера, збільшилася на 15 %. Йога сприяла значному зниженню рівня молочної кислоти в крові після фізичних навантажень на 17 % як у чоловіків, так і у жінок, а також покращила м'язову силу та гнучкість. Гідротерапія показала себе як ефективний засіб для зменшення м'язового напруження, покращивши тонус м'язів на 20 % і сприяючи більшому розслабленню спортсменів. Командні ігри, хоча і мали менший вплив на фізіологічні параметри, позитивно впливали на соціальну взаємодію та загальну мотивацію спортсменів, а також забезпечували помірне зростання витривалості. Отримані результати дозволили зробити висновок, що аеробні вправи та йога є найбільш ефективними засобами активної рекреації для підтримання фізіологічних параметрів спортсменів у перехідному періоді

Ключові слова: фізична активність; психологічна реабілітація; м'язова сила; рівень фізичної підготовки; спортсмени

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 29.05.2024. Revised: 30.09.2024. Accepted: 12.12.2024

UDC 796.422.2

DOI: 10.69587/tppcs/2.2024.64

Features of training runners for ultramarathon distances

Vitaliy Polishchuk*

PhD in Physical Education and Sport, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0002-3526-5098

Abstract. The study aimed to analyse the peculiarities of training athletes in preparation for an ultramarathon race. The study addressed the three phases of preparation for sports competitions – transition and recovery, the central training phase and the main competitive phase – and included a sample of 174 participants from Europe and other countries. The study revealed physiological and psycho-emotional characteristics of ultramarathon participants that distinguish them from participants in races at different distances and determine the peculiarities of the training process. These features include a lower body mass index of ultramarathon runners and an active desire to reduce it to achieve better results, a higher average age of ultramarathon participants, previous experience in other sports, and the integration of certain sports, mainly summer sports, into the process of training for a long-distance race. Based on the profiles of 65 participants who were preparing for an ultra-marathon race, the following training strategies were analysed: preliminary analysis of an athlete's profile to individualise training efforts; planning a sports season with three phases of training (recovery, preparation and competition) or a double training cycle; a combination of continuous low-intensity running and interval training; use of tracks with different surfaces to adapt to mechanical stress; parallel training in other sports to improve athletes' stability and endurance skills; ensuring long and quality sleep to prevent cognitive and psycho-emotional exhaustion of the competitors. The recommendations can be applied to the further development of the marathon movement in the country and abroad

Keywords: sports season; athlete's profile; endurance; oxygen saving; anthropometric indicators; motivation

Introduction

Running, including ultra-marathon distances, is not just a form of physical activity, but also a life philosophy that has received support and has been popularised internationally. The popularity of running is driven by the public demand for a healthy lifestyle and personal growth. To avoid contradictions, it should be noted that any distance exceeding 42 km 195 m is considered an ultramarathon. There are two types of ultramarathon competitions: time and distance. In the first type of competition, the winner is the participant who covers a certain distance in the shortest possible time, and in the second, the winner is the one who covers the longest distance. Although there are no clear limits for ultra-marathon competitions, the most popular distances are 50 km and 100 km. Among the world's leading ultra-marathon runners are Ukrainian athletes, including M. Ostrovska, whose 100 km record of 7:56:33 has been held for over 26 years. Another record holder is Ukrainian athlete S. Yanenko, who in 1997 ran the 100 km course at 6:25:25 and won the World Championship (IAU records, n.d.). Thus, the Ukrainian sports segment has sufficient potential for setting new records, the disclosure of which largely depends on effective training for ultra-marathon distances.

B. Knechtle *et al.* (2024) highlighted the growing popularity of ultra-marathon competitions, which have replaced short-distance competitions. Confirmation of this opinion was also discovered in studies conducted around the world since 2020. The first researchers emphasised the emergence of different types of ultra-marathon runners, including amateur and recreational runners. After analysing a sample of 1,149 Brazilian athletes, M. Thuany *et al.* (2020; 2022) concluded that belonging to one of these types determines the volume and frequency of training per week, training motivation and body mass index (BMI). According to D. Tanous *et al.* (2022), the motivation, and, accordingly, the peculiarities of preparation for competitions, are determined by the athlete's gender. Analysis of a sample of 210,455 runners aged 18 to 86 concluded that in contrast to male athletes who are more focused on the result, such as covering the distance in the shortest possible time. Female athletes pay more attention to such aspects of preparation

Suggested Citation: Polishchuk, V. (2024). Features of training runners for ultramarathon distances. *Theory and Practice of Physical Culture and Sports*, 3(2), 64-73. doi: 10.69587/tppcs/2.2024.64.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

for competitions as belonging to a sports movement and running as a meaning of life (Motevalli *et al.*, 2022).

A detailed profile of an ultramarathon competitor was also proposed by B. Knechtle & P.T. Nikolaids (2018), who compared the typical profile of marathon and ultra-marathon runners. According to the experts, a typical ultra-marathon runner is an educated male and aged 45 years or older. A typical representative of the ultra-marathon movement also has anthropomorphic features such as a low BMI and low body fat. In addition to these characteristics, the researchers also examined the training characteristics of ultra-marathon runners in comparison with other categories of runners. According to B. Knechtle & P.T. Nikolaids (2018), training for ultra-marathon runners is characterised by a higher volume and higher speed. Confirmation of this opinion was found in the study by D. Boullosa *et al.* (2020), who analysed the existing training practices of ultra-marathon runners and concluded that they are characterised by a weekly run of more than 70 km. Thus, creation of a detailed profile of an ultra-marathon runner can determine the specifics of their training and plan training in such a way as to achieve high results with minimal risk to the health and well-being of athletes.

T. Haugen *et al.* (2022) emphasised that the main goal of training athletes for a long-distance race is to improve three main indicators: maximal oxygen uptake (the rate at which the body can absorb and use oxygen during strenuous exercise), partial utilisation (i.e. the body's ability to maintain a high percentage of oxygen during running) and oxygen saving at a given submaximal running speed. According to K. Papadimitriou (2024), the effectiveness of efforts to improve these indicators depends on several factors, including whether athletes are professional or amateur. According to M. Besomi *et al.* (2019), the training of ultra-marathon runners depends on previous achievements, availability of training time, possible injuries, etc. Since the training of ultra-marathon runners involves many variables, there is no single training protocol that can guarantee consistently high results. Given the lack of a universal training protocol for athletes, the study aimed to analyse the characteristics of runners in preparation for ultramarathon distances. Based on the analysed features, effective strategies for training runners for ultra-marathon distances were identified and ways of their implementation were proposed depending on the type of athlete.

Materials and Methods

The periodisation of athletes' preparation for marathon and ultra-marathon competitions, which involves a three-phase preparation for participation in an ultra-marathon: transition & recovery, central preparation phase and main competitive phase, was used as the material for the analysis. At each of these stages, the following parameters were recorded: the number of training sessions per week; the number of km covered per week; the number of hours allocated for training. The data obtained through an online survey of athletes who provided informed consent to participate in the study, which was conducted in March 2024, were also used as materials. The survey was conducted using Google Forms tools to quickly collect and statistically process the data. The link to the online survey was sent to the email address provided during registration for the study and was active for 4 weeks from the date of sending. The survey participants were asked to answer 30 questions, which were divided into four semantic sections.

The first section contained seven questions aimed at collecting demographic and anthropometric information about the participants, including their age, gender, motivation for training, BMI and height. The second section of the questionnaire contained ten questions aimed at identifying macro-habits that determine the training regime of the participants. The questions asked in this section concerned the duration of preparation for the main competition, the specifics of training management and parallel participation in other sports activities. The third section contained six questions to identify the peculiarities of training runners at different stages of preparation for competitions. The questions in this section concerned the number and duration of weekly sessions at different stages of training. In the last section of the questionnaire, the participants were offered seven questions about the peculiarities of nutrition as an element of preparation for sports competitions. Questions were asked about dietary habits, dietary compliance during preparation for competitions, assistance in diet preparation, and the risks of overeating. The surveys were conducted in compliance with the requirements of The Declaration of Helsinki (2013). Participants were guaranteed anonymity, which involved coding confidential data and refusing to use it in the final version of the study.

Participants who met all the inclusion criteria and whose information was cleared by data cleaning were eligible for the cross-sectional study. The following inclusion criteria were applied to potential study participants: providing informed consent to participate in the study; age 18 years or older; completing an online survey; successful participation in a running event, including a half marathon or ultramarathon, no later than two years before the study. Participants were also asked to select an ultramarathon event in which they were willing to participate within 6 months of participating in the study.

At the initial stage of selection, 250 candidates applied to participate in the study, 76 of whom did not meet the selection criteria and were excluded from the final sample. Candidates were excluded from the sample for the following reasons: did not provide information about their age (6); did not provide information about a possible conflict of interest (48); did not provide information about a personal dietary regimen (22); BMI ≥ 30-3. Thus, the final sample consisted of 174 participants ($N = 174$) who, according to the results of the survey, were identified as participants of half marathon competitions ($n = 32$), participants of ultramarathon competitions ($n = 76$) and participants of 10 km races ($n = 66$). Participants belonging to the ultramarathon group were further divided into subcategories depending on the distance they ran. In the analysed sample, the shortest ultramarathon distance was 50 km, and the longest was 160 km.

The study participants were offered a 5-point scale for assessing heart rate. The proposed scale is based on an understanding of the mechanism of heart rate, in particular, the idea that a slow heartbeat in response to an increase in the intensity of physical activity is a sign of exhaustion. Thus, the participants were asked to assess the level of exhaustion after a week of training on a 5-point scale, where "1" meant the lowest level of exhaustion and "5" meant the

highest. The athletes' self-assessment data were collected weekly for one month and used to calculate the median value for each group of participants. The statistical analysis of the collected data was carried out using the χ^2 test:

$$\chi^2 = \frac{\sum(O_i - E_i)^2}{E_i}, \quad (1)$$

where O_i – observed (actual) value; E_i – expected value. Participants completed three self-assessment forms that were used to analyse the following parameters: mood, motivation and sleep quality, perceived effort and heart rate. At the end of each training week, participants were asked to rate these parameters using a 5-point Likert scale, with "1" indicating the lowest level of satisfaction with the aspects under study and "5" indicating the highest level of satisfaction. Participants were also asked to rate their efforts on a 10-point Likert scale. Participants were advised to choose "10" if they deemed that their running pace or power was fully consistent with the level of effort they expended, or "1" if it was completely inconsistent. Scores from 2 to 9, inclusive, were used to more accurately indicate the level of correspondence or inconsistency between the pace and power of running and the effort expended.

Results

Of the 174 participants whose questionnaires passed the data cleaning stage and were eligible for further study, 79 were women and 95 were men. The median age of the participants was 38.5 years, and the median body weight was 65 kg. The median BMI of the study participants was 21.7 kg/m^2. Most study participants were from Austria ($n = 69$) and Germany ($n = 52$). Another 11 participants were from Belgium, the Netherlands, Brazil, Canada, Italy, Luxembourg, Poland, Spain, and the United Kingdom. A significant difference ($p = 0.008$) in the median age of the study participants identified as half marathoners, ultra-marathoners and 10 km participants was documented. The oldest in the sample were marathon and ultra-marathon runners, with a median age of 44 years.

There were also significant anthropomorphic differences among runners at different distances. There was a significant difference ($p = 0.007$) in body weight: the highest median weight was 62 kg and was recorded for runners on 10 km distances. A statistically significant ($p = 0.007$) difference was also observed among different groups of athletes: the tallest were marathon and ultra-marathon runners, whose median height was 1.8 m. When analysing the results of the survey, a statistically significant difference was also observed between the motive for training and belonging to a particular group of runners ($p < 0.001$). Among 10 km runners, the predominant motive was health, which was chosen by 54% of respondents. For 64% of the half marathon runners who took part in the survey, recreation was the key motive for running and participating in competitions. Marathon and ultra-marathon runners mostly (58%) trained and participated in competitions to achieve high results. Thus, there was a significant difference in the motivation of the study participants, which was reflected in the choice of a particular distance for the race.

There was, however, no statistically significant relationship between the following variables: participants' education and choice of the race distance ($p = 0.177$), social status and choice of the race distance ($p = 0.744$). The analysis of demographic variables revealed that one-third (34%) of the study participants had vocational or vocational-technical education, and another third (32%) had a university degree. That is, it can be argued that the level of education is one of the factors that influence the motivation to engage in sports running but does not determine the choice of a specific type of physical activity. Analysis of the social status of participants revealed that most participants (69%) were married or living with a permanent partner, 6% were divorced, 2% were widowed, and another 23% chose not to disclose their social status. Given the analysis of the social status of the study participants, it is possible to assume that being married or living with a permanent partner can be a factor in participation in training and sports competitions but does not have a statistically significant impact on the choice of a specific type of sports activity. Table 1 documents the macro habits associated with participants' training, including the duration of training for sports competitions, training management and concurrent participation in other competitive sports.

The study examined the peculiarities of training runners for different distances by the phases of preparation. The results of the comparative analysis are presented in Table 2.

Table 1. Macro habits that determine the training regime of the study participants

Parameters	General	10 km	Half marathon	Marathon/ultramarathon	Statistics
	100% ($n = 174$)	37.9% ($n = 66$)	18.4% ($n = 32$)	43.7% ($n = 76$)	
Duration of preparation for the main competition					
1-2 months	17% (30)	17% (11)	22% (7)	12% (9)	$\chi^2_{(10)} = 7.91$ $V = 0.07$ $p = 0.638$
3-4 months	56% (97)	51% (34)	61% (20)	56% (42)	
4-6 months	21% (37)	23% (15)	13% (4)	26% (20)	
7-8 months	3% (5)	4% (3)	4% (1)	2% (2)	
9-10 months	1% (2)	2% (1)	-	1% (1)	
>12 months	2% (3)	3% (2)	-	3% (2)	
Training management					
Without guidance	77% (134)	73% (48)	73% (23)	85% (65)	$\chi^2_{(4)} = 4.29$ $V = 0.09$ $p = 0.371$
Professional guidance	15% (26)	18% (12)	19% (6)	7% (5)	
Alternative leadership	8% (14)	9% (6)	8% (3)	8% (6)	

Table 1, Continued

Parameters	General	10 km	Half marathon	Marathon/ultramarathon	Statistics
	100% (*n* = 174)	37.9% (*n* = 66)	18.4% (*n* = 32)	43.7% (*n* = 76)	
Parallel participation in other sports					
Downhill skiing	15% (26)	10% (7)	17% (5)	18% (14)	$\chi^2_{(2)} = 0.48$ $V = 0.03$ $p = 0.785$
Nordic skiing	11% (19)	7% (5)	14% (5)	11% (8)	$\chi^2_{(2)} = 1.39$ $V = 0.08$ $p = 0.49$
Backcountry	5% (9)	1% (1)	6% (2)	7% (5)	$\chi^2_{(2)} = 5.90$ $V = 0.17$ $p = 0.05$
Snowboarding	7% (12)	3% (2)	11% (4)	6% (5)	$\chi^2_{(2)} = 1.36$ $V = 0.06$ $p = 0.509$
Cycling	49% (85)	46% (30)	48% (15)	52% (40)	$\chi^2_{(2)} = 1.01$ $V = 0.05$ $p = 0.5$
Running on a track/hill	32% (56)	17% (11)	29% (9)	49% (37)	$\chi^2_{(2)} = 13.23$ $V = 0.21$ $p = 0.001$
Swimming	28% (49)	29% (19)	31% (10)	24% (18)	$\chi^2_{(2)} = 3.05$ $V = 0.13$ $p = 0.22$
Hiking	32% (56)	26% (17)	35% (11)	34% (26)	$\chi^2_{(2)} = 0.38$ $V = 0.05$ $p = 0.830$
Triathlon	16% (28)	12% (8)	18% (6)	19% (14)	$\chi^2_{(2)} = 0.51$ $V = 0.05$ $p = 0.78$

Source: compiled by the author

Table 2. Peculiarities of training runners at different stages of preparation for the competition

Frequency	Units	Overall	10 km	Half marathon	Marathon/ultramarathon
		100% (174)	34% (22)	38% (12)	29% (22)
Weekly	Sessions	3 (IR 1)	2 (IR 2)	2 (IR 1)	3 (IR 2)
	km	21.6 ± 19.1	17.9 ± 12.6	18.5 ± 14.96	33.1 ± 26.2
	Hours	1.79 ± 1.01	1.1 ± 0.85	1.01 ± 0.95	1.85 ± 1.55
Daily	km	8.01 ± 5.93	6.48 ± 4.35	6.5 ± 6.65	9.20 ± 6.5
	Hours	0.25 ± 0.22	0.24 ± 0.18	0.25 ± 0.22	0.35 ± 0.25
Weekly	Sessions	3 (IR 2)	3 (IR 2)	3 (IR 2)	4 (IR 2)
	km	31.0 ± 25.01	24.9 ± 19.2	25.8 ± 23.7	44.1 ± 32.1
	Hours	4.53 ± 3.8	3.9 ± 2.95	4.10 ± 3.5	6.70 ± 4.48
Daily	km	9.1 ± 6.71	8.01 ± 5.65	8.3 ± 7.5	10.9 ± 6.71
	Hours	0.5 ± 0.4	0.4 ± 0.25	0.38 ± 0.35	0.5 ± 0.31
Weekly	Sessions	3 (IR 2)	3 (IR 2)	3 (IR 2)	4 (IR 2)
	km	32.8 ± 28.5	27.6 ± 21.5	30.6 ± 26.5	48.2 ± 34
	Hours	4.9 ± 4.1	4.1 ± 3.2	4.5 ± 3.75	7.1 ± 4.95
Daily	km	9.5 ± 7.35	8.51 ± 6.6	8.9 ± 8.35	21.1 ± 7.1
	Hours	0.51 ± 0.33	0.39 ± 0.3	0.41 ± 0.39	0.61 ± 0.35
Training condition 3 (interval training, tempo, special focus on competition, moderate to high intensity)					
Weekly	Sessions	4 (IR 2)	3 (IR 2)	3 (IR 2)	4 (IR 1)
	km	37.3 ± 31.5	29.3 ± 22.8	32.9 ± 29.1	53.5 ± 41.1
	Hours	5.75 ± 4.65	4.65 ± 3.5	5.1 ± 4.35	8.5 ± 6.35
Daily	km	10.2 ± 8.1	9.1 ± 6.5	9.8 ± 9.5	13.1 ± 7.2
	Hours	0.5 ± 0.35	0.4 ± 0.25	0.45 ± 0.4	0.5 ± 0.3
Weekly	Sessions	4 (IR 2)	3 (IR 3)	4 (IR 1)	4 (IR 2)
	km	39.6 ± 36.1	30.9 ± 27.1	36.2 ± 35.8	57.2 ± 44.1
	Hours	6.1 ± 5.5	4.8 ± 3.8	5.4 ± 5.2	9.1 ± 6.7

Table 2, Continued

Frequency	Units	Overall	10 km	Half marathon	Marathon/ultramarathon
		100% (174)	34% (22)	38% (12)	29% (22)
Daily	km	10.8 ± 8.5	9.5 ± 7.8	11.1 ± 8.5	14.5 ± 8.9
	Hours	0.5 ± 0.4	0.44 ± 0.37	0.5 ± 0.4	0.7 ± 0.45
Weekly	Sessions	3 (IR 2)	3 (IR 3)	3 (IR 3)	4 (IR 2)
	km	32.5 ± 28.1	25.8 ± 21.1	28.0 ± 25.1	48.2 ± 35.1
	Hours	4.5 ± 3.9	3.6 ± 2.9	4.0 ± 3.45	6.5 ± 4.8
Daily	km	9.5 ± 8.5	8.9 ± 8.7	9.1 ± 9.5	11.5 ± 8.7
	Hours	0.5 ± 0.4	0.4 ± 0.4	0.4 ± 0.5	0.5 ± 0.4

Note: IR – inter-quarterly range
Source: compiled by the author

Based on the data in the tables, it is possible to state that there are no significant differences in the training macro-habits of the athletes included in the sample. In particular, the average duration of preparation for major competitions for all groups of participants was 3-4 months. Most athletes (77%) trained independently, i.e., without any professional supervision. Many athletes reported a willingness to combine training for running competitions with other sports. Among the study participants, however, summer sports such as cycling (49%), track running (32%), swimming (28%), hiking (32%) and triathlon (16%) were much more common than winter sports such as snowboarding (7%), alpine skiing (15%), Nordic skiing (11%) or backcountry skiing (5%). Thus, practising other sports, especially summer sports, in parallel with training for running competitions is a common practice among the surveyed athletes, but it does not have a statistically significant impact on the choice of race distance. The only exception was the statistically significant ($p = 0.001$) relationship between running on a track or hill and the choice of race distance. The choice of this sport as a parallel physical activity was chosen by 46% of marathon and ultra-marathon runners in preparation for the competition.

After analysing the data from Table 1, the participants who chose to participate in marathon and ultra-marathon races were asked to explain their choice of running on a track or hills as a parallel physical activity In response to the questions, 53% of marathon and ultra-marathon runners said that the activity chosen as a parallel sport increases their endurance, i.e. the ability to perform a certain activity, such as running, for a long time. For 19% of marathon and ultra-marathon runners surveyed, running on a track or hills was a way to train the economical use of oxygen, which is a key factor in a successful race. Based on the results, hill or track running can be suggested as one of the strategies for training for ultra-marathon events.

Having analysed the peculiarities of athletes' training at different stages of preparation for sports competitions, the researcher noticed significant differences between the main aspects of training – the number of training sessions, km and hours – among all groups of athletes. A comparative analysis revealed that the athletes who chose to participate in marathon and ultra-marathon races chose the longest distance for training and its hourly weekly duration. Compared to other participants in the study, athletes who chose marathon and ultra-marathon events spent more time on daily training and chose to cover more distance for such training. Thus, significant differences were documented in certain aspects of the training regime of athletes who chose to participate in a marathon or ultra-marathon race. The results of the participants' weekly self-assessments are presented in Table 3.

Table 3. The well-being of the study participants during the 4-week training process

Parameters	10 km ($n = 91$)					Half marathon ($n = 89$)					Marathon/ultramarathon ($n = 65$)				
	T.1	T.2	T.3	T.4	mean	T.1	T.2	T.3	T.4	mean	T.1	T.2	T.3	T.4	mean
Mood, motivation, sleep quality	4.1	4	3.8	3.8	3.925	4	3.9	3.9	3.9	3.925	3.9	4.1	4.1	4.2	4.075
Tangibility of effort	4.5	4.5	4.3	4.2	4.375	3.9	4.1	4.1	4	4.025	3.8	4.2	4.2	4.5	4.175
Heart rhythm	9	9	8.7	8.5	8.8	8.7	8.8	9	9.1	8.9	8.7	8.8	9.1	9	8.9

Note: T – week
Source: compiled by the author

Based on the results of the comparison presented above, the median level of mood, motivation and sleep quality was higher in participants who trained for marathon and ultra-marathon races (4.075) than in participants who chose to run a 10 km race (3.925) or a half marathon (3.925). It is possible to argue that training for participation in marathon and ultra-marathon events is one of the factors that improves the psycho-emotional state and overall quality of life. The groups of participants also differed in terms of the level of effort they exerted during training and the results obtained, which were manifested in the pace and power of running. The highest median compliance, 4.375, was recorded among the participants who chose to train for a 10 km race. The median level of perceived effort among participants preparing for marathon and ultramarathon competitions was 4.175 and exceeded the median level of perceived effort among representatives preparing for half marathon competitions (4.025).

The table also shows that the lowest median heart rate responsiveness of 8.8 points was recorded in the participants who were preparing for a 10 km race. The median level of heart rate responsiveness was the same and amounted to 8.90 points for participants preparing for a half marathon and a marathon/ultra-marathon race. Based on the data collected, it is possible to argue that the peculiarities of training for marathon and ultra-marathon races, including the frequency of training, its intensity and the choice of sport for parallel training, affect the insistence, quality of sleep and motivation to train, increase the perception of the efforts made and improve the responsiveness of the heart rate, reducing physical fatigue. Based on the results obtained, the researcher conducted an additional observation of the participants of the third group to identify the peculiarities of training runners in preparation for ultramarathon competitions.

The observation determined that preparation for competitions can begin long before the event itself and be conditioned by the runner's previous sporting achievements. In the analysed sample of participants preparing for marathon and ultra-marathon races, 64% had previously been involved in other sports, including swimming, martial arts, hiking, etc. About half of the surveyed respondents continued to engage in other sports while training for marathon and ultra-marathon races. It was also found that in 76% of cases, the application for participation in national or international marathon or ultra-marathon races was preceded by years of training and participation in lower-ranked competitions. Among the surveyed participants, the average duration of training for national or international competitions was 7 years. Based on the analysis, it is recommended to start training participants for marathon and ultra-marathon races with a comprehensive assessment of their level of training, including an analysis of their previous sports experience.

Another training strategy based on the observation of athletes preparing for marathon and ultra-marathon races is to divide the training period into separate cycles that differ in duration and intensity. Table 1 shows that the period of preparation for a competition lasts on average 12 months and includes stages of varying intensity. The analysis of the table data, as well as the observation of athletes planning to take part in marathon and ultra-marathon races, was used to identify three main phases: the transition period, the preparation period and the competition itself. The transition period is the first stage of training that begins immediately after the end of the previous competition season. In the analysed sample, the average duration of the transition period was 3 weeks, during which athletes either refused to train at all or switched to health training, including low intensity running. Given the duration, the transition period can be identified as a micro-phase of the overall process of preparation for competition.

The longest stage is the preparatory stage, which for the analysed sample participants averages 7-8 months. Given the length of the preparatory stage, it is usually divided into two phases: general and special training. At the general training stage, priority is given to the volume of training, the increase of which allows to create an aerobic basis for increasing the endurance of marathon runners. At the stage of specialised training, the volume of training exercises is reduced, with more attention paid to exercises aimed at improving individual skills maintaining the intensity of the race pace. In other words, the presented model of training for marathon and ultra-marathon competitions involves a sharp change in the intensity of training before the race. This model of preparation for competitions was recorded in 63% of participants who expressed a desire to take part in a marathon or ultra-marathon race.

About a third (28%) of the analysed athletes planned their preparation for competitions considering the double periodisation. The main difference between this training system and the one described above is the existence of two peak phases. Given this periodisation, a sporting year consists of a preparatory phase, an indoor or running season, another preparatory period and an outdoor season. Although this training scheme was quite common among the analysed participants, most of them (71%) used a slightly simplified version of it. This simplified version was that the participants considered participation in the first season of the competition as preparation for the final season. Accordingly, the courses chosen by the participants for the first season were shorter than the courses chosen for the final competition. This idea is illustrated by the fact that 15% of the participants who expressed a desire to take part in half marathon events also planned to take part in the marathon and ultra-marathon races at the end of the sporting year.

For 82% of the study participants preparing for marathon and ultra-marathon races, training involves alternating between various forms of long continuous running and interval training. The so-called "light" or "recovery" runs are part of the training process for 67% of participants, especially during the transitional stage of training. Based on the observations of this category of participants, it can be concluded that low physical activity during the transition period provides a sense of recovery and increases motivation for systematic training at other stages of training. The results of the observation also suggested that the accumulated volume of low intensity running stimulates adaptation to economical running, which is an important prerequisite for participation in marathon and ultra-marathon races.

Observing participants preparing for marathon and ultra-marathon races also revealed the specifics of training to maximise the volume of training. The study discovered that 67% of participants use the 80/20 method, planning their training in such a way that 80% of the race takes place on dirt or forest trails, and 20% on asphalt tracks. By choosing such a training regime, the competitors try to increase the mechanical load, thus maximising the amount of training. Based on the results of the survey, 82% of the participants of marathon and ultra-marathon competitions paid attention to the peculiarities of the surface when planning their training, including its periodisation. Given that most races are held on paved roads, marathoners plan runs of increasing duration on asphalt or other hard surfaces. In addition to the periodisation already analysed, the study participants' preparation for marathon and ultra-marathon races included two key stages of different lengths. The first, and longest, stage involved training on dirt or forest trails to accumulate the volume of running, thus preparing the body for increased load. In the second stage of training, the study participants trained on asphalt tracks to familiarise themselves with the features of the surface on which the competition was held.

The dietary patterns of the participants in the preparation for the race at different distances were analysed. Of the 174 participants who provided information about their dietary patterns, 8 (4.6%) identified themselves as vegetarians, whose diet included a limited list of animal products (e.g. dairy products), and in rare cases, fish and seafood. Another 2 (1.1%) of respondents identified themselves as vegans, who completely excluded animal products from their diet and whose diet consisted mainly of fruits, vegetables and cereals. The overwhelming majority (94.3%) of respondents included both plant and animal products in their dietary patterns. About 94% of respondents who included protein products in their diet preferred lean protein contained in fish and poultry. The consumption of fattier meat, such as pork or beef, was limited to 1 (68.3%) or 2 (31.7%) times a week. In 87% of cases, the analysed dietary patterns were considered to be balanced with foods belonging to four main categories: fruits and vegetables as a source of vitamins, minerals and antioxidants; lean proteins, the main source of which is fish, poultry, legumes, lentils and tofu cheese; healthy fats, contained in olive oil, avocados and nuts; and healthy carbohydrates, the source of which is rice, wholemeal bread, pasta and oatmeal.

Only 23% of respondents sought professional advice in creating their dietary plans, while 77% created independent plans. Participants who developed independent nutrition plans used a variety of information sources, including the most common: advice from other athletes (64%), Internet materials (58%), information from professional newspapers, magazines, etc. (31%), and research data (12%). Most participants (71%) used information from several sources after comparing them. Preparation for sports competitions for 67% of the study participants involved changes in dietary patterns and limited consumption of certain foods to reduce body weight. Changes in dietary patterns in preparation for competitions were observed in 56% of marathon and ultra-marathon participants and 44% of 10 km runners. In 83% of cases, changes in the dietary pattern began 2 months before the start of the sporting event. Cases of changes in the dietary pattern earlier (8%) or later (9%) than 2 months before the competition were less common, indicating that athletes systematically prepare for sports competitions. Despite a balanced approach to diet, 17% of participants admitted to overeating, especially in the week prior to the sporting event. Occasional overeating was more common among marathon (23%) and ultra-marathon (31%) participants than among 10 km participants (46%). This difference can be attributed to a higher number of marathon and ultra-marathon participants who restrict their diet before sporting events.

Thus, the study demonstrated that the peculiarities of training runners for marathon and ultra-marathon distances differ from the peculiarities of training participants of 10 km or half-marathon races. One of the characteristic features of marathon training and half marathon competitions was parallel training in other sports, mainly summer sports. Unlike participants of shorter distance races, participants of marathon and ultra-marathon competitions had previous experience in other sports, which they relied on in the preparation process. A characteristic feature of the training of participants in marathon and ultra-marathon races was also the periodisation of the training process, which most often included a recovery period, preparation for the competition and direct participation in the competition. Some participants used a double periodisation, however, given the competition distances and the amount of load, this periodisation was less common in the study sample. In addition to these features, the process of preparation for marathon and ultra-marathon races included alternating running on dirt or forest tracks to increase the volume of training and running on asphalt tracks to study the characteristics of the surface on which the competition is held.

Discussion

The conclusions made in this study regarding the psychophysiological characteristics of marathon and ultra-marathon runners were partially confirmed in previous studies by A.M. Armento *et al.* (2023), who analysed a sample of 59 participants preparing for a 10 km race, a half marathon and a marathon or ultra-marathon. Based on the data obtained, the researchers concluded that certain physiological characteristics, such as weight and BMI, of marathon and ultra-marathon participants differed from those of participants in races at other distances. A significant characteristic of marathon and ultra-marathon participants was that they tried to control their body weight to achieve optimal performance using diet and other means. However, in contrast to marathon competitors, ultra-marathon runners were more likely to report binge eating in the four weeks before the race.

The difference between ultra-marathon and other distance runners exists not only at the level of individual systems but also at the cellular level, as was shown in Z. Wicik *et al.* (2023). To confirm their hypothesis, the researchers analysed plasma samples from 22 ultramarathoners before and after the competition. Using Mann-Whitney analysis, the researchers identified 1,601 active metabolites with at least twofold downregulation after high-intensity running. Based on these findings, the researchers concluded that a twofold increase in metabolites after running is a potential marker of acute physical exertion, which may be closely associated with cardiovascular disease. Thus, it can be argued that training for and participation in ultra-marathon races can have an impact on the health of athletes, which was also concluded by K. Wirnitzer *et al.* (2022).

This idea was confirmed by V. Scheer & D. Rojas-Valverde (2021) in a secondary analysis of scientific papers published since 2016. According to the researchers, participation in marathon and ultra-marathon events does not pose a greater threat than participation in races at other distances but is associated with an increased risk of certain long-term effects on the overall health of athletes. Analysing the available data, scientists have concluded that such long-term risks include the following cardiovascular diseases associated with acute changes in biomarkers of cardiac damage, ventricular dysfunction, myocardial remodelling, etc.; acute kidney disease; severe muscle damage that may be asymptomatic for some time; and respiratory diseases caused by chronic airway inflammation, including exercise asthma, acute bronchial epithelial cell damage, respiratory muscle fatigue, etc. According to V. Scheer *et al.* (2021), who analysed data from 218 academic sources published over the past 35 years, the highest risk of these diseases is observed among young athletes and women. Similar conclusions were drawn by N. Sewry *et al.* (2024),

who analysed data from 103, 131 participants in the 90 km Friendship Run between 2014 and 2019 and concluded that women are at a higher risk of seeking medical care as a result of participating in a marathon race. The cited studies partially confirm the opinion proposed in this paper on the need for a detailed analysis of the profile of athletes, including age, gender and previous experience, before planning preparation for participation in marathon and ultra-marathon events. Understanding the factors that influence the physical condition of athletes and determining the outcome of competitions helps to plan training in such a way as to minimise the existing risks.

According to the study, the psycho-emotional state of athletes is as important as the physical state for maximising efforts in marathon and ultra-marathon races. Confirmation of this opinion was found in the study by P.T. Nikolaidis *et al.* (2023), who conducted a secondary analysis of 49 sources published since 2016 and concluded that there was a statistically significant positive relationship between sleep duration and quality and athletic performance. Similar conclusions were reached by N.V.S. Daniel *et al.* (2024), who analysed the relationship between sleep quality and performance in a sample of 38 ultra-marathoners over a distance of 217 km and 59 support team members. The clinical study indicated that sufficient, high-quality sleep increased the athletes' chances of reaching the final of the competition. Both studies cited, however, highlighted the fact that, compared to shorter-distance runners, ultra-marathon competitors are at increased risk of sleep deprivation, a condition that can last for several days before the event. Further analysis revealed some contradictions between previous studies and the data presented in this paper. In the current study, for example, participants in ultramarathon competitions had a higher median level of sleep quality than participants in shorter distances. This discrepancy can be explained by the fact that the present study was conducted a long time before the competition, meaning that the participants did not yet experience any excitement that could affect their sleep quality.

The study, however, fully coincides with the results obtained by M. Kazimierczak *et al.* (2020), according to which the psycho-emotional state of athletes is closely related to their physical condition and affects their sports performance. The conclusions drawn from the analysis of the data of the participants of the Karkonoski Winter Marathon in Poland confirm the need for an integrated approach to the preparation of athletes for participation in marathon and ultramarathon races, as stated in this paper. Comprehensive training of athletes can significantly reduce the risk of premature fatigue, which is formed under the influence of a combination of factors of different natures. This opinion has also appeared in previous studies, for example, A. Garbisu-Hualde & J. Santos-Concejero (2020) studied the nature of fatigue in a sample of 1,002 participants who had experience in racing at different distances. According to scientists, fatigue, which can lead to withdrawal from competitions or poor performance, is the result of not only physiological but also neuromuscular, biochemical, and cognitive exhaustion. Thus, when training runners, it is important to consider various negative factors that have a potential impact on the result and plan strategies to minimise their impact.

Some of the training strategies proposed in this study were confirmed in previous studies, including C. Llanos-Lagos *et al.* (2024). A comparative analysis of studies that included 195 moderately trained, 272 well-trained and 185 highly trained athletes proved the high efficiency of plyometric training compared to the constant use of high or moderate load. According to the researchers, the use of exercises during which the muscles exert maximum force in a short period allows for an increase in speed and power capacity, i.e., improves the runner's endurance. The proposed strategy of training athletes coincides with the recommendations proposed in this study to focus on training stability and endurance of athletes who plan to participate in marathon and ultramarathon competitions. Thus, previous studies partially or fully support the recommendations for comprehensive training of participants in marathon and ultramarathon races. Such preparation includes a detailed analysis of the competitor's profile to individualise training strategies; accounting for both physiological and psycho-emotional aspects of training and alternating exercises of varying intensity to increase the runner's stability and endurance.

Conclusions

The main characteristics of the training process are increased mileage (more than 70 km per week), an emphasis on oxygen conservation and low BMI among athletes. Women athletes focus more on integrating running into their lifestyle, while men focus on the effectiveness of their efforts. Motivation, training structure and training periods differ depending on the gender, age and social status of runners. The study revealed distinctive differences in the profile of athletes training for ultramarathon races and athletes who chose other distances. A characteristic difference between ultramarathon athletes is a higher average age and previous experience in other sports. As opposed to runners on other distances, ultra-marathoners often integrate other sports, mainly summer sports, into their training process. On average, the training cycle for an ultra-marathon lasts 12 months and is divided into three phases of varying length and intensity. Some athletes choose a double-cycle model, which involves participating in two key competitions a year. This model, however, often takes on a simplistic form when participation in a competition in the middle of the sports season is seen as preparation for the competition at the end of the season, which, accordingly, influences the choice of a shorter distance.

The vast majority of ultrarunners have a diet that includes both plant and animal products but with a preference for vegetables and fruits and foods containing light proteins, healthy fats and healthy carbohydrates. In contrast to participants preparing for shorter distances, ultra-marathoners are more likely to revise their dietary patterns to reduce their body weight. Stricter dietary restrictions among ultra-marathoners lead to more frequent binge eating, especially in the weeks before the main event. The paper considered an integrated approach to training runners for participation in ultramarathon competitions, which accounts for physiological, psycho-emotional and other factors that affect sports achievements. An important stage of preparation is planning the sports season in such a way that the body recovers from the previous competitive

period and accumulates a sufficient amount of slow and medium pace running. Training strategies include a combination of continuous low intensity running and interval training, alternating tracks with different surfaces to adapt to mechanical stress, and combining running with other sports such as swimming or cycling.

The study has several limitations, including a small sample of participants living exclusively in European countries, which makes it difficult to use the proposed strategies in other regions without their prior verification. Another limitation is that the research was conducted before the competition, which makes it impossible to assess the physiological and psychological changes of participants during and after ultramarathon participation. In future studies, these limitations can be overcome by expanding the geographical scope of the sample and focusing on the physiological and psycho-emotional transformations that occur with participants during and after ultramarathon running.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Armento, A.M., VanBaak, K.D., Seehusen, C.N., & Howell, D.R. (2023). Differences in training and health characteristics between trail ultrarunners and shorter distance runners. *Wilderness & Environmental Medicine*, 34(2), 182-186. doi: 10.1016/j.wem.2022.12.002.

[2] Besomi, M., Leppe, J., Amuri-Stecca, M.V., Hooper, T.L., & Sizer, P.S. (2019). Training volume and previous injury as associated factors for running-related injuries by race distance: A cross-sectional study. *Journal of Human Sport and Exercise*, 14(3), 549-559. doi: 10.14198/jhse.2019.143.06.

[3] Boullosa, D., Esteve-Lanao, J., Casado, A., Peyre-Tartaruga, L.A., da Rosa, R.G., & Del Coso, J. (2020). Factors affecting training and physical performance in recreational endurance runners. *Sports*, 8(3), article number 35. doi: 10.3390/sports8030035.

[4] Daniel, N.V.S., Barreira, J., Bastos, A.M., dos Santos, N.E., Franco, B., Esteves, A.M., & Belli, T. (2024). Ultramarathon runners and support crew: The influence of pre-race sleep and training profiles on performance in a 27-km mountain race. *Sleep Medicine*, 120, 85-89. doi: 10.1016/j.sleep.2024.06.005.

[5] Garbisu-Hualde, A., & Santos-Concejero, J. (2020). What are the limiting factors during an ultra-marathon? A systematic review of the scientific literature. *Journal of Human Kinetics*, 72, 129-139. doi: 10.2478/hukin-2019-0102.

[6] Haugen, T., Sandbakk, Ø., Seiler, S., & Tønnessen, E. (2022). The training characteristics of world-class distance runners: An integration of scientific literature and results-proven practice. *Sports Medicine – Open*, 8, article number 46. doi: 10.1186/s40798-022-00438-7.

[7] IAU records. (n.d.). Retrieved from https://iau-ultramarathon.org/iau-records.html.

[8] Kazimierczak, M., Dabrowska, A., Adamczewska, K., & Malchrowicz-Mosko, E. (2020). The impact of modern ultramarathons on shaping the social identity of runners. The case study of Karkonosze winter ultramarathon. *International Journal of Environmental Research and Public Health*, 17(1), article number 116. doi: 10.3390/ijerph17010116.

[9] Knechtle, B., & Nikolaidis, P. (2018). Physiology and pathophysiology in ultra-marathon running. *Frontiers in Psychology*, 9, article number 634. doi: 10.3389/fphys.2018.00634.

[10] Knechtle, B., Tanous, D., Thuany, M., Motevalli, M., Wirnitzer, G., Leitzmann, C., Weiss, K., Rosemann, T., & Wirnitzer, K. (2024). Differences in training characteristics of recreational endurance runners by race distance – results from the NURMI study (step 2). *Frontiers in Psychology*, 14, article number 1269374. doi: 10.3389/fpsyg.2023.1269374.

[11] Llanos-Lagos, C., Ramirez-Campillo, R., Moran, J., & Saez de Villarreal, E. (2024). Effect of strength training programs in middle- and long-distance runners' economy at different running speeds: A systematic review with meta-analysis. *Sports Medicine*, 54, 895-932. doi: 10.1007/s40279-023-01978-y.

[12] Motevalli, M., Tanous, D., Wirnitzer, G., Leitzmann, C., Rosemann, T., & Knechtle, B. (2022). Sex differences in racing history of recreational 10 km to ultra runners (part B) – results from the NURMI study (step 2). *International Journal of Research and Public Health*, 19, article number 3291. doi: 10.3390/ijerph192013291.

[13] Nikolaidis, P.T., Weiss, K., Knechtle, B., & Trakada, G. (2023). Sleep in marathon and ultramarathon runners: A brief narrative review. *Frontiers in Neurology*, 14, article number 1217788. doi: 10.3389/fneur.2023.1217788.

[14] Papadimitriou, K. (2024). Intensity and pace calculation of ultra short race pace training (USRPT) in swimming – take-home messages and statements for swimming coaches. *Sports*, 12(8), article number 227. doi: 10.3390/sports12080227.

[15] Scheer, V., & Rojas-Valverde, D. (2021). Long-term health issues in ultraendurance runners: Should we be concerned? *BMJ Open Sport & Exercise Medicine*, 7(3), article number e001131. doi: 10.1136/bmjsem-2021-001131.

[16] Scheer, V., Tiller, N.B., Doutreleau, S., Khodaee, M., Knechtle, B., Pasternak, A., & Rojas-Valverde, D. (2021). Potential long-term health problems associated with ultra-endurance running: A narrative review. *Sports Medicine*, 52, 725-740. doi: 10.1007/s40279-021-01561-3.

[17] Sewry, N., Boulter, J., Seocharan, I., Dyer, M., Jordaan, E., & Schwellnus, M. (2024). Risk factors associated with medical encounters in ultramarathon race starters – data from 103,131 race starters over 90 km: SAFER XLI. *Journal of Science and Medicine in Sport*, 27(11), 753-758. doi: 10.1016/j.jsams.2024.07.008.

[18] The Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki/.

[19] Thuany, M., Gomes, T., & Almeida, M. (2020). Is there any difference between "amateur" and "recreational" runners? A latent class analysis. *Motriz: Revista de Educação Física*, 26(4), article number e10200140. doi: 10.1590/s1980-65742020000400140.
[20] Thuany, M., Gomes, T.N., Villiger, E., Weiss, K., Scheer, V., Nikolaidis, P., & Knechtle, B. (2022). Trends in participation, sex differences and age of peak performance in time-limited ultramarathon events: A secular analysis. *Medicina*, 58(3), article number 366. doi: 10.3390/medicina58030366.
[21] Wicik, Z., Ciechanowicz, A., Marszalek, M., Keswani, D., Wiecha, S., Eyileten-Postula, C., Malek, M., Kucia, M., & Postula, M. (2023). Ultramarathon induces metabolite changes associated with the pathophysiology of cardiovascular diseases – in silico and in vivo analysis. *European Journal of Preventive Cardiology*, 30(1). doi: 10.1093/eurjpc/zwad125.306.
[22] Wirnitzer, K., Boldt, P., Wirnitzer, G., Leitzmann, C., Tanous, D., & Motevalli, M. (2022). Health status of recreational runners over 10-km up to ultra-marathon distance based on data of the NURMI study step 2. *Scientific Reports*, 12, article number 10295. doi: 10.1038/s41598-022-13844-4.

Особливості тренування бігунів під час підготовки до ультрамарафонських дистанцій

Віталій Поліщук

Кандидат наук з фізичного виховання і спорту, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0002-3526-5098

Анотація. Метою дослідження було проаналізувати особливості тренування атлетів під час підготовки до забігу на ультрамарафонські дистанції. Дослідження враховувало три фази підготовки до спортивних змагань – перехід та відновлення, центральний підготовчий етап та основний змагальний етап – та включало вибірку із 174 учасників з Європи та інших країн. У ході дослідження виявлено фізіологічні та психоемоційні особливості учасників ультрамарафону, які відрізняють їх від учасників забігів на інші дистанції та обумовлюють особливості тренувального процесу. До таких особливостей належать нижчий індекс маси тіла ультрамарафонців та активне прагнення до її зменшення для досягнення кращих результатів, вищий середній вік учасників ультрамарафонських змагань, попередній досвід занять іншими видами спорту та інтеграція окремих видів спорту, переважно літніх, у процес підготовки до забігу на довгі дистанції. Спираючись на дані профілів 65 учасників, які готувалися до забігу на ультрамарафонські дистанції, проаналізовано наступні стратегії підготовки: попередній аналіз профілю атлета для індивідуалізації тренувальних зусиль; планування спортивного сезону з врахуванням трьох фаз підготовки (відновлення, безпосередньо підготовка та участь у змаганні) або подвійного тренувального циклу; комбінація безперервного бігу низької інтенсивності та інтервальних тренувань; використання трас з різним покриттям для адаптації до механічних навантажень; паралельне тренування з інших видів спорту для вдосконалення навичок стійкості та витривалості атлетів; забезпечення тривалого та якісного сну для запобігання когнітивного та психоемоційного виснаження учасників змагань. Рекомендації можуть бути застосовані для подальшого розвитку марафонського руху в країні та за її межами

Ключові слова: спортивний сезон; профіль атлета; витривалість; економія кисню; антропометричні показники; мотивація

THEORY and PRACTICE
of Physical Culture and Sports

https://tppcs.com.ua/
Vol. 3, No. 2, 2024

Received: 27.06.2024. Revised: 23.10.2024. Accepted: 12.12.2024

UDC 797.2:615.8

DOI: 10.69587/tppcs/2.2024.74

Swimming in the rehabilitation and recreation of professional athletes

Serhii Savchuk*

PhD in Physical Education and Sport, Associate Professor
Lutsk National Technical University
43018, 75 Lvivska Str., Lutsk, Ukraine
https://orcid.org/0000-0003-0422-8582

Volodymyr Kovalchuk

PhD in Pedagogy, Associate Professor
Lutsk National Technical University
43018, 75 Lvivska Str., Lutsk, Ukraine
https://orcid.org/0000-0001-5888-7458

Abstract. Swimming plays a significant role in professional athletes' recovery, contributing to physical and psycho-emotional rehabilitation following competitions and injuries. However, research on the use of swimming for rehabilitation and recreation among athletes remains insufficiently developed, highlighting the relevance of this study and its necessity in sports practice. This study aimed to assess the effectiveness of aquatic exercises in rehabilitation programmes for professional athletes with mild to moderate injuries, compared to traditional rehabilitation methods. Additionally, the study sought to determine the conditions under which swimming is most appropriate and effective for improving physical performance, reducing pain, and enhancing participants' motivation. The study involved 120 athletes from various sports, who completed an 8-week aquatic exercise programme. The programme included aerobic, stretching, and recovery exercises, conducted four times per week with gradually increasing intensity. Evaluation of the results was conducted through measurements of physical indicators (strength, endurance, flexibility), analysis of subjective well-being, and the use of a visual analogue scale to assess pain levels. The findings indicated that endurance increased by 28%, flexibility by 20%, and muscle strength by 15%. The most significant improvements were observed in athletes with a moderate level of training. However, effectiveness was lower among participants with severe injuries, highlighting the need for an individualised approach that considers the specifics of each injury. The results confirm the appropriateness of incorporating swimming into rehabilitation programmes for athletes recovering from general injuries and overtraining. The practical significance of the study lies in the development of recommendations for sports physicians and coaches regarding the use of swimming as an effective means of restoring athletic performance

Keywords: physical recovery; aerobic exercise; sports adaptation; recovery methods; functional indicators

Introduction

Swimming is one of the most effective methods of physical rehabilitation and recreation for athletes, due to its unique properties, which include reduced joint stress, improved circulation, and facilitation of muscle function recovery. Recent research highlights the importance of aquatic exercises for post-injury rehabilitation and physical condition improvement, but many aspects of this topic remain underresearched. According to A. Conceição *et al.* (2022), a study analysing changes in muscle activity under various stability conditions on aquatic platforms demonstrated the high effectiveness of swimming in improving coordination and muscle strength. This indicates the significant potential of the aquatic environment in rehabilitation programmes, especially for professional athletes. The research by S.J. Bromley *et al.* (2018) revealed the importance of epidemiological studies for understanding the relationship between sports injuries and recovery methods. The authors emphasised the need to develop unified methodologies for assessing the role of swimming in athlete rehabilitation. The approach to rehabilitation through the application of aquatic exercises is becoming increasingly popular. Based on the research of S. Naz *et al.* (2024), a systematic analysis showed that aquatic therapy significantly reduces pain and improves functional performance. However, there remains

Suggested Citation: Savchuk, S., & Kovalchuk, V. (2024). Swimming in the rehabilitation and recreation of professional athletes. *Theory and Practice of Physical Culture and Sports*, 3(2), 74-83. doi: 10.69587/tppcs/2.2024.74.

*Corresponding author

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

a need for a detailed analysis of the physiological changes that occur during such training.

A review by R. Braun-Trocchio *et al.* (2022) supported the effectiveness of alternating hot and cold water therapy in athlete recovery, although the authors noted a lack of long-term studies to confirm their efficacy. Contemporary studies, such as R. Braun-Trocchio *et al.* (2022), indicated a growing popularity of aquatic therapies among athletes due to their ability to relax muscles and reduce pain. However, the absence of standardised guidelines for conducting rehabilitation programmes in aquatic environments creates a need for further research. Research by B. Najafi Ghagholestani *et al.* (2022) demonstrated that combining dynamic stabilisation with aquatic exercises significantly improves control over the lumbopelvic region and reduces pain in patients with non-specific back pain. This suggests the potential of aquatic exercises not only for post-injury rehabilitation but also for preventing recurrent injuries. Researchers C. Hsu *et al.* (2024) noted that swimming is an important rehabilitation tool for reducing the risk of lower back injuries in professional swimmers. They emphasised anatomical features and approaches to reducing the load on the lower back. S. Kumar *et al.* (2021) found that swimming promotes the regeneration of nerve fibres after injuries due to the activation of metabolic processes. Their results confirmed that aquatic exercises have the potential not only for physical recovery but also for neurophysiological recovery of the body. The study by R.B.T. Sette *et al.* (2024) found that high-intensity interval training in aquatic environments can improve cardiorespiratory fitness and physical performance in middle-aged and older adults. These results are crucial for optimising rehabilitation programmes considering the age-related characteristics of athletes. According to J.E. Moreno *et al.* (2022), the use of high-intensity interval training in an aquatic environment allows for significant improvements in the physical performance of athletes but requires further study to adapt to specific sports. The research of L.S. Andrade *et al.* (2020) showed that aquatic training can positively impact cardiorespiratory function and neuromuscular activity in older women. Although the main focus was on the elderly, the study's findings have practical value for professional sports. Additionally, the research by K. Ábel *et al.* (2022) demonstrated that manipulating swimming pace can significantly affect athletes' psychological states, indicating the potential of swimming to improve psychological well-being.

Thus, the contemporary literature highlighted a wide range of benefits associated with swimming as a rehabilitation tool. However, significant gaps remain in the standardisation of its application. Despite the positive experience of using swimming in rehabilitation programmes, the specific techniques adapted to the needs of professional athletes in various sports are insufficiently studied. The question of how the duration, intensity, and form of aquatic exercises affect the restoration of functional fitness, psychological state, and overall physical condition of athletes remains open. There is also a lack of consistent recommendations for the use of swimming in the context of rehabilitation after various types of injuries. In this regard, there is a need for a detailed analysis of the effectiveness of swimming as a universal means of rehabilitation and recreation, including determining its impact on key physiological and psychological aspects of recovery. This study aimed to evaluate the effectiveness of aquatic exercises in rehabilitation programmes for professional athletes with mild to moderate injuries, compared to traditional rehabilitation methods, as well as to determine the conditions under which the application of swimming is most appropriate and effective for improving physical performance, reducing pain, and increasing participant motivation.

Materials and Methods

The study was conducted in three rehabilitation centres with swimming pools located in Kyiv: the Olympic Style Sports Complex, the Government Institution "Ukrainian Medical Centre of Sports Medicine Ministry of Youth and Sports of Ukraine", and the Kyiv Sports Medicine Centre. Participants were involved for eight weeks, from January to February 2024. The choice of these centres was due to the presence of the necessary conditions for conducting water workouts, such as equipped pools, qualified instructors, and access to medical support. Particular attention was paid to monitoring the water temperature and ensuring optimal conditions for the safe conduct of classes. One hundred and twenty professional athletes aged 18-35 were involved in the study ($N = 120$). The sample included individuals with mild or moderate injuries, no contraindications to water activities, and a willingness to participate in the research. Participants were divided into an experimental group and a control group. The control group performed traditional rehabilitation methods such as therapeutic exercise, mechanotherapy, and massage. The experimental group participated in aquatic exercises that included aerobic, stretching, and recovery training. The selection of participants also took into account their level of sports training to ensure the homogeneity of the groups. The study was conducted following ethical standards, in particular the principles of the The Declaration of Helsinki (2013), with informed consent and data confidentiality ensured.

The programme for the experimental group was developed based on recommendations from previous studies (Moreno *et al.*, 2022; Sette *et al.*, 2024). Participants exercised 4 times a week for 60 minutes, with a gradual increase in training intensity. The exercise complex included distance swimming to improve the cardiovascular system, stretching exercises to increase flexibility, and relaxation exercises to reduce muscle tone. Additionally, the programme included exercises to develop proprioception, which is important for preventing re-injury. To assess participants' physical performance, the Cooper test was used to evaluate endurance, a sit-and-reach test for flexibility, and a hand dynamometer to assess muscle strength.

Subjective well-being was assessed using a questionnaire and a visual analogue scale (VAS), which was used to determine the level of pain. The questionnaire consisted of questions aimed at assessing the effectiveness of traditional and aquatic rehabilitation methods, including questions about reducing pain, improving overall physical condition, and the subjective well-being of participants. Additionally, the questionnaire included sections for collecting information about the level of motivation to exercise, satisfaction with rehabilitation procedures, and their impact on emotional state, which allowed for a qualitative analysis of participants' subjective perception of rehabilitation measures.

The collected data was analysed using a Student's *t* test to compare changes in physical parameters between the experimental and control groups. Furthermore, the Mann-Whitney U-test was used to assess the subjective perception of methods, allowing for the identification of differences in the level of motivation and satisfaction among participants. To identify correlations between physical and subjective indicators, regression analysis methods were used, which made it possible to establish the relationship between the type of exercise and the results achieved. The application of such methods allowed for an objective assessment of the effectiveness of swimming as part of rehabilitation programmes and confirmed its advantages compared to traditional methods.

Results

Swimming as an effective rehabilitation tool

Swimming has proven to be an effective method of recovery for athletes who have experienced injuries or overtraining. This is due to the unique properties of the aquatic environment, which allow for a significant reduction in the impact of gravity, reducing the load on joints and muscles, which is especially important during rehabilitation. Athletes can perform a wide range of movements without the risk of additional injuries or overstrain. Water also provides natural resistance, which helps to strengthen muscles and increase overall physical endurance, while providing a relaxation effect. The application of aquatic exercises also positively affects blood circulation, stimulating the improvement of oxygen and nutrient delivery to tissues. This is critical for the regeneration of damaged tissues and the restoration of muscle and joint function. Participants in the experimental group, who underwent an 8-week programme, demonstrated a significant improvement in endurance, strength, and flexibility. In particular, according to the Cooper test results, the endurance level increased by 28%, indicating a significant improvement in the functional state of the cardiovascular system.

Additionally, a 72% improvement in muscle strength was observed in the experimental group, confirming the effectiveness of aerobic and strength exercises performed in water. These exercises were particularly beneficial for athletes recovering from lower limb injuries. Similar results align with the findings of R.B.T. Sette *et al*. (2024), who emphasise the importance of using the aquatic environment for comprehensive recovery. Concurrently, swimming positively influenced the psychological state of participants. According to the survey, 88% of athletes reported that regular water workouts reduced feelings of fatigue and improved their physical condition. This once again underlines that swimming is not only physically beneficial but also helps improve overall well-being and motivation for rehabilitation.

The impact of aquatic exercises on pain reduction and flexibility improvement

Aquatic exercises, actively used in rehabilitation programmes, demonstrate high effectiveness in reducing pain. Participants in the experimental group who performed aerobic, stretching, and relaxation exercises in a water environment showed a significant reduction in pain levels on the VAS. Specifically, the average pain level decreased by 35%. This result can be explained by the unique properties of the aquatic environment, which reduces the mechanical load on joints and muscles, thereby reducing tension and alleviating pain. The properties of water, such as hydrostatic pressure and buoyancy, contribute to the reduction of pain as they create conditions for a uniform distribution of the load on the body. Similar conclusions are confirmed in the research of B. Najafi Ghagholestani *et al*. (2022), who established that water exercises not only reduce pain levels but also improve the psychological state of patients. This is especially important for athletes who are going through a long rehabilitation period. The relaxation effect of the aquatic environment allows for a reduction in muscle tone, and regular activity in water stimulates the production of endorphins, which contribute to pain relief. Thus, water exercises become an indispensable component of comprehensive therapy aimed at relieving pain.

Flexibility is an important component of an athlete's physical fitness, especially during the rehabilitation period after injuries or overtraining. The results of the sit-and-reach test, conducted before and after the 8-week programme, indicate an improvement in the flexibility of participants in the experimental group by 20%. This confirms the effectiveness of aquatic exercises for developing the mobility and elasticity of muscles. According to R.B.T. Sette *et al*. (2024), regular stretching exercises in water significantly improve flexibility by reducing the risk of injury during training. Water reduces joint stress and allows for a greater range of motion, increasing the effectiveness of stretching. Additionally, hydrotherapy improves blood circulation, promoting faster muscle recovery after exertion. Flexibility is also a crucial aspect in preventing re-injuries. As J.E. Moreno *et al*. (2022) noted, water exercises aimed at developing mobility are effective in strengthening the musculoskeletal system, preventing re-injuries, and ensuring joint stability. Participants in the experimental group performed exercises using swimming boards, which allowed them to focus on stretching individual muscle groups.

It is worth noting that the reduction in pain and improvement in flexibility were achieved through a comprehensive approach to training. The aquatic exercise programme included elements of aerobic exercise, which improved blood circulation and stimulated metabolic processes, as well as stretching exercises aimed at increasing joint mobility. The combination of these elements ensured the simultaneous achievement of several therapeutic goals, making aquatic exercises an effective tool in rehabilitation. A crucial aspect of the effectiveness of aquatic exercises is the gradual increase in training intensity. Participants in the experimental group began with basic exercises that were gradually made more complex, including elements of hydrokinesitherapy. This allowed for the adaptation of training to the level of each participant, contributing to maximum improvement in physical performance. The control group, which used traditional rehabilitation methods such as massage and therapeutic exercise, did not demonstrate such significant changes in flexibility and pain reduction. The average reduction in pain in the control group was only 18%, and the improvement in flexibility was 10%. This confirms the advantages of aquatic exercises compared to traditional methods. Figure 1 presents the results of the assessment of changes in pain levels on the VAS scale

and the improvement in flexibility of participants in the experimental group before and after the completion of the 8-week swimming rehabilitation programme. The graph shows that the level of pain decreased by 35%, while the flexibility indicators, according to the sit-and-reach test results, increased by 20%.

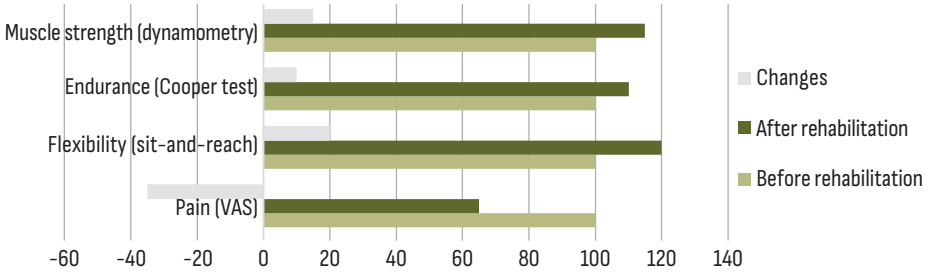

Figure 1. Results of pain reduction and improvement in flexibility, %
Source: created by the authors

A survey of participants in the experimental group revealed a high level of satisfaction with participation in the 8-week rehabilitation programme using aquatic exercises. Participants rated the overall effectiveness of the programme as 4.8 out of 5 possible points. The application of innovative rehabilitation methods contributes not only to physical but also to psycho-emotional recovery. This was confirmed by the results of the study, where most participants in the experimental group noted that aquatic exercises helped them reduce stress levels and improve overall well-being. Table 1 presents the results of a survey of participants in the experimental group, which allows for an analysis of their perception of the rehabilitation programme and an assessment of the subjective attitude towards the effectiveness of aquatic exercises, overall well-being after the programme, and the impact on the psycho-emotional state. The data demonstrates a high level of participant satisfaction and confirms the positive effect of using aquatic exercises in rehabilitation programmes.

Table 1. Results of a survey of participants in the experimental group

Parameter	Rating (out of 5 points)
Overall effectiveness of the programme	4.8
Satisfaction with well-being after the programme	4.6
Improvement in psycho-emotional state	4.7
Impact of aquatic exercises on stress reduction	4.5

Source: created by the authors

One important aspect noted by participants was an increased level of motivation for rehabilitation due to the interest and variety of aquatic exercises. Most participants reported that exercising in water seemed less exhausting compared to traditional rehabilitation methods such as mechanotherapy or land-based physical exercises. At the same time, they reported a decrease in anxiety levels and an improvement in mood after each workout. Participants also noted positive changes in their physical sensations during and after exercise. The main benefits they identified included reduced muscle and joint pain, ease of movement, and a feeling of relaxation. According to the VAS scale, the average pain level decreased by 35%, indicating the high effectiveness of aquatic exercises for relieving muscle tension. This is supported by the data of J.E. Moreno *et al.* (2022), according to which swimming and other exercises in the water contribute to reducing the load on the musculoskeletal system and improving blood circulation. In addition to physical recovery, participants noted a significant improvement in their psycho-emotional state. Many of them emphasised that being in a water environment created a relaxation effect, and smooth, repetitive movements contributed to calming and reducing stress levels. The sessions took place in a relaxed atmosphere, which, according to the participants, helped them to concentrate on the recovery process and not feel additional pressure.

Aquatic exercises also positively influenced the motivation of participants. Most participants noted that exercising in a water environment sparked interest and a desire to achieve better results. Due to the dynamics and variety of exercises, training was perceived as a pleasant pastime rather than a difficult rehabilitation procedure. Participants also emphasised the importance of support from instructors and group interaction, which contributed to creating a positive emotional climate during training. Questionnaires completed after the end of the programme indicate a significant improvement in the overall well-being of participants. In particular, over 80% of respondents rated their condition as "good" or "excellent" after the end of the 8-week programme, while before its start, only about 40% did so. Participants emphasised that the reduction in pain, increased mobility, and feeling of ease of movement positively influenced their overall well-being. It should be noted that most participants indicated that the results of the programme exceeded their expectations. Before starting rehabilitation, many doubted the effectiveness of aquatic exercises, but after a few sessions, they noticed a significant improvement in their condition. The high subjective assessment of the effectiveness of rehabilitation methods suggests that

aquatic exercises can be not only a tool for recovery but also a powerful motivator for further physical development. Participants who previously underwent rehabilitation using traditional methods, such as therapeutic exercise or mechanotherapy, noted the advantages of aquatic exercises.

Specifically, they indicated a lower level of discomfort during exercise and greater effectiveness in reducing pain. Figure 2 presents the results of a survey of participants in the control and experimental groups, which allows for an analysis of their perception of the effectiveness of the rehabilitation programme using aquatic exercises. The graph demonstrates key aspects such as the level of satisfaction, reduction in pain, improvement in overall well-being, and level of motivation for further training. The data illustrates the positive impact of aquatic exercises on both the physical condition of participants and their psycho-emotional comfort, confirming the high effectiveness of an integrated approach to rehabilitation.

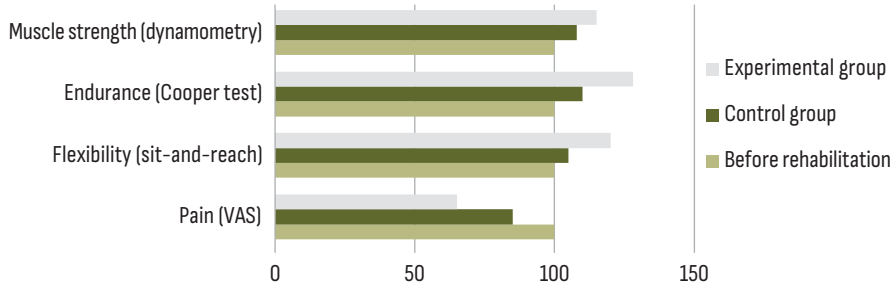

Figure 2. Results of a survey of the experimental and control groups, %
Source: created by the authors

A comparison of the results of the control and experimental groups clearly demonstrated the advantages of aquatic rehabilitation methods. Participants in the control group, who underwent traditional procedures such as therapeutic exercise, massage, and mechanotherapy, demonstrated only moderate improvements in physical and psycho-emotional indicators. For example, the reduction in pain in this group was on average 15%, while in the experimental group, this figure reached 35%. This indicates that traditional methods are less effective in relieving muscle tension and improving blood circulation. Participants in the experimental group who performed aquatic exercises demonstrated significantly greater progress in all key indicators. Endurance increased by 28%, flexibility by 20%, and muscle strength by 15%. Moreover, the subjective assessment of wellbeing among participants in the experimental group was significantly higher than in the control group. According to participants, aquatic exercises created comfortable conditions for rehabilitation and helped to avoid additional stress associated with physical exertion. Statistical analysis using Student's t test confirmed a significant difference between the groups for all key indicators ($p < 0.05$).

For example, the average pain level on the VAS scale in the control group decreased from 7.2 to 6.1 points, while in the experimental group, it decreased from 7.4 to 4.8 points. Similarly, in the sit-and-reach test, the improvement in flexibility in the control group was only 10%, while in the experimental group, it was 20%. The psycho-emotional state of the participants also differed significantly. Participants in the control group more often reported fatigue and anxiety after traditional procedures, while in the experimental group, most participants noted a feeling of relaxation and reduced stress after water exercises. Another important aspect was the participants' perception of the methods themselves. In the control group, only 55% of respondents rated the effectiveness of traditional methods as high or very high, while in the experimental group, this figure was 85%. Participants in the experimental group noted that water training seemed less exhausting, which increased motivation for further training. In addition, the group dynamics and support from instructors in the experimental group also contributed to better results. Participants noted the importance of group activities, which not only improved interaction but also created an atmosphere of mutual support, positively influencing the overall emotional state. In the control group, where most procedures were performed individually, this factor was less pronounced.

Figure 3 presents the results of a comparison of traditional and aquatic rehabilitation methods, allowing for an analysis of the effectiveness of both approaches in improving participants' physical performance. The graph illustrates that the experimental group, which used aquatic exercises, demonstrated a more significant improvement in all tested indicators, including reduced pain, increased flexibility, and endurance. Traditional methods, applied in the control group, also contributed to positive changes, but their impact was less pronounced.

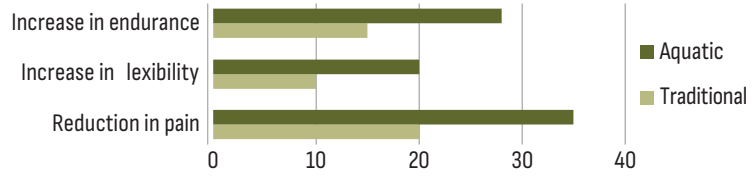

Figure 3. Comparison of the effectiveness of traditional and aquatic rehabilitation methods, %
Source: created by the authors

Results of the analysis indicate that the application of aquatic exercises contributes to a significant improvement in physical performance, reduction of pain, and an increase in the overall level of motivation among participants compared to traditional methods. This confirms the promise of integrating the aquatic environment into rehabilitation programmes as an effective means of achieving optimal results in restoring the health of professional athletes.

Distribution of results based on injury type

The distribution of results showed that participants with mild to moderate injuries achieved more significant improvements compared to those with severe injuries. In particular, in the group with mild injuries, pain reduction was observed by 40%, flexibility increased by 25%, and endurance improved by 30%. Participants with moderate injuries demonstrated similar trends, although their progress was somewhat less: pain reduction was 35%, flexibility increased by 20%, and endurance by 25%. On the other hand, participants with severe injuries had significantly less pronounced results. Pain reduction was only 20%, while improvements in flexibility and endurance were 10% and 15%, respectively. These data confirm the importance of an individual approach to developing rehabilitation programmes, focused on the needs of athletes depending on the complexity of their injuries. As noted by J.E. Moreno *et al.* (2022), adapting training and aquatic exercises to the physical condition of the patient significantly increases the effectiveness of rehabilitation. The graph clearly illustrates the distribution of results between groups with different types of injuries. Participants with mild injuries demonstrated the greatest progress, while the effectiveness of aquatic exercises for athletes with severe injuries was limited, indicating the need for additional or alternative rehabilitation methods. Figure 4 presents the results of the distribution of improvements depending on the type of injury of the rehabilitation programme participants.

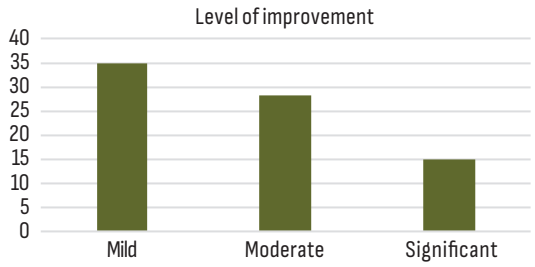

Figure 4. Distribution of improvements based on injury type, %
Source: created by the authors

The graph shows that athletes with mild and moderate injuries achieved significantly better results in terms of reducing pain, increasing flexibility, and endurance compared to participants with severe injuries. The presented results emphasise the need for an individual approach to developing rehabilitation programmes, which allows for maximum effectiveness for each category of injuries. The data obtained confirm that the effectiveness of rehabilitation programmes largely depends on the severity of the injury and also emphasises the importance of individualising approaches. The use of adaptive programmes that take into account the type and severity of the injury allows for the optimisation of the restoration of the physical functions of athletes and increases the effectiveness of the rehabilitation process. Thus, an individual approach becomes a key factor in ensuring a successful recovery.

Motivation for training

Aquatic exercises demonstrated not only a rehabilitative effect but also a significant impact on increasing participants' motivation to train. According to the survey results, 85% of respondents in the experimental group reported that exercising in a water environment positively influenced their emotional state after training. They felt lower levels of stress, increased energy, and a desire to continue training. It is also important to note that aquatic activities served not only as a means of recovery but also as an effective tool for recreation. Participants noted that the dynamics and variety of exercises made the training interesting, and the atmosphere in the aquatic environment itself contributed to relaxation. Such activities were perceived as an opportunity to relieve psychological stress after competitions or injuries. This was especially important for athletes returning to active training after a break. Figure 5 presents the results of an assessment of the impact of aquatic exercises on motivation for training and recreation among participants in the experimental group. The results demonstrate that exercising in a water environment not only contributes to physical recovery but also creates a positive psycho-emotional atmosphere that stimulates participants to continue training and contributes to the overall recreational effect.

Figure 5. Assessments of motivation for training and recreation by participants in the experimental group
Source: created by the authors

Regression analysis showed a high level of correlation ($R^2 = 0.76$) between physical improvements and satisfaction with the programme. This means that participants who demonstrated significant improvements in physical tests more often rated the programme as very effective. Specifically, improvements in endurance, flexibility, and muscle strength directly influenced the positive subjective perception of the rehabilitation process. Additional analysis revealed that the greatest impact on satisfaction with the programme was the reduction in pain ($\beta = 0.48$, $p < 0.01$) and improvement in psychological state ($\beta = 0.42$, $p < 0.01$). This indicates that not only physical indicators but also

emotional comfort during rehabilitation are key factors in successful recovery. Participants who reported a decrease in stress levels and increased motivation also reported ease of exercise and a high interest in continuing the programme.

Another significant relationship was found between the level of flexibility and the subjective perception of progress: participants who had significant improvements in the sit-and-reach test more often rated the programme as "excellent". This confirms that the feeling of mobility and ease of movement is an important criterion for evaluating rehabilitation programmes. On the other hand, participants with severe injuries, despite positive results, rated the programme less optimistically. This may be due to a longer recovery process and more noticeable limitations in movement. Such a result emphasises the importance of an individual approach to participants with different types of injuries, adapting programmes to their needs and expectations. The data obtained suggest that the subjective perception of the effectiveness of a rehabilitation programme depends on a combination of physical results and the emotional comfort created during the sessions. The use of aquatic exercises contributes to the achievement of both goals, making them an ideal tool for the rehabilitation of athletes.

Discussion

The results of the conducted study demonstrate the high effectiveness of using aquatic exercises in the rehabilitation of athletes. Participants in the experimental group, who performed aquatic exercises, demonstrated a significant improvement in physical performance compared to control groups where traditional rehabilitation methods such as therapeutic exercise and massage were used. This is consistent with the findings of R. Biswas & S.S. Ghosh (2022), who emphasised that training in an aquatic environment reduces joint load, improves anaerobic power, and reduces the risk of overload. The improvement in the emotional state of participants after water workouts also underlines the unique benefits of swimming for psycho-emotional recovery. According to S.E. Heywood *et al.* (2022), rehabilitation programmes based on aquatic exercises increase motivation for training and the overall well-being of athletes, which is confirmed by the responses of 85% of participants in the current study. R. Biswas & S.S. Ghosh (2022) noted the advantages of using plyometric exercises in an aquatic environment with additional weights to improve athletes' aerobic endurance. They have proven that the combination of aqua plyometrics and weights creates unique training conditions that reduce the impact of gravity and simultaneously provide a high level of exercise intensity. These findings are consistent with the results obtained, which demonstrate an increase in endurance by 28% after completing the 8-week programme. The research of R. Biswas & S.S. Ghosh (2022) also emphasised the adaptation of exercises to the specific needs of athletes, which is important in the context of individualised rehabilitation programmes. The results obtained confirm that the use of the aquatic environment allows for an effective combination of cardio load and exercises for restoring muscle strength, providing a comprehensive approach to rehabilitation. An important aspect is the appropriateness of adapting rehabilitation programmes to the specific characteristics of athletes' injuries.

The research of D. Pascoe & J. Cheslett (2024) showed that the forces of impact in the aquatic environment are significantly reduced, which creates comfortable conditions for rehabilitation even after serious injuries. This is confirmed by the results obtained, where participants with moderate injuries achieved significant improvements in flexibility and endurance. Aquatic exercises that include plyometric training also demonstrated a positive impact on the development of explosive strength and speed. As noted by S.S. Ghosh & R. Biswas (2023), training in an aquatic environment contributes to the development of specific physical qualities due to hydrostatic resistance. In the study, the experimental group showed significant improvements in these indicators. Aquatic exercises also have a particular value for improving specific physical characteristics. R. Ramirez-Campillo *et al.* (2022) in their meta-analysis noted that plyometric jumps in an aquatic environment significantly improve the physical fitness of athletes, especially in aquatic sports, due to the reduced impact of gravity and increased muscle control. The conducted study confirms these findings, demonstrating an increase in flexibility by 20% and endurance by 28% after completing the 8-week programme. A reduction in pain by 35% after an 8-week course of aquatic exercises confirms the high effectiveness of this approach for the rehabilitation of athletes. According to the research of B.K. Kim & H.J. Jeong (2022), such exercises reduce swelling and pain, which was confirmed by participants in the experimental group. It is important to note that the comfortable conditions of the aquatic environment contribute to psychological relaxation, which is an important component of successful rehabilitation.

Especially promising are programmes focused on developing explosive strength, speed, and aerobic endurance, as noted in the research of R.A. Salama *et al.* (2024). Their findings are consistent with the results, where participants in the experimental group demonstrated a significant improvement in speed-strength characteristics. According to R.K. Elnaggar & W.A. Abd El-Nabie (2021), the correlation between participants' subjective perception of the programme's effectiveness and their physical performance is an important aspect of the rehabilitation process. In the study, the correlation between physical improvements and satisfaction with the programme was $R^2 = 0.76$, indicating that aquatic exercises have both physical and psycho-emotional benefits. A systematic review by V. Simanjuntak *et al.* (2023) proved the effectiveness of using virtual reality-oriented water training to improve lower limb muscle strength. In this study, these exercises also proved effective, leading to the conclusion that the integration of modern digital technologies into water rehabilitation is a promising approach.

R.K. Elnaggar & M.S. Elfakharany (2022) demonstrated that aqua plyometric exercises not only improve muscle strength but also have a positive impact on bone mineral properties and overall physical fitness in patients with juvenile idiopathic arthritis. Their results show that a 12-week programme significantly reduces the risk of osteoporosis and improves physical activity. In the study, similar effects were observed among athletes with moderate injuries, who reported reduced pain and improved flexibility after performing aquatic exercises. These data confirm the

importance of aqua plyometric programmes for comprehensive recovery, especially in the context of musculoskeletal injury rehabilitation. Programmes with aqua plyometrics, which are used for recreational purposes, can be adapted for athletes of different fitness levels. As noted in the study by L.B. Faíl *et al.* (2022), such programmes contribute to strengthening muscles and improving endurance even in people with chronic diseases. In the research, athletes noted that the dynamics and variety of water exercises reduced the monotony of the training process, making it more attractive.

Furthermore, M. Jackson *et al.* (2022) emphasised the positive impact of aquatic exercises on mental health. Their research shows that such programmes can reduce anxiety levels, improve mood, and promote relaxation. These findings are consistent with the results obtained, where 85% of participants reported an improvement in their emotional state. L.A.D. Silva *et al.* (2022) also noted that aquatic exercises are effective in reducing oxidative stress and improving functional autonomy. This is confirmed by the responses of participants who noted that the exercises contributed to reduced fatigue and restored functional mobility. S. Ansari *et al.* (2021) investigated the impact of aqua aerobics on functional capacity, flexibility, and trunk muscle function in women with chronic non-specific low back pain. The results showed a significant reduction in the level of functional disability and an improvement in quality of life after an 8-week programme. The obtained results correlate with these findings, as aquatic exercises demonstrated effectiveness in reducing pain levels on the VAS scale by 35% and increasing overall flexibility by 20%. This confirms the appropriateness of using aquatic exercises in rehabilitation programmes aimed at improving motor activity and psycho-emotional state. The results presented by N.B. Moreira *et al.* (2020) indicate an improvement in quality of life after performing aquatic exercises among older people with musculoskeletal disorders. The study showed that a similar effect is achieved in athletes, regardless of age, due to the individualisation of programmes.

Thus, the use of aquatic exercises in rehabilitation and recreation offers numerous advantages, including physical and psycho-emotional recovery. The integration of modern approaches, such as aqua plyometrics, digital technologies, and adaptive programmes, allows for achieving high results in recovery and improving athletic performance. The presented data provides a basis for further research in this field and confirms the feasibility of implementing aquatic exercises in rehabilitation and recreation programmes. The results of the study confirmed that aquatic exercises are suitable for the rehabilitation of athletes with mild to moderate injuries, as well as for recreational recovery after intense loads. However, in cases of severe injuries or limited mobility, it is necessary to individually adapt programmes to guarantee the safety of participants.

Conclusions

The conducted study showed that aquatic exercises are an effective method of rehabilitation and recreation for athletes who have experienced injuries or overtraining. Results showed that participants in the experimental group who underwent an 8-week swimming programme achieved significant improvements in physical performance, including endurance (+28%), strength (+15%), and flexibility (+20%). These data confirmed the advantage of aquatic exercises over traditional rehabilitation methods, such as therapeutic exercise and massage, where the increase was less pronounced. One of the key results was a reduction in pain levels by 35% on the VAS scale, which confirms the high effectiveness of aquatic exercises in relieving muscle tension. Additionally, 85% of respondents rated their emotional state after training as "good" or "excellent", indicating an improvement in their psychological well-being. The survey results showed that aquatic exercises increased motivation for training and created a comfortable environment for rehabilitation.

The dynamics and variety of aquatic exercises allowed participants to perceive training as a pleasant pastime, contributing to a high level of satisfaction with the programme (rated 4.8 out of 5). A comparison of the results of the control and experimental groups demonstrated a significant correlation between physical improvements and subjective satisfaction with the programme ($R^2 = 0.76$). This confirms that the effectiveness of rehabilitation measures largely depends on their adaptation to the physical and emotional state of athletes. Furthermore, participants in the experimental group who had mild to moderate injuries achieved greater progress compared to those with severe injuries. Rehabilitation based on aquatic exercises is beneficial in many cases, including recovery from mild and moderate injuries, relieving muscle tension, and improving endurance and flexibility. However, its effectiveness may be limited for athletes with severe injuries who require more specialised approaches. It is promising to compare in the future studies the effectiveness of different types of water training, such as aqua plyometrics and aqua aerobics, to develop more comprehensive and flexible rehabilitation programmes.

Acknowledgements

None.

Conflict of Interest

None.

References

[1] Ábel, K., Szabó Rausz, A., & Szabo, A. (2022). Psychological effects of 50-meter swimming: Does tempo manipulation matter? *German Journal of Exercise and Sport Research*, 52, 331-340. doi: 10.1007/s12662-022-00829-8.

[2] Andrade, L.S., Pinto, S.S., Silva, M.R., Schaun, G.Z., Portella, E.G., Nunes, G.N., David, G.B., Wilhelm, E.N., & Alberton, C.L. (2020). Water-based continuous and interval training in older women: Cardiorespiratory and neuromuscular outcomes (WATER study). *Experimental Gerontology*, 134, article number 110914. doi: 10.1016/j.exger.2020.110914.

[3] Ansari, S., Elmieh, A., & Alipour, A. (2021). The effect of aquatic exercise on functional disability, flexibility and function of trunk muscles in postmenopausal women with chronic non-specific low back pain: Randomized controlled trial. *Science & Sports*, 36(3), 103-110. doi: 10.1016/j.scispo.2020.07.003.

[4] Biswas, R., & Ghosh, S.S. (2022). Effect of plyometric training in land surface aquatic medium & aquatic medium with a weighted vest on the aerobic capacity of athletes. *Journal of Physical Education and Sport*, 22(4), 930-940. doi: 10.7752/jpes.2022.04118.
[5] Braun-Trocchio, R., Graybeal, A.J., Kreutzer, A., Warfield, E., Renteria, J., Harrison, K., Williams, A., Moss, K., & Shah, M. (2022). Recovery strategies in endurance athletes. *Journal of Functional Morphology and Kinesiology*, 7(1), article number 22. doi: 10.3390/jfmk7010022.
[6] Bromley, S.J., Drew, M.K., Talpey, S., McIntosh, A.S., & Finch, C.F. (2018). A systematic review of prospective epidemiological research into injury and illness in Olympic combat sport athletes. *British Journal of Sports Medicine*, 52, 8-16. doi: 10.1136/bjsports-2016-097313.
[7] Conceição, A., Fernandes, O., Baia, M., Parraca, J.A., Gonçalves, B., & Batalha, N. (2022). Changes in muscular activity in different stable and unstable conditions on aquatic platforms. *Biology*, 11(11), article number 1643. doi: 10.3390/biology11111643.
[8] Elnaggar, R.K., & Abd El-Nabie, W.A. (2021). Efficacy of aqua-based plyometric exercises in the rehabilitation of patients with juvenile dermatomyositis: A randomized crossover pilot study. *International Journal of Rheumatic Diseases*, 24(7), 930-940. doi: 10.1111/1756-185X.14152.
[9] Elnaggar, R.K., & Elfakharany, M.S. (2022). Aqua-plyometric exercises-induced changes in muscle strength, bone mineral properties, and physical fitness in patients with juvenile idiopathic arthritis: A 12-week, randomized controlled trial. *Pediatric Exercise Science*, 35(4), 198-205. doi: 10.1123/pes.2022-0044.
[10] Faíl, L.B., Marinho, D.A., Marques, E.A., Costa, M.J., Santos, C.C., Marques, M.C., Izquierdo, M., & Neiva, H.P. (2022). Benefits of aquatic exercise in adults with and without chronic disease – a systematic review with meta-analysis. *Scandinavian Journal of Medicine & Science in Sports*, 32(3), 465-486. doi: 10.1111/sms.14112.
[11] Ghosh, S.S., & Biswas, R. (2023). Effect of plyometric training conducted in aquatic medium on speed and explosive strength of the athletes. *International Journal of Kinesiology and Sports Science*, 11(1), 16-26. doi: 10.7575/aiac.ijkss.v.11n.1p.16.
[12] Heywood, S.E., Mentiplay, B.F., Rahmann, A.E., McClelland, J.A., Geigle, P.R., Bower, K.J., & Clark, R.A. (2022). The effectiveness of aquatic plyometric training in improving strength, jumping, and sprinting: A systematic review. *Journal of Sport Rehabilitation*, 31(1), 85-98. doi: 10.1123/jsr.2020-0432.
[13] Hsu, C., Krabak, B., Cunningham, B., & Borg-Stein, J. (2024). Swimming anatomy and lower back injuries in competitive swimmers: A narrative review. *Sports Health*, 16(6), 971-981. doi: 10.1177/19417381231225213.
[14] Jackson, M., Kang, M., Furness, J., & Kemp-Smith, K. (2022). Aquatic exercise and mental health: A scoping review. *Complementary Therapies in Medicine*, 66, article number 102820. doi: 10.1016/j.ctim.2022.102820.
[15] Kim, B.K., & Jeong, H.J. (2022). Effect of acute aquatic plyometric training on muscle strength, edema and pain. *International Journal of Internet, Broadcasting and Communication*, 14(1), 224-232. doi: 10.7236/ijibc.2022.14.1.224.
[16] Kumar, S., Behera, S., Basu, A., Dey, S., & Ghosh-Roy, A. (2021). Swimming exercise promotes post-injury axon regeneration and functional restoration through AMPK. *ENEURO*, 8(3), article number 0414-20. doi: 10.1523/ENEURO.0414-20.2021.
[17] Moreira, N.B., da Silva, L.P., & Rodacki, A.L.F. (2020). Aquatic exercise improves functional capacity, perceptual aspects, and quality of life in older adults with musculoskeletal disorders and risk of falling: A randomized controlled trial. *Experimental Gerontology*, 142, article number 111135. doi: 10.1016/j.exger.2020.111135.
[18] Moreno, J.E., De León, L.G., Ortiz-Rodríguez, B., & Candia-Luján, R. (2022). High intensity interval training (HIIT) in an aquatic environment. A systematic review. *Science & Sports*, 37(5-6), 383-392. doi: 10.1016/j.scispo.2021.12.004.
[19] Najafi Ghagholestani, B., Gandomi, F., Assar, S., & Spears, L.R. (2022). Effects of dynamic neuromuscular stabilization and aquatic exercises on the pain, disability, lumbopelvic control, and spinal posture of patients with non-specific low back pain. *Iranian Rehabilitation Journal*, 20(3), 333-344. doi: 10.32598/irj.20.3.1319.2.
[20] Naz, S., Mangi, S., Saima, R., & Zehra, W. (2024). Aquatic therapy as a modality for managing chronic athletic injuries: A systematic review. *Allied Medical Research Journal*, 2(2), 267-276. doi: 10.59564/amrj/02.02/029.
[21] Pascoe, D., & Cheslett, J. (2024). Comparison of concentric and impact forces on land and in water. *Journal of Clinical Exercise Physiology*, 13(2), 459-459. doi: 10.31189/2165-7629-13-s2.459.
[22] Ramirez-Campillo, R., Perez-Castilla, A., Thapa, R.K., Afonso, J., Clemente, F.M., Colado, J.C., de Villarreal, E.S., & Chaabene, H. (2022). Effects of plyometric jump training on measures of physical fitness and sport-specific performance of water sports athletes: A systematic review with meta-analysis. *Sports Medicine-Open*, 8(1), article number 108. doi: 10.1186/s40798-022-00502-2.
[23] Salama, R.A., Baaziz, M., Khalfoun, J., Omar, M., Chanti, A., & Abderrahman, A.B. (2024). The impact of eight weeks of aquatic plyometric training on the explosive and agility capabilities of swimmers. *Advances in Social Sciences Research Journal*, 11(8), 18-34. doi: 10.14738/assrj.118.17354.
[24] Sette, R.B.T., Morais, T.C., Rêgo Costa, A.C.S.R., Sousa, L.V.A., Zangirolami-Raimundo, J., Daboin, B.E.G., Leite, H.F., Cavalcanti, M.P.E., & Raimundo, R.D. (2024). Aquatic high-intensity interval training improves cardiometabolic profile and physical fitness in active middle-age and older adults: Quasi-randomized clinical trial study. *Journal of Hyman Growth and Development*, 34(2), 342-353. doi: 10.36311/jhgd.v34.16305.

[25] Silva, L.A.D., Menguer, L.D.S., Doyenart, R., Boeira, D., Milhomens, Y.P., Dieke, B., Volpato, A.M., Thirupathi, A., & Silveira, P.C. (2022). Effect of aquatic exercise on mental health, functional autonomy, and oxidative damages in diabetes elderly individuals. *International Journal of Environmental Health Research*, 32(9), 2098-2111. doi: 10.1080/09603123.2021.1943324.
[26] Simanjuntak, V., Setiawan, E., Yanti, N., Lalu Moh, Y.I., & Winarno, M.E. (2023). Virtual-based aquatic plyometric training: How it effects lower extremity muscle strength? *Central European Journal of Sport Sciences and Medicine*, 44, 95-105. doi: 10.18276/cej.2023.4-08.
[27] The Declaration of Helsinki. (2023). Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki/.

Плавання у процесі реабілітації та рекреації професійних спортсменів

Сергій Савчук

Кандидат наук з фізичного виховання і спорту, доцент
Луцький національний технічний університет
43018, вул. Львівська, 75, м. Луцьк, Україна
https://orcid.org/0000-0003-0422-8582

Володимир Ковальчук

Кандидат педагогічних наук, доцент
Луцький національний технічний університет
43018, вул. Львівська, 75, м. Луцьк, Україна
https://orcid.org/0000-0001-5888-7458

Анотація. Плавання відіграє важливу роль у відновленні професійних спортсменів, сприяючи фізичній та психоемоційній реабілітації після змагань і травм. Водночас дослідження застосування плавання для реабілітації та рекреації спортсменів є недостатньо розробленими, що обґрунтовує актуальність цього дослідження та його необхідність у спортивній практиці. Метою роботи було оцінити ефективність водних вправ у реабілітаційних програмах для професійних спортсменів із легкими та середньої тяжкості травмами, порівняно з традиційними методами реабілітації, а також визначити умови, у яких застосування плавання є найбільш доцільним і результативним для покращення фізичних показників, зниження больових відчуттів і підвищення мотивації учасників. У дослідженні брали участь 120 спортсменів із різних видів спорту, які проходили восьмитижневу програму водних вправ. Програма включала аеробні, розтягувальні та відновлювальні вправи, які проводилися 4 рази на тиждень із поступовим підвищенням інтенсивності. Оцінка результатів здійснювалася за допомогою вимірювання фізичних показників (сила, витривалість, гнучкість), аналізу суб'єктивного самопочуття та використання візуально аналогової шкали для оцінки больового синдрому. Результати показали, що витривалість зросла на 28 %, гнучкість – на 20 %, а сила м'язів – на 15 %. Найкращі результати спостерігалися у спортсменів із середнім рівнем підготовки. Водночас для учасників із тяжкими травмами ефективність була нижчою, що вказує на необхідність індивідуального підходу та врахування специфіки травм. Отримані результати підтверджують доцільність застосування плавання в реабілітаційних програмах для спортсменів із загальними травмами та перевтомою. Практична значимість дослідження полягає у створенні рекомендацій для спортивних лікарів і тренерів щодо використання плавання як ефективного засобу відновлення спортивної форми

Ключові слова: фізичне відновлення; аеробні вправи; спортивна адаптація; методи відновлення; функціональні показники

Scientific and practical journal
“THEORY AND PRACTICE
OF PHYSICAL CULTURE AND SPORTS”

Volume 3, No. 2
2024

Managing Editor:
A. Pyvovar

Editing Bibliographic Lists:
A. Pyvovar

Desktop Publishing:
O. Glinchenko

Signed to the print with the original layout 12.12.2024
Conventional Printed Sheet 9.9
Circulation 100 copies

Publisher:
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
E-mail: info@tppcs.com.ua
https://tppcs.com.ua/

Науково-практичний журнал
«ТЕОРІЯ І ПРАКТИКА
ФІЗИЧНОЇ КУЛЬТУРИ І СПОРТУ»

Том 3, № 2
2024

Відповідальний редактор:
А. Пивовар

Редагування бібліографічних списків:
А. Пивовар

Комп'ютерна верстка:
О. Глінченко

Підписано до друку з оригінал-макета 12.12.2024
Ум. друк. арк. 9,9
Тираж 100 примірників

Видавництво:
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
E-mail: info@tppcs.com.ua
https://tppcs.com.ua/