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By the order of the Ministry of Education and Science of Ukraine dated 16.07.2018 № 775 and by the order of the Ministry of Education and Science dated 02.07.2020 № 886 the journal is included in category B of professional publications of Ukraine. Specialties: physical culture and sports (017, 24.00.01, 24.00.02, 24.00.03); pedagogical sciences (011, 012, 013, 014, 015, 016, 13.00.02).

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Professional scientific publication on problems of physical education, sports, formation of a healthy way of life, rehabilitation, physical therapy.

Foundation year: 2015

Branch and problems: sport, physical education, training of movements, technology of physical education, physical therapy, rehabilitation, sports medicine

The journal presents articles on topical issues of physical education and sport, as well as on the problems of the formation, restoration, strengthening and preservation of health of representatives of different groups of people, physical rehabilitation and physical therapy, rehabilitation, sports medicine.
It also reflects materials on the theory and methodology of training of sportsmen's; the means of physical culture, its forms and methods, the basic principles of health-saving technologies and disease prevention.

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Здоров'я, спорт, реабілітація

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Наказом МОН України від 16.07.2018 № 775 та наказом МОН від 02.07.2020 № 886 журнал включено в **категорію Б фахових видань** України. Спеціальності: фізична культура і спорт (017, 24.00.01, 24.00.02, 24.00.03); педагогічні науки (011, 012, 013, 014, 015, 016, 13.00.02).

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Свідоцтво про державну реєстрацію:
КВ № 22450-12350Р від 01.12.2016

Фахове наукове видання з проблем фізичного виховання, спорту, формування здорового способу життя, реабілітації, фізичної терапії, спортивної медицини

Рік заснування: 2015
Галузь і проблематика: спорт, фізичне виховання, навчання рухам, організація фізичного виховання, рекреація, фізична терапія, спортивна медицина

У журналі представлені статті з актуальних проблем фізичного виховання і спорту, а також з проблем формування, відновлення, зміцнення і збереження здоров'я представників різних груп населення, фізичної реабілітації та фізичної терапії, спортивної медицини.
У ньому також відображені матеріали з теорії та методики підготовки спортсменів; засоби фізичної культури, її форми та методи, основні принципи здоров'язберігаючих технологій та профілактики захворювань.

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Здоровье, спорт, реабилитация

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Год основания: 2015

Область и проблематика: спорт, физическое воспитание, обучение движениям, организация и технологии физического воспитания, физическая терапия, реабилитация, спортивная медицина

В журнале представлены статьи по актуальным проблемам физического воспитания и спорта, а также по проблемам формирования, восстановления, укрепления и сохранения здоровья представителей различных групп населения,, физической терапии и спортивной медицины. В нем также отражены материалы по теории и методике подготовки спортсменов; средства физической культуры, ее формы и методы, основные принципы здоровьесберегающих технологий и профилактики заболеваний.

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REVIEW ARTICLES

Features of the organization of teaching for future physical education teachers in the People's Republic of China and the possibility of implementing an individual approach in their training: a review article

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Abstract

Purpose: to determine the main directions of training of teachers of physical culture in the People's Republic of China according to the data of modern literature.
Material and methods. The analysis of literature sources was carried out by working with scientific works, which are presented in the databases "Web of Science", "Scopus", "Pub Med" and others. The search for literary sources was carried out by the keywords: "physical education teacher training", "physical education", "sports", "coach training". A total of 10157 works were found based on key words, of which 33 works were selected for literary review. The selection was carried out as follows: first, the topic of the article was analyzed, then, if the topic corresponded to the direction of our study, the annotation was analyzed. If the annotation corresponded to the direction of our research, the text of the article was analyzed. Also in the analysis of literature sources, preference was given to sources presented in the quartiles "Web of Science" and "Scopus" 1-3 level. In addition, articles on the training of physical education and sports professionals in China were analyzed separately. Of the 33 works presented in the literature review, 15 sources - research, 10 - review, 8 - randomized trials.
Results. In the People's Republic of China, the problem of individual approach is especially relevant in connection with national characteristics, traditions, which provide for the predominance of collective action in all types of work. In addition to basic sports, the training of future physical education teachers in the People's Republic of China should include in-depth study of the sport in which it could improve and be a high-level specialist.
Conclusions. Training of physical education teachers in the People's Republic of China should be based on modern concepts of individualization, which apply to all stages of training: from choosing a sport in which the student would like to improve and receive a specialty of physical education teacher with professional knowledge of a particular sport. physical education teachers in the study of the chosen sport.
Keywords: individual approach, teacher, physical culture, training

Анотація

Ван Сяофей, Коробейнік В.А., Козіна Ж.Л. Особливості організації навчання майбутніх вчителів фізичної культури в Китайській Народній Республіці та можливість реалізації індивідуального підходу в їх підготовці: оглядова стаття.

Мета: визначити основні напрямки підготовки вчителів фізичної культури в Китайській Народній Республіці за даними сучасної літератури..

Матеріал і методи. Аналіз літературних джерел проводився шляхом роботи з науковими роботами, які представлені в базах «Web of Science», «Scopus», «Pub Med» ті інші. Пошук літературних джерел проводився за ключовими словами»: «підготовка вчителя фізичної культури», «фізична культура», «спорт», «підготовка тренера». Всього було знайдено за ключовими словами 10157 робіт, з яких було відібрано для літературного огляду 33 роботи. Відбір проводився таким чином: спочатку аналізувалася тема статті, потім, якщо тема відповідала спрямованості нашого дослідження, аналізувалася анотація. Якщо анотація відповідала спрямованості нашого дослідження, то аналізувався текст статті. Також при аналізі літературних джерел перевага віддавалася джерелам, представленим у квартілях «Web of Science» та «Scopus» 1-3 рівня. Крім того, окремо аналізувалися статті, що стосувалися підготовки фахівців з фізичного виховання і спорту в Китаї. З 33 робіт, представлених в огляді літератури, 15 джерел – дослідницького характеру, 10 – оглядового, 8 – рандомізовані дослідження.

Результати. У Китайській Народній Республіці проблема індивідуального підходу має особливу актуальність у зв'язку з національними особливостями, традиціями, які передбачають переважання колективних дій при всіх видах робіт. У підготовку майбутніх вчителів фізичної культури в Китайській Народній Республіці необхідно, крім базових видів спорту включити поглиблене вивчення виду спорту, в якому він міг би вдосконалюватися і бути фахівцем високого рівня.

Висновки. Підготовка вчителів фізичної культури в Китайській Народній Республіці повинна спиратися на сучасні концепції індивідуалізації, які стосуються всіх етапів підготовки: від вибору виду спорту, в якому студент хотів би вдосконалюватися і отримувати спеціальність вчителя фізичної культури з професійним володінням певним видом спорту, до врахування індивідуальних особливостей майбутніх вчителів фізичної культури при вивченні обраного виду спорту.

Ключові слова: індивідуальний підхід, вчитель, фізична культура, підготовка

Аннотация

Ван Сяофей, Коробейник В.А., Козина Ж.Л.. Особенности организации обучения будущих учителей физической культуры в Китайской народной республике и возможность реализации индивидуального подхода в их подготовке: обзорная статья

Цель: определить основные направления подготовки учителей физической культуры в Китайской народной республике по данным современной литературы.

Материал и методы. Анализ литературных источников проводился путем работы с научными работами, которые представлены в базах «Web of Science», «Scopus», «Pub Med» те другие. Поиск литературных источников проводился по ключевым словам»: «подготовка учителя физической культуры», «физическая культура», «спорт», «подготовка тренера». Всего было найдено по ключевыми словам 10157 работ, из которых были отобраны для литературного обзора 33 работы. Отбор проводился следующим образом: сначала анализировалась тема статьи, затем, если тема отвечала направленности нашего исследования, анализировалась аннотация. Если аннотация отвечала направленности нашего исследования, то анализировался текст статьи. Также при анализе литературных источников предпочтение отдавалось источникам, представленным в квартиль «Web of Science» и «Scopus» 1-3 уровня. Кроме того, отдельно анализировались статьи, касающиеся подготовки специалистов по физическому воспитанию и спорту в Китае. Из 33 работ, представленных в обзоре литературы, 15 источника – исследовательского характера, 10 – обзоры, 8 – рандомизированные исследования.

Результаты. В Китайской Народной Республике проблема индивидуального подхода имеет особую актуальность в связи с национальными особенностями, традициями, которые предусматривают преобладание коллективных действий при всех видах работ. В подготовку будущих учителей физической культуры в Китайской Народной Республике необходимо, кроме базовых видов спорта включить углубленное изучение вида спорта, в котором он мог бы совершенствоваться и быть специалистом высокого уровня.

Выводы. Подготовка учителей физической культуры в Китайской Народной Республике должна опираться на современные концепции индивидуализации, которые касаются всех этапов подготовки: от выбора вида спорта, в котором студент хотел бы совершенствоваться и получать специальность учителя физической культуры с профессиональным владением определенным видом спорта, с учетом индивидуальных особенностей будущих учителей физической культуры при изучении выбранного вида спорта.

Ключевые слова: индивидуальный подход, учитель, физическая культура, подготовка

Introduction

In the last decade, China has set out to create a strong, competitive state in the world, which has led to increased interest in Western cultures and practices [1, 2]. This requires the creation of conditions for the improvement of professionals from all fields, able to prove themselves in international economic and technological competition. Physical education is no exception, because physical education itself creates the basis for the formation of a physically healthy, intellectually and spiritually developed person. First of all, it concerns the training of specialists in physical education, which is an integral part of education.

At the present stage in the world there is a tendency to an individual approach to education [3, 4, 5]. This applies to all stages of the educational process: from kindergarten to university and postgraduate education. At the same time, with the increase of the educational level, the individualization of the learning process also increases. The field of physical culture and sports is no exception. In countries such as the United States, Europe and others, the trend towards a personal approach to physical education is realized in physical education at school by allowing students to choose sports to improve motor skills, health and psychological [6, 7, 8, 9] .

This places certain demands on the training of specialists in physical education and sports to work as physical education teachers at school. The modern teacher of physical culture at school must have not only basic sports at the primary-secondary level, but also be a perfect specialist in a particular sport [9, 10]. This is necessary to ensure a strategy of individual approach to the process of physical education of schoolchildren. In order for each student to be able to choose a sport for physical education, the school must have specialists in a large number of sports and physical activity.

The implementation of the individual approach consists in the following provisions: definition of the chosen sport in the early stages of learning [11, 12, 13, 14]; improvement in the chosen sport based on the individual characteristics of students - athletes.

In the People's Republic of China, the difficulties characteristic of all countries in the field of training specialists - future teachers of physical education, are added to the country-specific [1]. Physical education in the People's Republic of China has long been based on national traditions, and has focused on health promotion and training of servicemen [1, 15]. For this purpose, traditional Chinese systems were used: wu-shu, qigong and others, but not the sports for which competitions are held in the world, which is typical for Europe, USA, CIS countries and others (Andriamampianina P., Moussa AS, 2005). . Physical education in the People's Republic of China began to focus on the various sports for which competitions are held in the world, only the last 3-4 decades [1].

Therefore, on the one hand, physical education in the People's Republic of China has less experience in the implementation of sports that are used in competitions around the world, compared to Europe, the United States, the CIS and others. On the other hand, the introduction of sports in physical education is contrary to the cultural traditions of China and meets with some resistance from the population [1, 16].

Therefore, at the present stage, according to the direction of China's chosen direction of development, in the training of specialists in physical education and sports - future physical education teachers, there are several problems that need to be addressed. The first problem is the need for a harmonious combination of traditional Chinese practices in physical education with the implementation of a steamy approach focused on sports for which competitions are held in the world. The second problem is the need to combine the implementation of an individual approach, which is to improve in the chosen sport, with the study of basic types. The third problem is the need to take into account the individual characteristics of students when improving in the chosen sport.

Thus, at this stage it is necessary to develop an experimental training program for students - future teachers of physical education, focused on an individual approach, which takes into account: 1 - a combination of Chinese traditions with current trends in physical education in the world; 2 - a combination of improvement in the chosen sport with the study of basic sports; 3 - reliance on individual characteristics of students with advanced nor in the chosen sport.

This determined the chosen direction of our research.

Purpose: to determine the main directions of individual approach to the training of physical education teachers according to modern literature.

Material and methods

Eligibility criteria

The review included articles on the organization of the process of training physical culture teachers in the World and, in particular, in the People's Republic of China.

Articles were to be written in English and published in a peer-reviewed journal with the full version of the article available. All entries were allowed. Studies that were neither randomized studies nor reviews were excluded.

The review also included articles devoted to an individual approach to physical education of students and to the preparation of athletes.

Sources of information and search strategy

The analysis of literature sources was carried out by working with scientific works, which are presented in the databases "Webmof Science", "Scopus", "Pub Med" and others. The search for literary sources was carried out by the keywords ":" physical education teacher training "," physical education "," sports "," coach training ".

Study selection

The selection was carried out as follows: first, the topic of the article was analyzed, then, if the topic corresponded to the direction of our study, the annotation was analyzed. If the annotation corresponded to the direction of our study, the text of the article was analyzed. Also, in the analysis of literature sources, preference was given to sources presented in the quarters level 1-3 "Web of Science" and "Scopus". The first author (WX) selected articles to be included in the review. If any of the selection criteria were not met, the article was excluded from the systematic review. In case of doubt, the article was discussed with one of the co-authors (ZK) until a consensus was reached.

In addition, articles related to the training of specialists in physical education and sports in China were analyzed separately.

Results

A total of 10157 works were found by keywords, of which 33 works were selected for literary review.

Analysis of literature sources showed the following.

The study [1] examined the role of physical education teachers and related curricula in the emergence of specific concepts in physical education in Europe and the People's Republic of China. One of the key assumptions was that physical education teachers who work with a particular program will either support it or will doubt that physical education programs affect physical fitness and teaching methods.

Research [1] included a comparison of two very different and influential social models and academic systems. Comparisons were made between European and Chinese universities in terms of education, taking into account other comparative studies of higher education in the People's Republic of China, as well as research in higher education and teacher training in Europe [17, 18]. The work [1] is based on research conducted at European universities and at the Beijing University of Physical Education (People's Republic of China).

Because both Europe and the People's Republic of China have centralized education systems, both physical education universities can be considered representative of national teaching methods here and there. Teacher training is organized in almost the same way in all universities in Europe [1]. The same applies to the People's Republic of China, although some universities are quite autonomous [1, 19, 20, 21].

In Europe, various models of human modelling, reflecting changes due to technological progress, have influenced both the orientation and the content of exercise in the last century [1]. As a result, in Europe there are several approaches to the study of the theory of physical education: training in movement technique was based on a biomechanical model; regulation of loads (physiological pedagogy) was based on a bioenergetic model; The concept of how the human body is arranged in the application to the theory and practice of physical education, led to a three-dimensional concept of the human body: one dimension is a mechanical mode in which visible movements are studied, the other is an energy mode in which predominate physiological aspects, and thirdly, the neural mode in which the exchange and transmission of signals.

From a philosophical and psychological point of view, physical education was also influenced by Cartesian dualism, associationism, Gestalt theory, phenomenology, psychoanalysis, structuralism and systematism [22].

Analysis of the evolution of physical education shows that in Europe the emphasis is on sports [23]. Indeed, sports have long predominated in physical education. Although teachers have a place for creativity, different sports are a cultural landmark taught in schools and universities. However, the increasing dominance of sports practices in physical education has faced some opposition. Psychomotor skills, traditional local games, spontaneous classes, self-expression and free outdoor activities have been advanced in an attempt to balance the dominance of the sport. Currently, although sport continues to dominate in European physical education, these countercurrents have helped to increase diversity in the discipline of "Physical Culture" [23].

In terms of teacher training, European universities are relatively autonomous when it comes to determining the content of the curriculum. Pedagogical training covers three main subjects: theoretical sciences, pedagogy, didactics of physical activity and sports. Each subject affects the concept of learning and includes the conflict between "practitioners" and "theorists" (Andriamampianina P., Moussa A. S., 2005); between university teachers and high school teachers; between the scientific statements of universities and the commitment of teachers of physical education exclusively to practical training. Physical education curricula should be consistent with the research work and the practical experience of the teacher's physical education. European University Physical Education Courses (STAPS) reflect a desire to strengthen academic legitimacy at a time when universities are increasingly adapting their curricula to the requirements of practicing teachers [1].

In the People's Republic of China, physical education is determined by socio-political expectations and attitudes, not by abstract conflicts. There is the greatest conflict within the discipline of "Physical Culture" between the supporters of traditional Chinese practices and the founders of modern sports practices, which are usually more accessible to the general public and focused on integration with Europe [1].

Since the founding of the People's Republic of China, competitive sports have become an integral part of physical education. The government has taken steps to encourage the development of sports, both to improve health and to build national identity. Therefore, physical education, along with sports, is seen as a means of strengthening the relationship between man and the state. Thus, there is a close connection between the state and the school [1].

Chinese and traditional practices differ from Western sports in four main principles [15, 16]: 1 - their main purpose - to improve health; 2 - in movements often there is an imitation of living beings; 3 - they embody philosophical concepts; 4 - their development reflects the development of Chinese society as a whole. Moreover, they can be divided into different categories [1].

On the one hand, there are traditional health and fighting practices, such as wushu, taijiquan, qigong. On the other hand, there are entertaining, festive and popular practices, such as dragon boat races, dragon dances, kite launches, horse racing, work games, farm games and traditional games for minorities. To this list one could also add state-sponsored practices, such as exercise programs broadcast on the radio or held during breaks, which are usually aimed at increasing production [1].

The development of physical education in the People's Republic of China was closely linked to military training and health activities until the end of the XIX century. The growing influence of the West has broken several age-old Chinese traditions. Since then, Western sports practices have become more and more popular and widespread. As a result, modern physical culture in the People's Republic of China is based on Western natural physical education under the influence of European and American theorists and teachers, such as Bazedov, Hutsmut, Gaulhofer, Eber, and Rousseau. The adoption of Western physical education is also an expression of the reaction against religious asceticism in favor of a "full" form of physical education, which allows everyone to find a "natural" movement [1].

This type of physical education has replaced military training, and its humanistic nature and values have led to one of the most profound transformations in Chinese physical education. The adoption of sports undermined Confucian traditions and marked a turning point in the development of physical education practices, although this phase was later followed by the rehabilitation of traditional practices. Currently, physical education in the People's Republic of China can be divided into three separate forms: health practices, military practices and Western sports practices. The emphasis is currently on sports practices [1].

With regard to teacher training, there is little evidence of internal contradictions, however, there is some tension in the People's Republic of China between "practical" and "academic" approaches. The modern system of education was developed in the late XIX century.

The system of educational colleges is very similar to the European system in that trainee teachers are hired after high school.

Both in Europe and in the People's Republic of China, the largest number of hours is devoted to practical subjects, albeit in different quantities (866 hours in Europe compared to 1596 hours in the People's Republic of China). In three years of study, Chinese students receive 2,640 hours of study, compared with 1,910 hours for European students. This difference in the total number of hours of study is equivalent to one European academic year [1].

Subjects for the study of foreign languages in the People's Republic of China and in Europe [1]:

Here it is necessary to consider four basic provisions:

1. The Chinese curriculum contains subjects related to the philosophy and politics of the modern People's Republic of China, which make up 8% of the curriculum, which is not included in the curriculum in Europe for the study of foreign languages;

2. Foreign languages are important (10% of the curriculum) at Peking University, and in European universities they are almost absent (1%) in the curriculum;

3. In both the People's Republic of China and Europe, biology is more important than the social sciences, although to varying degrees (19% of the curriculum in Europe and 7% in the People's Republic of China), while the social sciences play a much smaller role among the curriculum components. in the People's Republic of China (2%) compared to Europe (15%);

4. Finally, school practice is a minimum of three years of basic teacher qualification in Europe (2%) and is completely absent in the People's Republic of China [1].

With regard to the main sports activities offered in the first two years, the three key subjects in both cases are the same: athletics, gymnastics and team sports [1].

However, there is a wide range of activities in Europe. It would seem that due to the fact that curriculum developers prefer to focus on traditional sports, these basic classes are a mandatory requirement for students, beginners [1]

Thus, physical activity is at the heart of both curricula, reflecting the intention for future teachers to have theoretical and practical knowledge in the field of physical education. Of the three main elements of teacher training (physical activity, basic sciences and pedagogy) in the curriculum in Europe is dominated by physical activity. Although it can hardly be argued without a careful study of the content of the course, and teacher training - to promote the development of teaching skills [1].

Curricula are based on tools and methods specific to the professional activities of physical education teachers. At first glance, it seems that both curricula are based on a pragmatic approach with an emphasis on physical education and their educational programs. In the Chinese curriculum, research seems to be an additional rather than a major subject. But both in the People's Republic of China and in Europe, only a small part of the training is devoted to professional practice. Curricula offer training for professional purposes, but without practical teaching experience [1].

Rating of which items [1].

Europe:

1. Physical activity and sports
2. Biological sciences
3. Social sciences
4. Research methodology
5. Another
6. Practically at school
7. Written and oral self-expression
8. Computer science
9. Foreign languages
10. Legal / institutional framework

People's Republic of China:

1. Physical activity and sports
2. Foreign languages
3. Philosophy and politics
4. Biological sciences
5. Another
6. Informatics
7. Research methodology
8. Humanities
9. Written and oral language
10. Legal / institutional framework

Subjects that are not directly related to the field of physical education: foreign language, sightseeing and modern history of the People's Republic of China. The relationship between politics and education remains strong, both in form and content, but it is currently designed to reflect an "open door policy." Judging by the curriculum, a Chinese physical education teacher must be an expert in physical activity with extensive knowledge of Chinese philosophy and political history; he also has everything he needs to participate in international information exchanges due to his linguistic and computer skills [1].

The curriculum for physical education in Europe is mainly characterized by the fact that the emphasis is on scientific disciplines (which is more than a third of the curriculum) [1, 24, 25, 26]. Many authors [27, 28] point to the need to improve the quality of training of future professionals in the field of physical culture and sports, among which a special place is occupied by future physical education teachers.

Discussion

The problem of modern physical education at all stages of the educational process is that there is a gap in the needs of society in providing appropriate means and forms of physical activity and real human resources. In the training of future teachers of physical culture, insufficient attention is paid to improvement in the chosen sport, as well as - the development of modern forms and means of physical education and physical activity. In modern society it is necessary to implement an individual approach to the teaching of physical culture, which would take into account the benefits of choosing the type of physical activity of each person, and especially - schoolchildren and students.

A specialist in the field of physical education must have both basic theoretical and motor training, and have a perfect command of at least one type of motor activity (sport). In this case, he will be able to ensure the implementation of an individual approach to at least one parameter - the choice of sport by students. In addition, he must be able to think creatively for the selection of means and methods of physical education depending on the level of training and individual characteristics of students. Therefore, there is a problem: a graduate of a higher education institution can not take an individual approach to physical education due to lack of knowledge about a particular sport, and the student can not take an individual approach due to lack of basic theoretical and practical knowledge [29, 30].

The root of the solution to the problem of individual approach in physical culture and sports lies in the training of specialists in the field of physical education and sports. This is especially true for the training of physical education teachers. But how can a graduate of a higher educational institution implement an individual approach in the physical education of students, because the training of future physical education teachers does not implement an individual approach?

The lack of a solution to the problem of individual approach in the training of future physical education teachers leads to a decrease in students' motivation to engage in physical education, which leads to lower quality of physical education in general and increased health problems. Therefore, solving the problem of individual needs in physical education is in the implementation of an individual approach in the training of future teachers of physical education.

In the People's Republic of China, the problem of individual approach is especially relevant in connection with national characteristics, traditions, which provide for the predominance of collective action in all types of work. In addition, in the People's Republic of China there is resistance from many organizations and professionals to introduce in physical education sports for which competitions are held instead of traditional Chinese health and combat [31, 32, 33].

In addition to basic sports, the training of future physical education teachers in the People's Republic of China should include in-depth study of the sport in which he could improve and be a high-level specialist. Training of physical education teachers in the People's Republic of China should be based on modern concepts of individualization, which apply to all stages of training: from choosing a sport in which the student would like to improve and receive a specialty of physical education teacher with professional knowledge of a particular sport. physical education teachers at studying the chosen sport.

In modern society it is necessary to implement an individual approach to the teaching of physical culture, which would take into account the benefits of choosing the type of physical activity of each person, and especially - schoolchildren and students. A specialist in the field of physical education must have both basic theoretical and motor training, and have a perfect command of at least one type of motor activity (sport).

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The development of physical education in the People's Republic of China was closely linked to military training and health activities until the end of the XIX century. The growing influence of the West has broken several age-old traditions of China [3, 4, 5]. Since then, Western sports practices have become more and more popular and widespread. As a result, modern physical culture in the People's Republic of China is based on Western natural physical education under the influence of European and American theorists and teachers such as Bazedov, Hutsmut, Gaulhofer, Eber, and Rousseau. The adoption of Western physical education is also an expression of the reaction against religious asceticism in favor of a "full" form of physical education, which allows everyone to find a "natural" movement [1].

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With regard to teacher training, there is little evidence of internal contradictions, however, there is some tension in the People's Republic of China between "practical" and "academic" approaches. The modern system of education was developed in the late XIX century.

The system of educational colleges is very similar to the European system in that trainee teachers are hired after high school.

Conclusions

1. Theoretical generalization of literary sources has shown that in modern society requires the implementation of an individual approach to teaching physical education, which would take into account the benefits of choosing the type of motor activity of each person, and especially - schoolchildren and students. A specialist in the field of physical education must have both basic theoretical and motor training, and have a perfect command of at least one type of motor activity (sport).

In the People's Republic of China, the problem of individual approach is especially relevant in connection with national characteristics, traditions, which provide for the predominance of collective action in all types of work. In addition, in the People's Republic of China,there is resistance from many organizations and professionals to introduce sports in physical education, for which competitions are held instead of traditional Chinese health and combat systems.

3. In addition to basic sports, the training of future physical education teachers in the People's Republic of China should include in-depth study of a specific sport in which he could improve and be a high-level specialist. Training of physical education teachers in the People's Republic of China should be based on modern concepts of individualization, which apply to all stages of training: from choosing a sport in which the student would like to improve and receive a specialty of physical education teacher with professional knowledge of a particular sport. physical education teachers in the study of the chosen sport.

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Conflict of interest

The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLES. PHYSICAL EDUCATION

Effects of Whole-Body Electromyostimulation and Resistance Training on Body Composition and Maximal Strength in Trained Women

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Abstract

Purpose: to investigate the effect of WB-EMS training and resistance training on body composition and maximal strength in trained women.
Material and methods: 30 trained women (with a mean age of 25.70 ± 2.27 years, height of 1.63 ± 0.032 m, and weight of 60.46 ± 5.50 kg) were randomly divided into three groups of ten (WB-EMS training, strength training (ST), and control group (CG)). The training program was performed for 6 weeks and two sessions per week (WB-EMS: 20 minutes, 85 Hz, 350 μs, 6 s pulse duration, 4 s rest; and ST: 1-RM 60-80%, 3 sets, 8-12 repeats, 50-90 s rest between each set). In all three groups, BF%, LBM and Maximal Strength were measured before and after the training period.
Results: Intragroup comparison in WB-EMS group showed a significant difference in BF% and LBM ($P \le 0.05$); while in the intergroup comparison, no significant difference was observed between the WB-EMS group and CG. Also in ST group, BF% and LBM values did not show any significant changes. There was also a significant difference in Maximal Strength in the intragroup comparison between both WB-EMS and ST groups and a significant difference between the WB-EMS group and CG and between ST group and CG in the intragroup comparison after the test ($P \le 0.05$); while there was no significant difference between WB-EMS and ST groups.
Conclusions: According to the findings, it can be concluded that both types of exercise can improve maximal strength, although each of these exercises has its own benefits.
Keywords: Electrical Stimulation, physical activity, fitness, weight control

Анотація

Садегіпур С., Мірзай Б., Коробейников Г.В., Тропін Ю. Вплив електростимуляції всього тіла і тренувань з обтяженнями на склад тіла і максимальну силу у тренованих жінок

Мета: вивчити вплив тренування з електростимуляцією всього тіла (WB-EMS) і силових тренувань на композицію тіла і максимальну силу у тренованих жінок.

Матеріал і методи: 30 тренованих жінок (середній вік 25,70 ± 2,27 років, зростання 1,63 ± 0,032 м і вага 60,46 ± 5,50 кг) були випадковим чином розділені на три групи по десять чоловік (тренування WB-EMS , силові тренування (СТ), і контрольна група (КГ)). Програма тренувань проводилася протягом 6 тижнів і двох занять на тиждень (WB-EMS: 20 хвилин, 85 Гц, 350 мкс, тривалість імпульсу 6 с, відпочинок 4 с; і ST: 1-RM 60-80%, 3 підходи, 8 -12 повторень, відпочинок 50-90 с між підходами). У всіх трьох групах BF%, LBM і максимальна сила вимірювалися до і після періоду тренування.

Результати. Внутрішньогрупове порівняння в групі WB-EMS показало значну різницю в BF% і LBM (P ≤ 0,05); в той час як при міжгруповому порівнянні не спостерігалося значної різниці між групою WB-EMS і CG. Також в групі ST значення BF% і LBM не показали значних змін. Також спостерігалася значна різниця в максимальній силі при внутрішньогруповому порівнянні між групами WB-EMS і ST і значна різниця між групою WB-EMS і CG, а також між групою ST і CG у внутрішньогрупповому порівнянні після тесту (P ≤ 0,05); в той час як не було значної різниці між групами WB-EMS і ST.

Висновки. Згідно з отриманими даними, можна зробити висновок, що обидва типи вправ можуть поліпшити максимальну силу, хоча кожне з цих вправ має свої переваги.

Ключові слова: електростимуляція, фізична активність, фітнес, контроль ваги.

Аннотация

Садегипур С., Мирзаи Б., Коробейников А.В., Тропин Ю. Влияние электромиостимуляции всего тела и тренировок с отягощениями на состав тела и максимальную силу у тренированных женщин

Цель: изучить влияние тренировки с электростимуляцией всего тела (WB-EMS) и силовых тренировок на композицию тела и максимальную силу у тренированных женщин.

Материал и методы: 30 тренированных женщин (средний возраст 25,70 ± 2,27 года, рост 1,63 ± 0,032 м и вес 60,46 ± 5,50 кг) были случайным образом разделены на три группы по десять человек (тренировки WB-EMS, силовые тренировки (СТ), и контрольная группа (КГ)). Программа тренировок проводилась в течение 6 недель и двух занятий в неделю (WB-EMS: 20 минут, 85 Гц, 350 мкс, длительность импульса 6 с, отдых 4 с; и ST: 1-RM 60-80%, 3 подхода, 8-12 повторений, отдых 50-90 с между подходами). Во всех трех группах BF%, LBM и максимальная сила измерялись до и после периода тренировки.

Результаты. Внутригрупповое сравнение в группе WB-EMS показало значительную разницу в BF% и LBM (P ≤ 0,05); в то время как при межгрупповом сравнении не наблюдалось значительной разницы между группой WB-EMS и CG. Также в группе ST значения BF% и LBM не показали значительных изменений. Также наблюдалась значительная разница в максимальной силе при внутригрупповом сравнении между группами WB-EMS и ST и значительная разница между группой WB-EMS и CG, а также между группой ST и CG во внутригрупповом сравнении после теста (P ≤ 0,05); в то время как не было значительной разницы между группами WB-EMS и ST.

Выводы. Согласно полученным данным, можно сделать вывод, что оба типа упражнений могут улучшить максимальную силу, хотя каждое из этих упражнений имеет свои преимущества.

Ключевые слова: электростимуляция, физическая активность, фитнес, контроль веса.

Introduction

Today's lifestyle in the digital age has minimized the opportunity to move. Sedentary lifestyle will have consequences such as reduced efficiency, increased health costs, and therefore a sick community. Having an active lifestyle by engaging in physical activity and having high physical fitness and proper weight control, helps to reduce a variety of deaths, heart disease, high blood pressure, hyperlipidemia, some types of cancers, type 2 diabetes, osteoporosis, hip fractures, menstrual disorders, and mental health [1].

Researches on physical activity and exercise programs have shown that resistance training can improve physical function and health indicators in women [2]. Most of these studies have reported increased cross-sectional area, volume, strength, and muscle function after resistance training [3]. Resistance training can also rebuild lost muscle tissue, prevent muscle mass loss, and even reverse the process [4]. Moreover, recent studies have shown that electrical whole-body electromyostimulation (WB-EMS) also plays an important role in increasing muscle strength, reducing fat percentage and increasing lean body mass. This exercise method (WB-EMS) has been proposed as a new training and therapeutic method to strengthen muscles in cases where there is immobility or when there is a limit to voluntary exercise such as time constraint or disability and physical or motivational limitation to exercise normally [5].

WB-EMS technology is a method that stimulates muscles with an electric current and causes muscle contraction. Electrical pulses from the electrodes embedded in the WB-EMS special clothing are sent directly from the skin surface to the muscles and travel to the deepest layers of them. This device is able to activate 14-18 areas or 8-12 muscle groups simultaneously (upper legs, arms, buttocks, abdomen, waist, back, latissimus dorsi, and four free options; over 2800 cm^2 of stimulated area) [6].

As reported in the studies, using this technique can clearly achieve improvements in body composition, cardiovascular risk factors, and muscle strength, rehabilitation, etc. [7-11]. In a study, Kemmler et al (2010) examined the effects of WB-EMS on body composition and maximal strength in 30 postmenopausal women and reported significant improvements in body composition and strength [7]. Kemmler et al. [8] also compared the effects of WB-EMS and HIT (high-intensity resistance training) on body composition and strength in 46 healthy middle-aged men. They reported improved body composition and strength in both groups, but there was no significant difference between the groups [8]. In addition, Micke et al. (2018) evaluated the effects of 8 weeks of WB-EMS on leg muscle strength and power in 18 young trained men and reported that strength and power improved significantly in the WB-EMS group. But in general, WB-EMS did not show more benefits than traditional resistance training in healthy young adults [9]. D'Ottavio et al. [10] studied the effects of two WB-EMS protocols (frequency of 85 Hz and 50 Hz) on strength and power in 22 physical education students with a moderate to high fitness level. They reported that in all three groups, i.e., two experimental groups (two WB-EMS protocols) and a control group (circuit training with overloads), the variables improved, but no significant difference was observed between the groups [10]. Dormann et al. (2019) studied the effects of WB-EMS and short-term resistance training on fitness factors in 22 young trained women and reported comparable findings on fitness factors in both groups. However, they concluded that WB-EMS had no greater effect on physical fitness factors in active women than traditional resistance training [11].

In previous studies there were many differences in WB-EMS exercise protocols such as duration of the training period, Voluntary exercises while using WB-EMS, exercises that were compared with this method, programs, variable evaluation method, etc. However, based on the results of a small number of studies done on young people, most studies did not report the superior effect of WB-EMS training over other exercises in healthy young people. Nevertheless, in the community, the majority of users of this exercise method are young adults, and especially because of the positive effects that WB-EMS studies reported on body composition and strength, we see the promotion of this method of exercise among healthy young women. In addition, time constraints are often reported as a major barrier to continuing exercise, which, given that WB-EMS is a time-saving exercise protocol, it has been welcomed by more and more users. Therefore, more research is needed to find more scientific and reliable methods to evaluate the effects of WB-EMS training compared to traditional exercises in the same training duration and load in young adults. Therefore, the aim of this study was to investigate the effects of WB-EMS training and resistance training on body composition and maximum strength in trained women.

Material and Methods

The present study was an applied study with pre-test and post-test design. The statistical population of this study consisted of active women between 20 and 30 years old who had at least 2 years of regular physical activity in one of the sports. After reviewing their medical history and ensuring of their health (no cardiovascular diseases, neurological diseases, mental illnesses, cancer, blood and viral diseases, skin diseases, thyroid, orthopedic problems, hypertension and pregnancy), 30 active women with a mean age of 25.70 ± 2.27 years, height of 1.63 ± 0.032 m, weight of 60.46 ± 5.50 kg and BMI of 22.54 ± 1.59 kg/m^2 were randomly selected as samples and were divided into three groups of ten: whole-body electromyostimulation (WB-EMS), strength training (ST), and control group (CG) (they did not have any regular and planned physical activity and performed their normal daily activities). It should be noted that the participants, after being aware of the possible benefits and risks of the tests and reading the test guide and completing the consent form, undertook not to have any training program outside the training protocol, they also guaranteed to continue their daily diet and not take any medication or supplements during this period. This research project was approved by the research ethics committee of the Research Institute of Physical Education and Sports Sciences with the ethics ID IR.SSRC.REC.1400.008.

Then, initial measurements including height, weight, limb circumference, and subcutaneous fat thickness and one-repetition maximum test in order to measure the maximum strength (comprehensive explanation in the measurement section) were done for all 3 groups, one week before beginning the main protocol. After completing the pre-test, the subjects performed their training protocol for 6 weeks. At the end of the training protocol, all subjects participated in the post-test 48 hours after the last training session (same as the pre-test) on different days of the week and the same tests were taken again at the same time.

Training Procedure

Whole-Body Electromyostimulation

The subjects performed their exercises with the WB-EMS device under the brand name of MihaBodytec, manufactured in Germany. This device is able to contract the body muscles, thus 14-18 areas or 8-12 muscle groups (upper legs, arms, buttocks, abdomen, chest, waist, back, latissimus dorsi, and four free options; an area of more than 2.800 cm^2) are simultaneously stimulated [6]. The exercise was performed individually with an expert instructor. First, the subjects performed stretch and flex exercises for 5-10 minutes in order to warm up the body. Subjects performed their exercises for 6 weeks and 2 sessions per week for 20 minutes per session. The electrical stimulation program in this study was selected based on the recommended WB-EMS protocol [12]. So that 12 training sessions with frequency of 85 Hz, pulse amplitude of 350μs, pulse duration of 6 seconds, rest time of 4 seconds, and the Borg Rating of Perceived Exertion (RPE) [13] of "somewhat hard and hard" RPE 14-16 were performed. Every 3-5 minutes, the instructor increased the intensity of the current used in each muscle area (leg, abdomen, etc.) separately and slowly, until the perceived exertion was maintained in the "somewhat hard and hard" range. The perceived amount of exertion reported by the subjects at the end of each session was recorded by the instructor on individual cards for quick adjustment in subsequent sessions.

It is noteworthy that the subjects wore special clothes (cotton) in the WB-EMS sessions. Also, before wearing the electrical stimulation vest, first all the electrodes embedded in the surface of the vest, belt, arm and leg cuffs were soaked in serum or water. In addition, in order to prevent any injury during the 20-minute WB-EMS exercise, simple exercises were performed to create voluntary contractions and angles in the main joints. The various exercises without overload that were performed during 20 minutes of WB-EMS under the guidance of an instructor included: squat (6 s down) and vertical chest press / squat (6 s up) and vertical rowing; squat (6 s down) and lat pulldown / squat (6 s up) and military press; deadlift (6 s down) with arm curls (ext.) / deadlift (6 s up) with arm-curls (flex.); squat (6 s down), crunch with butterfly / squat (6 s up) and reverse fly; squat (6 s down) and trunk flexion (crunches) / return to upright position; these exercises were suggested by Kemmler et al. (2016) [8]. It should be noted that there is a relationship between these movements and electrical stimulation, so that during the pulse or stimulation, voluntary contractions (such as squats, etc.) are performed and when at rest, the body is in a state of rest with no voluntary contraction. Continuous monitoring of breathing is another important recommendation during WB-EMS training. Meaning the inhalation process is done at rest and the exhalation process is done during the pulse and stimulation. Breathing should also be short and fast, deep breathing in the abdomen causes the person to be unable to hold the muscles of their body properly, therefore deep breathing causes the body to relax. The correct breathing technique during WB-EMS exercises is reminded by the instructor and performed by the subject.

Strength Training

All subjects in this study participated in a demonstration training program for one week before beginning the study in order to get acquainted with the training equipment and to learn the correct movement techniques. Subjects in this group performed each movement for 3 sets with 80-60% of one repetition maximum (1-RM) and eight to twelve repetitions in 6 weeks and 2 sessions per week. The rest interval between each turn was 60 to 90 seconds.

The training movements consisted of:

1. Leg press machine, 2. Chest fly machine, 3. Leg extensions machine, 4. Seated cable rows, 5. Hamstring machine.

Measurements

A digital scale with a measurement accuracy of 0.1 kg and a wall-mounted stadiometer were used to measure weight and height. BMI was calculated as weight divided by height squared. Subcutaneous fat thickness measurement method was used to measure body fat percentage. Subcutaneous fat thickness was measured by Caliper Lafayette instrument (manufactured in USA) and was calculated according to Jackson-Pollock equation (equation bellow) [14]. Measurements were performed 2 or 3 times on the right side of the body and in 7 areas in a way that the subject was in a standing position. After calculating the body fat percentage (BF %), lean body mass was calculated by subtracting the body weight from the fat mass weight.

Body density = $1.097 - 0.00046971 \times (\sum 7) + 0.00000056 \times (\sum 7)^2 - 0.00012828 \times x^2$

$\sum 7$= total subcutaneous fat thickness (mm), x^2 = age (year)

%BF = {(4.95/body density) – 4.5} × 100

LBM= TBW – BFM

The maximal strength of the subjects was measured by leg press exercise using the formula of one-repetition maximum (equation below) according to Brzezinski method [15].

One-repetition maximum = weight (kg) / (1.0278 – 0.0278 × repetition)

First the participants performed the general warm-up exercises and then, with 40-60% of their estimated maximum weight, performed 8-12 repetitions of the mentioned exercises for the specific warm-up. After two minutes of rest, the weights were increased so that the heaviest weight that the subject was unable to perform for more than six repetitions was recorded and the obtained load and repetition were put into the equation and the calculation results were recorded as the subjects' maximal strength.

To assess Confounding Factors (such as: health and disease status, medication, lifestyle, daily activity level, etc.), a medical history questionnaire and a physical activity readiness questionnaire (PARQ) were used.

Statistical analysis

Standard mean and standard deviation were used to describe the individual characteristics of the subjects and the research variables. Shapiro-Wilk test was used to evaluate the data distribution type and Leven test was used to examine the homogeneity of variance. To compare the mean of the research variables, mixed-design analysis of variance (2 × 3) and Bonferroni post hoc tests were used. All hypotheses were tested using SPSS software version 23 at a significance level equal to or less than 0.05.

Results

Subjects' individual information such as age, height, weight and body mass index are presented separately in Table 1. The results of Shapiro-Wilk test showed that the research variables in three groups were naturally distributed ($p < 0.05$), therefore, all calculations were performed using parametric statistical methods.

The results of mixed analysis of variance (2×3) test for the mean of BF% variable showed time effect (F= 36.087, P=0.001, η^2= 0.735), time interaction effect × type of exercise (F= 37.524, P=0.001, η^2= 0.572) is statistically significant but the intergroup effect of exercise type (F= 0.312, P=0.734, η^2= 0.023) is not statistically significant. The results of Bonferroni post hoc test for intragroup comparison of mean of BF% variable show a significant difference between the mean value of BF% variable in pre-test and pot-test (P= 0.001) in the intragroup comparison in WB-EMS group, but in ST and Control groups, no significant difference was observed between the mean value of BF% in pre-test and post-test.

Table 1

Mean and standard deviation of subjects' individual characteristics

Variable	WB-EMS	ST	CG
	Standard Deviation ± Mean	Standard Deviation ± Mean	Standard Deviation ± Mean
Age (year)	26.5 ± 2.17	24.90 ± 2.07	25.70 ± 2.49
Weight (kg)	58.60 ± 3.56	62.23 ± 6.28	60.56 ± 6.16
Height (m)	1.64 ± 0.03	1.63 ± 0.02	1.64 ± 0.03
BMI (kg/m^2)	21.79 ± 1.109	23.34 ± 1.63	22.49 ± 1.71

The results of mixed analysis of variance (2×3) test for the mean of LBM variable showed that the effect of time (F= 23.885, P=0.001, η^2= 0.469), the interactive effect of time × type of exercise (F= 15.945, P=0.001, η^2= 0.542), and the intergroup effect of type of exercise (F= 3.475, P=0.045, η^2= 0.205) were statistically significant. The results of Bonferroni post hoc test for intragroup comparison of mean of LBM variable show a significant difference between the mean value of LBM variable in pre-test and pot-test (P= 0.001) in the intragroup comparison in WB-EMS group, but in ST and Control groups, there was no significant difference between the mean value of LBM variable in pre-test and post-test. The results of Bonferroni post hoc test for intergroup comparison of mean of LBM variable show that in intergroup comparison in post-test, a significant difference was observed between the mean value of LBM variable between WB-EMS and ST groups (P = 0.028) but no significant difference was observed between WB-EMS and ST groups with CG, also in the pre-test there was no significant difference between the mean value of LBM variable between WB-EMS, ST and CG (Table 2).

Table 2

Changes of study outcomes in the three study groups

Variable		WB-EMS (n=10)	ST (n=10)	CG (n=10)	Between-group comparison
		Mean ± SD	Mean ± SD	Mean ± SD	P
Body fat (%)	Pre-test	25.88 ±1.53	24.38 ±3.79	24.74 ±3.32	0.734
	Post-test	25.01 ±1.46	24.40 ±3.81	24.73 ±3.33	
Within-group comparison	P	0.001*	0.415	0.418	-
lean body mass	Pre-test	44.29 ±1.01	46.85 ±2.49	45.42 ±2.97	0.045*
	Post-test	43.96 ±0.90	46.82 ±2.48	45.40 ±2.94	
Within-group comparison	P	0.001*	0.388	0.699	-
Maximal Strength	Pre-test	63.66 ±4.70	66.21 ±6.81	65.40 ±67	0.001*
	Post-test	80.64 ±3.86	83.35 ±5.77	65.32 ±6 86	
Within-group comparison	P	0.001*	0.001*	0.734	-

The results of mixed analysis of variance (2×3) for the mean of the Maximal strength (leg press) variable showed that the effect of time (F= 2043.382, P=0.001, η^2= 0.987), interactive effect of time × type of exercise (F= 518.567, P=0.001, η^2= 0.975), and the intergroup effect of exercise type (F= 6.894, P=0.001, η^2= 0.338) are statistically significant. The results of Bonferroni post hoc test for intragroup comparison of the mean of the maximal strength variable show that in the intragroup comparison in WB-EMS and ST groups, a significant difference was observed between the mean value of the maximal strength variable in the pre-test and post-test (P= 0.001) but in the CG, no significant difference was observed between the mean value of the maximal strength variable in pre-test and post-test. The results of Bonferroni post hoc test for intergroup comparison of mean of maximal strength variable show that in intergroup comparison in post-test a significant difference was observed between the mean value of maximal strength variable between WB-EMS and CG (P = 0.001) and between ST and CG (P = 0.001) But no significant difference was observed between WB-EMS and ST groups, also in the pre-test there was no significant difference between the mean value of the maximal strength variable between WB-EMS, ST and CG.

Changes in the variables in all 3 groups before and after the study are shown in Table 2.

Discussion

The results of this study showed that 6 weeks of WB-EMS training did not have a significant effect on BF%, because although a significant decrease in BF% was observed in the WB-EMS group, but this decrease was not significant in the post-test compared to the CG. Also, no significant effect was observed on BF% in ST group. In addition, the findings showed that WB-EMS training did not have a significant effect on LBM, because although a significant decrease in LBM was observed in the WB-EMS group, but this decrease was not significant in the post-test compared to the CG. Also, no significant effect was observed in LBM in ST group. However, both WB-EMS and ST exercises showed a significant increase in maximal strength (leg press) and no significant difference was observed between WB-EMS and ST groups for maximal strength.

The results of some studies on body fat percentage changes are consistent with the findings of the present study; For example, in a study, Filipovic et al. (2019) reported no change in BF% after 7 weeks of WB-EMS training, the results of which are consistent with the results of the present study [16]; It is also consistent with the results of Kemmler et al. (2014) that showed a significant reduction in BF% after WB-EMS training [17]. However, Kemmler et al. (2010 and 2016) reported a significant reduction in BF% after WB-EMS training, which is not consistent with the present study [7, 8]. It is likely that a significant reduction in BF% in the study of Kemmler et al. (2010) and (2016) was due to the duration of the training period. In the present study, the subjects were intervened for only 6 weeks; while the training period of the mentioned studies was more than twice the present study. Moreover, in the mentioned studies, the experimental groups were not compared with the non-training control group, while in the present study; WB-EMS group was compared with control group and it was observed that although there was a significant intragroup change in the WB-EMS group, there was no significant difference in these changes in the intergroup comparison with the CG. Based on this intergroup comparison, we concluded that WB-EMS had no significant effect on BF%. Also, as in the BF% changes in the present study, a significant decrease in intragroup changes was observed in the WB-EMS group on LBM, while non-significant intergroup changes in LBM were observed in the comparison between WB-EMS and CG which indicates ineffectiveness of WB-EMS on LBM; These results contradict the study of Kemmler et al. (2014) as well as Kemmler et al. (2016) who reported a significant increase in LBM [17, 8]. Reasons for this discrepancy may include fluctuations in body weight and nutrition. In the present study, there was a significant reduction in body weight in the WB-EMS group. As a result of this weight loss, both BF% and LBM showed a significant reduction in intra-group changes in the WB-EMS group. Nutrition is also one of the reasons that can affect LBM changes. Studies have reported that energy constraints as well as weight loss reduce LBM [18]. In addition, in the present study, no significant effect was observed on BF% and LBM in the ST group, which is consistent with the study of Monikh et al. (2015) who did not observe any significant changes on BF% and LBM after 6 weeks of strength training [19]. However, it is not consistent with the study of Gholami et al. (2018) who observed a significant difference in BF% and LBM after 8 weeks of resistance training [20]. Possible reasons for this discrepancy can be different training protocol and training duration.

The findings of this study in the field of maximal strength, which shows the positive effect of WB-EMS and ST exercises on maximal strength of the lower extremity muscles, are consistent with the results of many studies. For example, it is consistent with the results of D'Ottavio et al. (2019) who reported a significant increase in lower extremity muscle strength after 6 weeks of WB-EMS and Dynamic Strength training, while no significant differences were observed between the groups [10]; and with the results of Dormann et al. (2019) who showed that WB-EMS and ST training had a significant effect on maximal lower extremity muscle strength, while they did not observe any significant differences between the groups [11]; Micke et al. (2018) who, after 8 weeks of WB-EMS and ST training, showed an improvement in maximal leg muscle strength and did not observe significant differences between the two groups of WB-EMS training and traditional strength training [9]; Filipovic et al. (2019) who showed a significant increase in maximal lower extremity strength after 7 weeks of WB-EMS training [16]; Wirtz et al. (2016) who showed significant improvement after 6 weeks of WB-EMS and ST training on maximal strength and did not observe any significant differences between the two groups of WB-EMS training and traditional strength training [21]; Filipovic et al. (2012) who, in a systematic review, showed that after 3 to 6 weeks of electromyostimulation, a significant increase occurs in maximal strength [22]; Kemmler et al. (2010), (2013) and (2014) who reported a significant increase in maximal lower extremity strength after WB-EMS training [7, 23 and 17]; Kemmler et al. (2016) who showed that both WB-EMS and HIT exercises significantly increase maximal strength, but did not report any significant differences between the two groups [8]. The results of the studies showed a clear consistency with the results of the present study on maximal strength. Also, no study was found to report the ineffectiveness of this type of exercise on maximal strength. According to the findings of the present study, both WB-EMS and ST exercises have a positive effect on maximal strength and since there was no significant difference in maximal strength between WB-EMS and ST groups, it can be concluded that both exercises improve maximal strength.

Conclusion

In summary, no significant effects were observed on body composition after 6 weeks of WB-EMS and ST training, while positive effects on maximal strength were observed in both types of training. Given that there is no difference between these two types of exercise to increase maximal strength, traditional exercise can be recommended to healthy and young people who have enough time to exercise traditionally and also because it is cost-effective. However, according to the existing results, WB-EMS training can be recommended as a time-effective workout as well as an effective exercise method for people who are not motivated enough to do traditional exercises.

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Conflicts of interest

The authors certify that there was no conflict of interest with any financial organization regarding the material discussed in this study.

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ORIGINAL ARTICLES. SPORT

Features of vascular regulation of students – future specialists in physical education and sports of different sports specializations with different body lengths

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Abstract

Purpose: to reveal the features of the indicators of the orthostatic test in students with different body lengths and different sport´s specializations, studying in the specialty "Physical education and sports".
Material and methods. The study involved 42 students who play sports at the amateur level. The following research methods were used in the work: method of analysis of literary sources; method of determining body length; orthostatic test method; method of determining stroke volume and minute blood volume.
Results. The influence of both factors (body length and sport) on the orthostatic test was significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p < 0{,}005$; $p < 0{,}01$; $p < 0{,}001$). The more significant influence of judo and football classes in comparison with running short and medium distances on the indicators of vegetative-vascular regulation was determined: the best indicators - in judo, the next place - in football, then - athletes. It was found that students with a body length of more than 190 cm have difficulty with vegetative-vascular regulation.
Conclusions. To improve the adaptive capacity of vascular regulation to change the position of the body from horizontal to vertical in tall athletes is effective to use any exercise, but the most effective exercises that activate aerobic and anaerobic glycolytic energy systems. Also useful are exercises that require frequent transitions from lying down (sitting) to standing position, as well as changes in the direction of movement.
Key words: orthostatic test, body length, athletes, students

Анотація

Крету М., Борисенко І.В., Ушмарова В.В., Гриньова В.М., Масіч В.В. Особливості вегетосудинної регуляції студентів – майбутніх фахівців з фізичного виховання і спорту різних спортивних спеціалізацій з різною довжиною тіла

Мета: виявити особливості показників ортостатичної проби у студентів з різною довжиною тіла і різних спортивних спеціалізацій, які навчаються за спеціальністю «Фізичне виховання і спорт».

Матеріал і методи. В дослідженні взяли участь 42 студента – майбутніх фахівців з фізичного виховання і спорту. В роботі застосовувались такі методи дослідження: метод аналізу літературних джерел; метод визначення довжини тіла; метод ортостатичної проби; метод розрахунку ударного об'єму крові та хвилинного об'єму крові.

Результати. Вплив обох факторів (довжина тіла і вид спорту) на показники ортостатичної проби виявився достовірним для наступних даних: систолічний артеріальний тиск у вертикальному положенні, діастолічний артеріальний тиск у вертикальному положенні; зміна діастолічного артеріального тиску при зміні положення тіла з горизонтального на вертикальне; ЧСС у вертикальному та горизонтальному положеннях; зміна ЧСС при переході з горизонтального у вертикальне положення; ударний обсяг крові у вертикальному положенні; зміна ударного обсягу крові при переході з горизонтального у вертикальне положення; все показники хвилинного обсягу кровотоку (p<0,005; p<0,01; p<0,001). Визначено більш суттєвий вплив занять дзюдо та футболом у порівнянні з заняттями бігом на короткі і середні дистанції на показники вегетосудинної регуляції: найліпші показники – у представників дзюдо, наступне місце – у представників футболу, потім – легкоатлети. Виявлено, що у студентів з довжиною тіла понад 190 см спостерігається утруднення вегетосудинної регуляції.

Висновки. Для поліпшення адаптаційних можливостей вегетосудинної регуляції до зміни положення тіла з горизонтального на вертикальне у високих спортсменів ефективним є застосування будь-яких фізичних вправ, але найбільш ефективні вправи, які активізують аеробні та анаеробні гліколітичні системи енергозабезпечення. Також корисними є вправи, які вимагають частих переходів з положень лежачи (сидячи) в положення стоячи, а також зміни напрямку рухів.

Ключові слова: ортостатичний тест, довжина тіла, спортсмени, студенти

Аннотация

Крету М., Борисенко И.В., Ушмарова В.В., Гринева В.Н., Масич В.В. Особенности вегетососудистой регуляции студентов – будущих специалистов по физическому воспитанию и спорту различных спортивных специализаций с разной длиной тела

Цель: выявить особенности показателей ортостатической пробы у студентов с разной длиной тела и разных спортивных специализаций, обучающихся по специальности «Физическое воспитание и спорт».

Материал и методы. В исследовании приняли участие 42 студента – будущих специалистов по физическому воспитанию и спорту. В работе использованы следующие методы исследования: метод анализа литературных источников; метод определения длины тела; метод ортостатической пробы; метод расчёта ударного объема и минутного объема крови.

Результаты. Влияние обоих факторов (длина тела и вид спорта) на показатели ортостатической пробы оказался достоверным для следующих данных: систолическое артериальное давление в вертикальном положении, диастолическое артериальное давление в вертикальном положении; изменение диастолического артериального давления при изменении положения тела из горизонтального в вертикальное ЧСС в вертикальном и горизонтальном положениях; изменение ЧСС при переходе из горизонтального в вертикальное положение; ударный объем крови в вертикальном положении; изменение ударного объема крови при переходе из горизонтального в вертикальное положение; все показатели минутного объема кровотока (p <0,005; p <0,01; p <0,001). Определены более существенное влияние занятий дзюдо и футболом по сравнению с занятиями бегом на короткие и средние дистанции на показатели вегетососудистой регуляции: лучшие показатели - у представителей дзюдо, следующее место - у представителей футболу, потом - легкоатлеты. Выявлено, что у студентов с длиной тела более 190 см наблюдается затруднение вегетососудистой регуляции.

Выводы. Для улучшения адаптационных возможностей вегетососудистой регуляции к изменению положения тела с горизонтального на вертикальное в высоких спортсменов эффективно применение любых физических упражнений, но наиболее эффективные упражнения, которые активизируют аэробные и анаэробные гликолитические системы энергообеспечения. Также полезны упражнения, которые требуют частых переходов из положений лежа (сидя) в положение стоя, а также изменения направления движения.

Ключевые слова: ортостатическая проба, длина тела, спортсмены, студенты

Introduction

Vegetovascular regulation is one of the main mechanisms for ensuring the normal functioning of the body [1-3]. One of the manifestations of vegetative-vascular regulation is vasoconstriction and dilation in response to external influences [4, 5]. One of the simplest and most accessible methods for determining the quality of vegetative-vascular regulation is the orthostatic test [6, 7]. The orthostatic test is based on determining the body's adaptation to a change in body position from horizontal to vertical [5–8].

In athletes, the orthostatic test is based on training-induced changes in the functioning of the autonomic nervous system [9–10]. The results of the orthostatic test are influenced by a combination of such external factors as psychological stress, sleep quality, latent diseases, changes in environmental parameters (temperature, altitude), and others [7–10]. The results of the orthostatic test help to optimize the training process and prevent fatigue in athletes [2, 10, 11].

Orthostatic test is performed on the basis of measurements of heart rate (HR) and blood pressure [4, 5]. Changes in heart rate and blood pressure reflect changes in the state of the autonomic nervous system and cardiovascular system. During this test, the indicators of heart rate and blood pressure are measured in the supine position, heart rate in the standing position. The indicators measured during the orthostatic test are a reliable criterion for the load on the autonomic nervous system.

Nazarenko [11] assessed the balance function in athletes and people who do not go in for sports before and after an active orthostatic test. The athletes showed a higher level of balance function in comparison with the control, which decreased to a much lesser extent after an active orthostatic test, which indicates a positive effect of sports on the stability of the statokinetic system. At the same time, statistically significant differences in the balance function between wrestlers and football players appear after an active orthostatic test. In studies [12] it was revealed that athletes - basketball players of taller stature adapt worse to orthostatic load in comparison with athletes of average and below average height.

It is also known [12–14] that in people of high body length, the change in performance during the transition from horizontal to vertical body position is more pronounced, because a larger volume of blood falls sharply to the lower extremities. This leads to the need for more pronounced adaptation mechanisms of heart rate and blood pressure. In our previous study [13], the increase in heart rate in tall people did not differ significantly from this figure in students of medium and below average body length. But blood pressure, both systolic and diastolic, is significantly higher in tall students compared to others. This fact can be regarded as a more pronounced adaptive response of students with a body length above 190 cm from the cardiovascular system and vascular regulation. These adaptive responses are not sufficient, because the magnitude of the shock volume of blood and minute volume of blood flow in the vertical position in students of high body length is significantly smaller compared to students with a body length of 150-175 cm [13, 14].

Iordanskaya, Buchina [10] revealed the features of orthostatic stability in the vegetative support of the organism's working capacity of highly qualified athletes. The authors examined a group of 203 people, of whom 109 were men and 94 were women in two sports, volleyball (104 athletes) and rowing (99 athletes). The authors have developed a program and criteria for assessing the operational diagnosis of the functional state of the autonomic nervous system, including an orthostatic test with an assessment of heart rate, blood pressure, electrocardiogram in terms of monitoring training and pre-competition loads of the annual training cycle. The interrelation of the level of orthostatic stability in the vegetative support of the working capacity of volleyball players was revealed, taking into account the growth indicators and the playing role. In tall volleyball players of diagonal and central blockers, symptoms of dysadaptation of the cardiovascular system in response to orthostasis are more often diagnosed. In the group of rowing athletes, the relationship between the level of orthostatic stability with age and gender was revealed: young men and juniors more often show symptoms of dysadaptation in response to orthostasis and extreme physical load on the CONCEPT rowing ergometer. It was revealed that the speed-power loads of male rowers are more often reflected in the appearance of hypertension and hypertensive reaction in the work "to failure" on the rowing ergometer. Prompt diagnosis of orthostatic autonomic stability reveals early symptoms of cardiovascular overstrain in a timely manner and serves as a signal for stress correction and recovery.

We [13, 14] found that students with a body length of more than 190 cm have difficulty with vegetative-vascular regulation. The effect of body length on the orthostatic test was also significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute blood volume. However, the question of the joint influence of body length and sports specialization on the indicators of the orthostatic test has not been investigated. There was a significant positive relationship between body length and heart rate c in horizontal, vertical positions and changes in heart rate when changing body position from horizontal to vertical (r = 0.50-0.71). There was also a positive significant relationship between body length and the value of systolic pressure in the vertical position (r = 0.72); negative significant relationship between body length and the value of the stroke volume of blood in the vertical position (r = -0.65).

However, despite the presence of studies showing the effect of body length on the indicators of the orthostatic test in athletes from different sports, this issue remains open and requires additional research. Among athletes, a special place is occupied by students involved in various sports and studying in the specialty "Physical Education and Sports". This category of students is especially significant, since they not only improve their sports skills, but also must bring knowledge to their students in the future.

Purpose: to reveal the features of the indicators of the orthostatic test in students with different body lengths and different sport´s specializations, studying in the specialty "Physical education and sports".

Material and methods

Participants

The study involved 42 students who play sports at the amateur level. The number of students with a body length of more than 190 cm was 12 people. The number of students whose body length was 150-175 cm was 30 people. There were no students with a body length of 176-189 cm in the study. This was the basis for the division of students into such groups according to body length, because it is known that large values of body length (over 190 cm) negatively affect the adaptation of the cardiovascular system in the transition from horizontal to vertical position.

The study was conducted on the basis of H.S. Skovoroda Kharkiv National Pedagogical University.

Procedure

The following research methods were used in the work: method of analysis of literature sources; method of determining body length; orthostatic test method; method of determining stroke volume and minute blood volume; methods of statistical data processing (comparison of averages by the Student's method, multivariate analysis of variance and correlation analysis).

An orthostatic test measures heart rate and blood pressure. These values are measured in a horizontal position, then repeat these measurements in the subject after actively getting up in a vertical position at the 10th minute [15–18].

A natural reaction to the orthostatic test is an increase in heart rate. As a result, the minute volume of blood is slightly reduced. In well-trained athletes, heart rate is relatively small and ranges from 5 to 15 beats per minute. In young athletes, the reaction may be more pronounced. Systolic blood pressure either remains unchanged or even decreases slightly (by 2-6 mm.Hg); diastolic blood pressure naturally increases by 10-15% relative to its value in the horizontal position. If during a 10-minute study the systolic pressure approaches the initial values, the diastolic pressure remains elevated. Signs of orthostatic instability are a sharp drop in blood pressure and a very large increase in heart rate [9, 12].

Measurements of body length are performed in a standing position using a vertical height meter. The person stands on a wooden plane with his back to the vertical bar, touching her heels, buttocks, interscapular area with the shoulders set back (head not resting). The arms should be lowered along the torso, the abdomen - tightened, the heels - together, the socks - separately. The position of the head should be such that the upper edge of the earlobe and the lower edge of the orbit are in the same horizontal plane. The movable bar is attached to the head without pressure, but tightly.

The magnitude of the stroke volume depends on the force of the heart contraction and the amount of blood flowing to it during diastole through the veins. Stroke volume (SV) can be calculated by Starr's formula [12–14].

The minute blood volume (MBV) is determined by the stroke volume and heart rate, depending on the position of the human body, its sex, age, fitness, environmental conditions and many other factors.

Calculate the minute blood volume (MBV) according to the formula [12]:

MBV = SV × heart rate.

Statistical analysis

For each indicator, the arithmetic mean, standard deviation S (standard deviation), error of the mean (m) and estimation of the probability of discrepancies in the Student's t-test with the appropriate level of probability (p) were determined for groups of students involved in football, track and field, judo and for groups of students with body length above average (more than 190 cm) and average (below average) (150-175 cm). Differences and relationships were considered reliable at the significance level p <0.05 [13, 14].

Multivariate analysis of variance was also used using a general linear model. The dependent values were heart rate, systolic and diastolic blood pressure, stroke volume and minute blood flow in horizontal and vertical positions, as well as the difference between these indicators in different body positions. Independent values were body length and sport. Body length of 150-175 cm was denoted by the number 1, body length greater than 190 cm was denoted by the number 2. There were no students with body length values of 175-190 cm in the study.

We also marked the conditional numbers of the sports that students were involved in: athletics - 1; football - 2; judo wrestling - 3) [13, 14].

For statistical processing of the obtained data were used computer programs Microsoft Excel "Data Analysis" - 2013, SPSS - 17.

Results

Comparison of orthostatic tests of students – representatives of different sports showed that the lowest values of heart rate in the horizontal position and in the vertical position of the body in judo. The same applies to blood pressure in the horizontal and vertical position (p <0.001) (Table 1-3). The highest heart rate and blood pressure in students - athletes. According to these indicators, footballers occupy an intermediate place.

Table 1

Comparative characteristics of orthostatic test indicators of students involved in track and field and football

Indicators	Kind of sport	Statistical Indicators					
		N	$\bar{x}$	S	M	t	p
Systolic pressure (mm.Hg) in the horizontal position	track and field	18	115.67	3.40	0.80	5.15	0.000
	football	12	110.00	2.09	0.60		
Systolic pressure (mm.Hg) in the vertical position	track and field	18	130.67	0.97	0.23	2.13	0.043
	football	12	129.00	3.13	0.90		
Systolic pressure (mmHg) Difference	track and field	18	15.00	4.20	0.99	-3.22	0.003
	football	12	19.00	1.04	0.30		
Diastolic pressure (mm.Hg.) in the horizontal position	track and field	18	77.33	5.90	1.39	1.48	0.150
	football	12	74.00	6.27	1.81		
Diastolic pressure (mm.Hg.) in the vertical position	track and field	18	88.33	3.40	0.80	9.19	0.000
	football	12	79.00	1.04	0.30		
Diastolic pressure Difference (mm.Hg)	track and field	18	11.00	8.27	1.95	2.23	0.034
	football	12	5.00	5.22	1.51		
Heart rate (beats·min^{-1}) in the vertical position	track and field	18	69.33	2.11	0.50	3.79	0.001
	football	12	58.00	12.53	3.62		
Heart rate (beats·min^{-1}) in the vertical position	track and field	18	71.33	5.59	1.32	0.65	0.522
	football	12	69.50	9.92	2.86		
Heart rate (beats·min^{-1}) difference	track and field	18	5.33	0.49	0.11	-9.85	0.000

	football	12	11.50	2.61	0.75		
Stroke volume (ml) in a horizontal position	track and field	18	60.27	8.79	2.07	-0.46	0.649
	football	12	61.60	5.85	1.69		
Stroke volume (ml) in the vertical position	track and field	18	56.17	4.19	0.99	-7.73	0.000
	football	12	65.60	0.42	0.12		
Stroke volume (ml) difference	track and field	18	11.77	3.37	0.79	4.18	0.000
	football	12	6.00	4.18	1.21		
Minute blood volume ($1\cdot min^{-1}$) in a horizontal position	track and field	18	4.17	0.55	0.13	1.74	0.093
	football	12	3.64	1.11	0.32		
Minute blood volume ($1\cdot min^{-1}$) in the vertical position	track and field	18	3.98	0.03	0.01	-3.92	0.001
	football	12	4.56	0.62	0.18		
Minute blood volume Difference ($1\cdot min^{-1}$)	track and field	18	0.51	0.18	0.04	-3.23	0.003
	football	12	0.92	0.49	0.14		
Body Length	track and field	18	178.33	12.24	2.89	-0.15	0.882
	football	12	179.00	11.49	3.32		

That is, the adaptive capabilities of the cardiovascular system and vegetative-vascular regulation when changing the position of the body from horizontal to vertical in our study were found in students who are engaged in judo. This somewhat contradicts the literature on the best adaptive capabilities of long- and medium-distance running. In our study, athletes were representatives of short and medium distance running. It was found that their adaptive capacity when changing body position is significantly lower compared to football and judo.

Table 2

Comparative characteristics of orthostatic test indicators of students engaged in track and field and judo

Indicators	Kind of sport	Statistical Indicators					
		N	$\bar{x}$	S	M	t	p
Systolic pressure (mm.Hg) in the horizontal position	track and field	18	115.67	3.40	0.80	6.80	0.000
	judo	12	105.00	5.22	1.51		
Systolic pressure (mm.Hg) in the vertical position	track and field	18	130.67	0.97	0.23	73.36	0.000
	judo	12	110.00	0.00	0.00		
Systolic pressure (mmHg) difference	track and field	18	15.00	4.20	0.99	5.80	0.000
	judo	12	5.00	5.22	1.51		
Diastolic pressure (mm.Hg.) in the horizontal position	track and field	18	77.33	5.90	1.39	3.34	0.002
	Judo	12	66.00	12.53	3.62		
Diastolic pressure (mm.Hg.) in the vertical position	track and field	18	88.33	3.40	0.80	22.97	0.000
	Judo	12	65.00	1.04	0.30		
Diastolic pressure Difference (mm.Hg)	track and field	18	11.00	8.27	1.95	-0.83	0.415
	Judo	12	13.00	1.04	0.30		
Heart rate (beats$\cdot min^{-1}$) in the vertical position	track and field	18	69.33	2.11	0.50	29.15	0.000
	Judo	12	48.50	1.57	0.45		

Heart rate (beats·min^{-1}) in the vertical position	track and field	18	71.33	5.59	1.32	7.26	0.000
	Judo	12	59.50	0.52	0.15		
Heart rate (beats·min^{-1}) difference	track and field	18	5.33	0.49	0.11	-20.12	0.000
	Judo	12	11.00	1.04	0.30		
Stroke volume (ml) in a horizontal position	track and field	18	60.27	8.79	2.07	-1.66	0.108
	Judo	12	67.90	16.40	4.73		
Stroke volume (ml) in the vertical position	track and field	18	56.17	4.19	0.99	-12.31	0.000
	Judo	12	71.50	1.15	0.33		
Stroke volume (ml) difference	track and field	18	11.77	3.37	0.79	-3.83	0.001
	Judo	12	16.80	3.76	1.09		
Minute blood volume (1·min^{-1}) in a horizontal position	track and field	18	4.17	0.55	0.13	3.22	0.003
	Judo	12	3.32	0.90	0.26		
Minute blood volume (1·min^{-1}) in the vertical position	track and field	18	3.98	0.03	0.01	-22.13	0.000
	Judo	12	4.25	0.03	0.01		
Minute blood volume Difference (1·min^{-1})	track and field	18	0.51	0.18	0.04	-1.91	0.067
	Judo	12	0.94	0.93	0.27		
Body Length	track and field	18	178.33	12.24	2.89	5.43	0.000
	Judo	12	159.00	1.04	0.30		

We can explain the results by the fact that both football and judo are a load of mixed aerobic-anaerobic orientation, while running short and medium distances is mainly a job that requires creatine-phosphate and glycolytic mechanisms of energy supply.

Table 3

Comparative characteristics of orthostatic test indicators of students involved in football and judo

Indikators	Kind of sport	Statistical Indikators					
		N	$\bar{x}$	S	m	t	p
Systolic pressure (mm.Hg) in the horizontal position	Football	12	110.00	2.09	0.60	3.08	0.005
	Judo	12	105.00	5.22	1.51		
Systolic pressure (mm.Hg) in the vertical position	football	12	129.00	3.13	0.90	21.01	0.000
	Judo	12	110.00	0.00	0.00		
Systolic pressure (mmHg) difference	football	12	19.00	1.04	0.30	9.11	0.000
	Judo	12	5.00	5.22	1.51		
Diastolic pressure (mm.Hg.) in the horizontal position	football	12	74.00	6.27	1.81	1.98	0.061
	Judo	12	66.00	12.53	3.62		
Diastolic pressure (mm.Hg.) in the vertical position	football	12	79.00	1.04	0.30	32.83	0.000
	Judo	12	65.00	1.04	0.30		
Diastolic pressure Difference (mm.Hg)	football	12	5.00	5.22	1.51	-5.20	0.000
	Judo	12	13.00	1.04	0.30		
Heart rate (beats·min^{-1}) in the vertical position	football	12	58.00	12.53	3.62	2.61	0.016
	judo	12	48.50	1.57	0.45		

Heart rate (beats·min^{-1}) in the vertical position	football	12	69.50	9.92	2.86	3.49	0.002
	judo	12	59.50	0.52	0.15		
Heart rate (beats·min^{-1}) difference	football	12	11.50	2.61	0.75	0.62	0.544
	judo	12	11.00	1.04	0.30		
Stroke volume (ml) in a horizontal position	football	12	61.60	5.85	1.69	-1.25	0.223
	judo	12	67.90	16.40	4.73		
Stroke volume (ml) in the vertical position	football	12	65.60	0.42	0.12	-16.72	0.000
	judo	12	71.50	1.15	0.33		
Stroke volume (ml) difference	football	12	6.00	4.18	1.21	-6.66	0.000
	judo	12	16.80	3.76	1.09		
Minute blood volume (1·min^{-1}) in a horizontal position	football	12	3.64	1.11	0.32	0.78	0.442
	judo	12	3.32	0.90	0.26		
Minute blood volume (1·min^{-1}) in the vertical position	football	12	4.56	0.62	0.18	1.68	0.107
	judo	12	4.25	0.03	0.01		
Minute blood volume Difference (1·min^{-1})	football	12	0.92	0.49	0.14	-0.07	0.944
	judo	12	0.94	0.93	0.27		
Body Length	football	12	179.00	11.49	3.32	6.01	0.000
	judo	12	159.00	1.04	0.30		

Significant influence of both body length and sport on most indicators of orthostatic test was found (Table 4). The results of analysis of variance confirmed the results of comparing the averages of the Student's t-test. The influence of sport on heart rate, systolic and diastolic pressure, as well as the calculated values of stroke volume and minute blood flow in the supine and standing positions was significant for almost all indicators ($p < 0.05$; $p < 0.001$) (Table 4). The only exception is the rate of stroke blood volume in the horizontal position ($p > 0.05$) (Table 4). Thus, the analysis of variance confirmed the results of comparing the means of the Student's t-test for the best effect on vascular regulation and the state of the cardiovascular system in judo. Short and medium distance running by students at the level of mass discharges has a less pronounced effect on orthostatic test performance. Football classes occupy an intermediate place between judo and athletics in terms of impact on vascular regulation.

Body length also significantly affects the indicators of vascular regulation (Table 4). There is a significant effect of body length on systolic blood pressure in the standing position, diastolic blood pressure in the supine and standing positions, heart rate in the supine and standing positions, stroke blood volume in the standing position, minute blood flow in the supine and standing positions ($p < 0.001$) (Table 4).

The influence of both factors (body length and sport) on the orthostatic test was also significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p < 0.005$; $p < 0.01$; $p < 0.001$).

The influence of both factors (body length and sport) on the orthostatic test was also significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p < 0.005$; $p < 0.01$; $p < 0.001$).

Table 4

Indicators of multivariate analysis of variance of the influence of sport and body length on the orthography of students (Tests of Between-Subjects Effects)

Source	Dependent Variable	Tests of Between-Subjects Effects				
		Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Systolic pressure (mm.Hg) in the horizontal position	888.000a	4	222	16.695	0.000
	Systolic pressure (mm.Hg) in the vertical position	3560.571b	4	890.143	2744.607	0.000
	Systolic pressure (mmHg) difference	1280.571c	4	320.143	19.742	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	1373.143d	4	343.286	5.484	0.001
	Diastolic pressure (mm.Hg.) in the vertical position	4053.000e	4	1013.25	430.922	0.000
	Diastolic pressure Difference (mm.Hg)	806.143f	4	201.536	6.81	0.000
	Heart rate (beats·min^{-1}) in the vertical position	4994.143g	4	1248.536	1184.508	0.000
	Heart rate (beats·min^{-1}) in the vertical position	2452.286h	4	613.071	92.21	0.000
	Heart rate (beats·min^{-1}) difference	437.571i	4	109.393	269.836	0.000
	Stroke volume (ml) in a horizontal position	824.096j	4	206.024	1.786	0.152
	Stroke volume (ml) in the vertical position	1959.673k	4	489.918	128.314	0.000
	Stroke volume (ml) difference	1027.783l	4	256.946	44.508	0.000
	Minute blood volume (1·min^{-1}) in a horizontal position	19.290m	4	4.823	12.729	0.000
	Minute blood volume (1·min^{-1}) in the vertical position	6.619n	4	1.655	2065.344	0.000
	Minute blood volume Difference (1·min^{-1})	4.784o	4	1.196	4.536	0.004
Intercept	Systolic pressure (mm.Hg) in the horizontal position	438703.7	1	438703.7	32991.95	0.000
	Systolic pressure (mm.Hg) in the vertical position	556475	1	556475	1715798	0.000
	Systolic pressure (mmHg) difference	6993.204	1	6993.204	431.248	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	194326.9	1	194326.9	3104.531	0.000
	Diastolic pressure (mm.Hg.) in the vertical position	225666.2	1	225666.2	95972.97	0.000
	Diastolic pressure Difference (mm.Hg)	3104.92	1	3104.92	104.915	0.000
	Heart rate (beats·min^{-1}) in the vertical position	124863.2	1	124863.2	118460	0.000
	Heart rate (beats·min^{-1}) in the vertical position	163461	1	163461	24585.6	0.000
	Heart rate (beats·min^{-1}) difference	3048.124	1	3048.124	7518.705	0.000
	Stroke volume (ml) in a horizontal position	137842.2	1	137842.2	1194.89	0.000
	Stroke volume (ml) in the vertical position	141439	1	141439	37044.27	0.000
	Stroke volume (ml) difference	4050.128	1	4050.128	701.567	0.000

	Minute blood volume ($1 \cdot min^{-1}$) in a horizontal position	483.904	1	483.904	1277.286	0.000
	Minute blood volume ($1 \cdot min^{-1}$) in the vertical position	634.008	1	634.008	791360.4	0.000
	Minute blood volume Difference ($1 \cdot min^{-1}$)	21.647	1	21.647	82.09	0.000
Kind of sport	Systolic pressure (mm.Hg) in the horizontal position	631.75	2	315.875	23.755	0.000
	Systolic pressure (mm.Hg) in the vertical position	2467	2	1233.5	3803.292	0.000
	Systolic pressure (mmHg) difference	945.75	2	472.875	29.161	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	427	2	213.5	3.411	0.044
	Diastolic pressure (mm.Hg.) in the vertical position	3172	2	1586	674.506	0.000
	Diastolic pressure Difference (mm.Hg)	349	2	174.5	5.896	0.006
	Heart rate (beats·min^{-1}) in the vertical position	4441.75	2	2220.875	2106.984	0.000
	Heart rate (beats·min^{-1}) in the vertical position	1588	2	794	119.423	0.000
	Heart rate (beats·min^{-1}) difference	418.75	2	209.375	516.458	0.000
	Stroke volume (ml) in a horizontal position	140.507	2	70.254	0.609	0.549
	Stroke volume (ml) in the vertical position	1642.17	2	821.085	215.05	0.000
	Stroke volume (ml) difference	636.077	2	318.039	55.091	0.000
	Minute blood volume ($1 \cdot min^{-1}$) in a horizontal position	11.741	2	5.871	15.496	0.000
	Minute blood volume ($1 \cdot min^{-1}$) in the vertical position	2.603	2	1.302	1624.679	0.000
	Minute blood volume Difference ($1 \cdot min^{-1}$)	2.996	2	1.498	5.681	0.007
Body length	Systolic pressure (mm.Hg) in the horizontal position	15.429	1	15.429	1.16	0.288
	Systolic pressure (mm.Hg) in the vertical position	42.857	1	42.857	132.143	0.000
	Systolic pressure (mmHg) difference	6.857	1	6.857	0.423	0.520
	Diastolic pressure (mm.Hg.) in the horizontal position	289.714	1	289.714	4.628	0.038
	Diastolic pressure (mm.Hg.) in the vertical position	96.429	1	96.429	41.01	0.000
	Diastolic pressure Difference (mm.Hg)	51.857	1	51.857	1.752	0.194
	Heart rate (beats·min^{-1}) in the vertical position	685.714	1	685.714	650.549	0.000
	Heart rate (beats·min^{-1}) in the vertical position	189	1	189	28.427	0.000
	Heart rate (beats·min^{-1}) difference	34.714	1	34.714	85.629	0.000
	Stroke volume (ml) in a horizontal position	248.919	1	248.919	2.158	0.150
	Stroke volume (ml) in the vertical position	56.679	1	56.679	14.845	0.000
	Stroke volume (ml) difference	8.297	1	8.297	1.437	0.238
	Minute blood volume ($1 \cdot min^{-1}$) in a horizontal position	6.432	1	6.432	16.977	0.000
	Minute blood volume ($1 \cdot min^{-1}$) in the vertical position	2.403	1	2.403	2999.62	0.000

	Minute blood volume Difference (1·min^{-1})	0.693	1	0.693	2.63	0.113
Kind of sport· Body length	Systolic pressure (mm.Hg) in the horizontal position	42.857	1	42.857	3.223	0.081
	Systolic pressure (mm.Hg) in the vertical position	84	1	84	259	0.000
	Systolic pressure (mmHg) Difference	6.857	1	6.857	0.423	0.520
	Diastolic pressure (mm.Hg.) in the horizontal position	207.429	1	207.429	3.314	0.077
	Diastolic pressure (mm.Hg.) in the vertical position	21	1	21	8.931	0.005
	Diastolic pressure Difference (mm.Hg)	360.429	1	360.429	12.179	0.001
	Heart rate (beats·min^{-1}) in the vertical position	1344	1	1344	1275.077	0.000
	Heart rate (beats·min^{-1}) in the vertical position	1296.429	1	1296.429	194.991	0.000
	Heart rate (beats·min^{-1}) Difference	51.857	1	51.857	127.914	0.000
	Stroke volume (ml) in a horizontal position	183.639	1	183.639	1.592	0.215
	Stroke volume (ml) in the vertical position	92.61	1	92.61	24.255	0.000
	Stroke volume (ml) difference	326.469	1	326.469	56.551	0.000
	Minute blood volume (1·min^{-1}) in a horizontal position	9.219	1	9.219	24.334	0.000
	Minute blood volume (1·min^{-1}) in the vertical position	2.46	1	2.46	3070.976	0.000
	Minute blood volume Difference (1·min^{-1})	2.627	1	2.627	9.964	0.003
Error	Systolic pressure (mm.Hg) in the horizontal position	492	37	13.297	-	-
	Systolic pressure (mm.Hg) in the vertical position	12	37	0.324	-	-
	Systolic pressure (mmHg) Difference	600	37	16.216	-	-
	Diastolic pressure (mm.Hg.) in the horizontal position	2316	37	62.595	-	-
	Diastolic pressure (mm.Hg.) in the vertical position	87	37	2.351	-	-
	Diastolic pressure Difference (mm.Hg)	1095	37	29.595	-	-
	Heart rate (beats·min^{-1}) in the vertical position	39	37	1.054	-	-
	Heart rate (beats·min^{-1}) in the vertical position	246	37	6.649	-	-
	Heart rate (beats·min^{-1}) Difference	15	37	0.405	-	-
	Stroke volume (ml) in a horizontal position	4268.31	37	115.36	-	-
	Stroke volume (ml) in the vertical position	141.27	37	3.818	-	-
	Stroke volume (ml) difference	213.6	37	5.773	-	-
	Minute blood volume (1·min^{-1}) in a horizontal position	14.018	37	0.379	-	-
	Minute blood volume (1·min^{-1}) in the vertical position	0.03	37	0.001	-	-
	Minute blood volume Difference (1·min^{-1})	9.757	37	0.264	-	-
Total	Systolic pressure (mm.Hg) in the horizontal position	518862	42	-	-	-
	Systolic pressure (mm.Hg) in the	652344	42	-	-	-

	vertical position					
	Systolic pressure (mmHg) Difference	9294	42	-	-	-
	Diastolic pressure (mm.Hg.) in the horizontal position	228384	42	-	-	-
	Diastolic pressure (mm.Hg.) in the vertical position	266262	42	-	-	-
	Diastolic pressure Difference (mm.Hg)	5982	42	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	156954	42	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	193656	42	-	-	-
	Heart rate (beats·min^{-1}) difference	3642	42	-	-	-
	Stroke volume (ml) in a horizontal position	170884.4	42	-	-	-
	Stroke volume (ml) in the vertical position	170086.6	42	-	-	-
	Stroke volume (ml) difference	6851.22	42	-	-	-
	Minute blood volume (1·min^{-1}) in a horizontal position	631.834	42	-	-	-
	Minute blood volume (1·min^{-1}) in the vertical position	756.172	42	-	-	-
	Minute blood volume Difference (1·min^{-1})	38.022	42	-	-	-
Corrected Total	Systolic pressure (mm.Hg) in the horizontal position	1380	41	-	-	-
	Systolic pressure (mm.Hg) in the vertical position	3572.571	41	-	-	-
	Systolic pressure (mmHg) difference	1880.571	41	-	-	-
	Diastolic pressure (mm.Hg.) in the horizontal position	3689.143	41	-	-	-
	Diastolic pressure (mm.Hg.) in the vertical position	4140	41	-	-	-
	Diastolic pressure Difference (mm.Hg)	1901.143	41	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	5033.143	41	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	2698.286	41	-	-	-
	Heart rate (beats·min^{-1}) difference	452.571	41	-	-	-
	Stroke volume (ml) in a horizontal position	5092.406	41	-	-	-
	Stroke volume (ml) in the vertical position	2100.943	41	-	-	-
	Stroke volume (ml) difference	1241.383	41	-	-	-
	Minute blood volume (1·min^{-1}) in a horizontal position	33.308	41	-	-	-
	Minute blood volume (1·min^{-1}) in the vertical position	6.648	41	-	-	-
	Minute blood volume Difference (1·min^{-1})	14.541	41	-	-	-

a. R Squared =0.643 (Adjusted R Squared = 0.605); b. R Squared =0.997 (Adjusted R Squared =0.996); c. R Squared =0.681 (Adjusted R Squared =0.646); d. R Squared =0.372 (Adjusted R Squared =0.304); e. R Squared =0.979 (Adjusted R Squared =0.977); f. R Squared =0.424 (Adjusted R Squared =0.362); g. R Squared =0.992 (Adjusted R Squared =0.991); h. R Squared =0.909 (Adjusted R Squared =0.899); i. R Squared =0.967 (Adjusted R Squared =0.963); j. R Squared =0.162 (Adjusted R Squared =0.071); k. R Squared =0.933 (Adjusted R Squared =0.925); l. R Squared =0.828 (Adjusted R Squared =0.809); m. R Squared =0.579 (Adjusted R Squared =0.534); n. R Squared =0.996 (Adjusted R Squared =0.995); o. R Squared =0.329 (Adjusted R Squared =0.256)

Discussion

The purpose of the work set in this study was fully confirmed. It has been shown that students who engage in different sports have different adaptive capabilities in terms of vascular regulation. It was also shown that students with a body length greater than 190 cm have less adaptive capacity for vascular regulation compared to students of medium and below average body length.

Our data confirmed the results of other authors [4, 9, 10], that in athletes orthostatic instability associated with decreased venous tone develops relatively rarely. However, when conducting orthostatic tests, it can sometimes be detected [12]. Therefore, the use of orthostatic tests to assess the functional state of the body of athletes is considered appropriate.

A natural reaction to the orthostatic test is an increase in heart rate [1, 4, 6]. Due to this, the minute volume of blood flow is reduced slightly. In well-trained athletes, heart rate is relatively small and ranges from 5 to 15 beats • min-1. In young athletes, the reaction may be more pronounced [9]. Systolic blood pressure either remains unchanged or even decreases slightly (by 2-6 mm Hg); diastolic blood pressure naturally increases by 10-15% relative to its value in the horizontal position. If during 10 - minute research systolic pressure approaches initial values, arterial pressure remains raised.

Signs of orthostatic instability are a sharp drop in blood pressure and a very large increase in heart rate [4]. But at the present stage, a simple assessment of the orthostatic sample according to heart rate continues to be refined. The fact is that such a seemingly reliable indicator, which is the increase in heart rate in the vertical position relative to the heart rate in the horizontal position, sometimes gives inaccurate data. This is especially true for athletes with bradycardia in a horizontal position: their heart rate can increase by 30-25 beats • min1 without any signs of orthostatic instability. In this regard, it is recommended to evaluate the orthostatic test on the basis of the actual heart rate in the vertical position of the body. If the heart rate does not exceed 89 beats per minute for 10 minutes, the reaction is considered normal. A heart rate of 90-95 beats • min-1 indicates a decrease in orthostatic stability, and a heart rate exceeding 95 beats • min-1 indicates low resistance to changes in body position in space, at which orthostatic collapse is possible. This approach to the assessment of orthostatic reactions is based on the so-called principle of invariance, the essence of which is that under the influence of a perturbing effect, the performance of the body's autonomic systems do not depend (or depend to a small extent) on baseline and are determined exclusively current needs of the organism [4, 12].

The response to the orthostatic test improves under the influence of sports training [10, 11]. And this applies to all athletes, not just those sports in which a change of body position is a mandatory element.

According to the literature [2, 4, 8], orthostatic hypotension and orthostatic collapse are abnormal, pathological phenomena. Osadchy [4] writes that a decrease in systemic blood pressure is often accompanied by dizziness, blurred vision, sweating and even loss of consciousness with a sudden transition from horizontal (or sitting) to a vertical position. Physiological effects of this change in body position are the result of increased hydrostatic pressure in veins and the arteries of the lower and lowering - in the vessels of the upper half of the body and the corresponding redistribution of blood mass.

Cerebral circulation is protected from fluctuations in hydrostatic pressure in the vascular system due to the same pressure of this factor on both intravascular and extravascular (in the spinal canal) pressure. Under these conditions, the cerebral tie is under the control of systemic blood pressure and therefore a decrease in the latter immediately leads to a decrease in the arteriovenous gradient

Therefore, despite the presence of nervous and humoral mechanisms that reduce the resistance of cerebral vessels and prevent the effects of oscillations of systemic arterial suppression [4], an essential factor in maintaining cerebral blood flow is adequate blood pressure [4].

Thus, in those individuals in whom the orthostatic is written off above the compensatory mechanisms can not prevent a significant decrease in blood pressure, decreased cerebral blood flow, which causes "fainting" or "unconsciousness" (depending on the intensity of the above symptoms of cerebral circulatory disorders). In the scientific literature, "fainting" (or "syncope", "collapse") entered as the most important element of the syndrome, referred to as "orthostatic hypotension". This term refers to such conditions in which the violation of circulatory homeostasis during a change in body position is the main pathogenetic mechanism of the disease, and the main manifestation - low average blood pressure [4].Thus, we obtained results that confirm the results of the literature on the difficult vascular regulation of tall people [12–14]. In addition, these results are clarified by the fact that a significant increase not only in diastolic blood pressure, but also systolic, in the transition from horizontal to vertical position. But these changes are insufficient for the adaptation to changes in body position in tall students was similar to students whose body length does not exceed the average.

Based on the results, the following recommendations can be made: to improve the adaptive capacity of vascular regulation to change body position from horizontal to vertical, it is effective to use any exercise, but the most effective exercises that activate aerobic and anaerobic glycolytic energy systems. In addition, exercises that require frequent transitions from lying down (sitting) to standing position, as well as changes in the direction of movement are useful [19, 20].

Conclusions

1. The influence of both factors (body length and sport) on the orthostatic test was significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p<0.005$; $p<0.01$; $p<0.001$).

2. The more significant influence of judo and football classes in comparison with running short and medium distances on the indicators of vegetative-vascular regulation was determined: the best indicators - in judo, the next place - in football, then - athletes. It was found that students with a body length of more than 190 cm have difficulty with vegetative-vascular regulation. To improve the adaptive capacity of vascular regulation to change the position of the body from horizontal to vertical in tall athletes is effective to use any exercise, but the most effective exercises that activate aerobic and anaerobic glycolytic energy systems. Also useful are exercises that require frequent transitions from lying down (sitting) to standing position, as well as changes in the direction of movement.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Factor structure of the complex preparedness of young football players 12-13 years old

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Abstract

Purpose: to determine the factor structure of the complex readiness of young football players 12-13 years old based on the level of development of physical qualities, mastery of technical elements and indicators of psychophysiological functions.

Material and methods. Participants: 48 football players 12-13 years old participated in the study of the sports club “Kolos”, Kharkiv, Ukraine. All children started to play football in the age of 10-11, that is, the duration of football classes was 1-2 years. Research methods. The following data were determined: indicators of the level of physical preparedness, indicators of the level of technical preparedness, indicators of the psychophysiological functional state. The structure of complex preparedness was determined using factor analysis (SPSS-17, Dimension Redaction - Factor; Extraction Method: Principal Component Analysis; Varimax with Kaiser Normalization).

Results. In the structure of complex training of young football players aged 12-13, 4 main factors were identified: 1 - "Speed-power and technical training" (30.36% of the total dispersion); 2 - "Attention switching" (20.7% of the total variance); 3 - "Sensitivity of the nervous system" (15.4% of the total dispersion); 4 - "Mobility of the nervous system" (13.9% of the total dispersion).

Conclusions. Speed and strength, technical training in combination with switching of attention and mobility of the nervous system are dominated in the structure of complex training of young football players aged 12-13. The obtained data create conditions for recommendations in the training process of young football players aged 12-13 increase the number of exercises that require the development of speed and strength, technical training in combination with exercises to switch attention.

Keywords: football, training structure, factors, speed and power qualities, technique, attention switching

Анотація

Цеслицька М., Мушкета Р., Бейтка М., Гринь І. Факторна структура комплексної підготовленості юних футболістів 12-13 років

Мета: визначити факторну структуру комплексної підготовленості юних футболістів 12-13 років на основі показників фізичної, технічної підготовленості та показників психофізіологічних функцій.

Матеріал і методи. Учасники: 48 футболістів взяли участь у дослідженні спорт-клубу "Колос", м. Харків, Україна, віком 12-13 років. Усі діти почали грати у футбол у віці 10-11 років, тобто тривалість занять футболом становила 1-2 роки. Методи дослідження. Були визначені наступні дані: показники рівня фізичної підготовленості; показники рівня технічної підготовленості; показники психофізіологічного стану. Структура комплексної підготовленості визначалася за допомогою факторного аналізу (SPSS-17, Dimension Redaction – Factor; Extraction Method: Principal Component Analysis; Varimax with Kaiser Normalization).

Результати. В структурі комплексної підготовленості юних футболістів 12-13 років було виділено 4 основних фактори: 1 - «Швидкісно-силова та технічна підготовленість» (30,36% від загальної сумарної дисперсії); 2 - «Перемикання уваги» (20,7 % від загальної сумарної дисперсії); 3 - «Чутливість нервової системи» (15,4 % від загальної сумарної дисперсії); 4 - «Рухливість нервової системи» (13,9 % від загальної сумарної дисперсії).

Висновки. В структурі комплексної підготовленості юних футболістів 12-13 років переважає швидкісно-силова, технічна підготовка у поєднанні з перемиканням уваги та рухливістю нервової системи. Отримані дані створюють умови для рекомендацій в тренувальний процес юних футболістів 12-13 років збільшувати кількість вправ, що вимагають розвитку швидкісно-силових якостей, технічної підготовленості у поєднанні з вправами на перемикання уваги.

Ключові слова: футбол, структура підготовленості, фактори, швидкісно-силові якості, техніка, перемикання уваги

Аннотация

Цеслицкая М., Мушкета Р., Бейтка М., Гринь И. Факторная структура комплексной подготовленности юных футболистов 12-13 лет

Цель: определить факторную структуру комплексной подготовленности юных футболистов 12-13 лет на основе уровня развития физических качеств, владения техническими элементами и показателей психофизиологических функций.

Материал и методы. Участники: В исследовании приняли участие 48 футболистов 12-13 лет спорт-клуба «Колос», г. Харьков, Украина. Все дети начали заниматься футболом в возрасте 10-11 лет, то есть продолжительность занятий по футболу составляла 1-2 года. Методы исследования. Определялись следующие данные: показатели уровня физической подготовленности, показатели уровня технической подготовленности, показатели психофизиологического состояния. Структура комплексной готовности определялась с помощью факторного анализа (SPSS-17, Dimension Redaction - Factor; Extraction Method: Main Component Analysis; Varimax with Kaiser Normalization).

Результаты. В структуре комплексной подготовленности юных футболистов 12-13 лет было выделено 4 основных фактора: 1 - «Скоростно-силовая и техническая подготовленность» (30,36% от общей дисперсии); 2 - «Переключение внимания» (20,7% от общей дисперсии); 3 - «Чувствительность нервной системы» (15,4% от общей дисперсии); 4 - «Подвижность нервной системы» (13,9% от общей дисперсии).

Выводы. В структуре комплексной подготовки юных футболистов 12-13 лет преобладают скоростно-силовая, техническая подготовка в сочетании с переключением внимания и подвижностью нервной системы. Полученные данные создают условия для рекомендаций в тренировочном процессе юных футболистов 12-13 лет увеличить количество упражнений, требующих развития скорости и силы, технической подготовки в сочетании с упражнениями на переключение внимания.

Ключевые слова: футбол, структура подготовленности, факторы, скоростно-силовые качества, техника, переключение внимания.

Introduction

Football attracts and captures millions of fans [1, 2]. It is recognized as one of the most common sports games [3]. Games on the green field attract both kids and people of a fairly solid age. The diverse impact of football on all functional systems of man and the requirements of football for the development of functional systems [4] indicate the integral impact of football on the body. Modern football is an Olympic sport that requires lightning filigree technique, virtuoso variety of tactics, advanced comprehensive training [5]. That is why at the present stage the training of young football players is of great importance.

Football belongs to sports in which the success of competitive activities depends not only on the development of motor skills, but also on the nervous system, which is reflected in increasing the speed of response to various stimuli, the speed of switching attention [6-8]. In the process of training young football players, the amount of special tools that affect the development of psychophysiological functions is constantly increasing [9]. For rational management of the training process of young athletes it is necessary to have information about the peculiarities of the dynamics of development of physical development, psychological characteristics, physical and technical fitness of players [10-12]. These issues are widely covered in modern scientific research.

Da Silva et al. [13] showed that there are differences in the somatotipological construction in football players of different ages and different regions. Neogi et al. [14] showed the influence of different training systems on the somatic, physiological aspects and indicators of physical and technical fitness of young players.

Duncan et. al. [5] found that the best technical skills (passing, dribbling, hitting) in youth football are due to age and a more positive attitude towards the development of individual skills. Therefore, Duncan et. al [5] recommend that coaches avoid one-sided training, paying attention not only to football-type exercises, but also to a number of sports with children aged 8-12. Duncan et. al [5] also recommend creating and strengthening a broad framework for the development of fundamental motor skills and strategies that positively influence a child's perception of competence.

Jagim et. al. [15] showed that subjective perception of exercise intensity can help predict neuromuscular fatigue rates the next day. The authors [15] recommend the use of subjective perception of load intensity for small sports programs, which may not have the resources to purchase modern wearable technoogical systems. Internal and external derivatives of training load affect both neuromuscular and subjective indicators of recovery, which should be taken into account when observing athletes. The authors [15] also found that positional differences in mechanical load can occur during the pre-season training period. Therefore, the combination of indicators can provide the most reliable profile of training loads and general recovery indicators.

Thus, for the rational construction of the training process it is necessary to monitor not only the indicators of physical and technical fitness, but also the psychological state, the subjective perception of the load. Currently, psychophysiological indicators have been widely used to monitor the functional state of athletes [16–19]. Computer programs for registration of psychophysiological functions are being developed [20, 21].

However, the question of how to combine the development of psychophysiological functions with the development of technical and physical fitness of young athletes remains unclear. The application of methods of multidimensional analysis of testing indicators of athletes - factor and cluster analysis - has shown high efficiency. Factor analysis allows us to identify hidden relationships between indicators that reflect different aspects of fitness: functional status, psychophysiological functions, technical and physical fitness [22]. Indicators, combining into factors in the degree of interrelationships, allow us to determine what is most important for the studied group of athletes in terms of quantity and quality of relationships with other indicators [22]. Therefore, to determine what is most important for football players aged 12-13, it is necessary to identify the factor structure of the training of young athletes on the basis of extensive testing.

Purpose: to determine the factor structure of complex preparedness of young football players 12-13 years old on the basis of indicators of physical, technical fitness and indicators of psychophysiological functions.

Material and Methods

Participants

48 football players participated in the study 12-13 years old of the spot club "Kolos", Kharkiv, Ukraine. All children started to play football in the age of 10-11, that is, the duration of football classes was 1-2 years.

Experimental protocol

Initially, the level of psycho-physiological functions, physical and technical preparedness of young football players of 12-13 and 15-16 years at the beginning of the preparatory period of the annual cycle of the training process was determined. Young footballers have been tested for 2 training sessions. On the first day, testing was conducted on the level of technical preparedness. The second day was tested on the level of physical fitness. Psychophysiological testing was conducted on the third day from 17-00 to 19-00.

Determination of the level of physical preparedness

1. Running for 60 m (s)

This test was conducted on treadmills, running from a high start, the assistant coach gives the team "For start! Warning! Rush! ", And at the finish, the coach with the stopwatch determines the time for which the footballers ran, the races were held by two men.

2. Running for 1000 m (min)

This running test was carried out at speed and measured by time, the players started on the starting line, on the team "Rush!", The players began to move, at the finish the final results were fixed assistant coach.

3. Shuttle run 4x30 meters (s)

Conducting this test was on the football field, it was performed 30x4, that is, you need to run 4 times in 30 meters, the start was arbitrary on the whistle, this test was measured in seconds, you need to run as soon as possible distance.

4. Pull-up (number)

The test for physical strength, performed very simply, the young athlete approaches the crossbar, he needs to climb on the crossbar. The test is measured in the quantities of correctly executed repetitions.

5. Jump from place (m)

This test is carried out from place, the player is in front of the line, he has 3 attempts, the best goes off, it is measured in centimeters.

Determination of the level of technical preparedness

1. Juggling ball. The main task of this test, the player needs to fill the ball so that it does not fall to the ground, it is done by the feet, the athlete must fill the ball as many times as possible.

2. Shock on range. Being out of the line of the field, the player must strike the ball from the run as far as the distance, this distance is measured in meters.

Psychophysiological methods

The following parameters characteristic of the psychophysiological state, typological features of the nervous system, indicators of the nervous system efficiency, and attention indicators [21] have been set using the computer program "Psychodiagnostics" (Kharkiv, Ukraine, KhNPU):

– A set of indices for the time of a simple visual-motor reaction (mean of 30 attempts (ms), standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

– A set of indicators of a complex visual-motor reaction of selecting 2 element from 3 (mean value of 30 attempts (ms), standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

– A set of indicators of a complex visual-motor reaction of selecting 2 elements out of 3 in the feedback mode, i.e. as the response time changes, the signal delivery time changes. The 'short version' is carried out in the feedback mode, when the duration of exposure changes automatically depending on the response of the subject: after a correct answer, the duration of the next signal is reduced by 20 ms, and after a wrong one, it increases by the same amount. The range of the signal exposure change during the test subject's operation is 20–900 ms, with a pause between exposures of 200 ms. The correct answer is to press the left (right) mouse button while displaying a certain exposure (image), or during a pause after the current exposure. In this test, the time to reach the minimum exposure of the signal and the time of the minimum exposure of the signal reflect the functional mobility of the nervous processes; the number of errors reflects the strength of the nervous processes (the lower these parameters, the higher the mobility and strength of the nervous system). The duration of the initial exposure is 900 ms; the amount of change in the duration of the signals with correct or erroneous responses is 20 ms; pause between the presentation of signals – 200 ms; the number of signals is 50. The indicators are fixed: the average value of the latent period (ms); root mean square deviation (ms); number of mistakes; time of test execution (s); minimum exposure time (ms); time of exposure to the minimum exposure (s).

The indicators of mental working capacity were also determined in accordance with the Schulte test. In this test, the subject needs 5 × 5 tables of 25 digits (from 1 to 25) arranged in a random order, to mark the numbers from 1 to 25. After passing the first table, the second with a different order of digits immediately appears, and so on. In total, the subject passes 5 tables. The reported outcomes were: the time of work on each of the 5 tables (min), the efficiency of work as the arithmetic average of the time of operation on 5 tables (min), the performance of the nervous system as a private time of work on the 4th and 1st tables, and the workability of the nervous system as a private work time for the 2nd and 1st tables.

The response time of the selection for the signals appearing at various points of the screen in a button selection program ('Ermakov test') was also determined [21].

Diagnosis of the psychophysiological state of a person according to the program of measuring the reaction of choosing a point in space: "Select a button" ('Ermakov test') (1 series, 15 s).

In this test, the time of the reaction of the choice of a point in space is measured, which includes conducting one series or several series of tests, which according to the algorithm consists of a sequence of actions:

• on the touch screen of the electronic device, displays the image of the object for response, and the object is displayed each time in a new location, the time interval between the appearance of the object is not constant;

• response to the appearance of the object on the screen is carried out by touching the image of the object,

• Sum up the number of items in each series, the number of correct touches and the number of series

Parameters to be recorded: Total test run time; The total number of correct answers; Number of errors.

Ethical approval

The research related to human use has been complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the authors' institutional review board.

Informed consent

Informed consent has been obtained from the participant included in this study.

Statistical analysis

The digital material obtained during the study was processed using traditional methods of mathematical statistics. For each indicator, the arithmetic mean X, the standard deviation S (standard deviation), the value Minimum, Maximum, Variance were determined using the program SPSS-17 (Descriptive Statistics - Descriptives).

The structure of complex preparedness was determined using factor analysis (SPSS-17, Dimension Redaction - Factor; Extraction Method: Principal Component Analysis; Varimax with Kaiser Normalization). When conducting factor analysis by the method of principal components, indicators that are obviously correlated with each other were excluded. The following indicators were selected for factor analysis: Time of simple visual-motor reaction (ms); Time of reaction of choice of 2 elements from 3 (ms); Mistakes in the test of reaction of choice of 2 elements from 3 in the mode of feedback (number), Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms); Time of exposure to the minimum exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (s); Working time on the table 2 in the Schult test (s); Reaction of choosing a point in space: "Select a button" ('Ermakov test') (the number of correct touches); Running 60 meters (s); Running for 1000 meters (min); Shuttle run 4x30 meters (s); Pull-up (number); Jump in length from the place (m); Juggling ball (number); Shock on range (m).

Results

The results of testing the level of psychophysiological condition, physical and technical fitness of young football players aged 12-13 years showed that most indicators correspond to the level of training of young athletes aged 12-13 years [4] (Table 1).

Table 1

Indicators of physical, technical preparedness and psychophysiological state of young footballers 12-13 years old (n=48)

Indicators	Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation	Variance
Time of simple visual-motor reaction (ms)	389,00	552,00	453,08	44,10	1944,59
Time of reaction of choice of 2 elements from 3 (ms)	483,00	534,00	510,58	15,14	229,36

Mistakes in the test of reaction of choice of 2 elements from 3 in the mode of feedback (number)	19,00	28,00	24,42	2,39	5,70
Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms)	340,00	420,00	376,67	28,38	805,67
Time of exposure to the minimum exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (s)	22,00	87,00	53,08	24,07	579,48
Working time on the table 2 in the Schult test (s)	74,00	101,00	88,67	7,66	58,61
Reaction of choosing a point in space: "Select a button" ('Ermakov test') (the number of correct touches)	32,00	40,00	35,83	2,10	4,40
Running 60 meters (s)	8,20	10,30	9,80	0,55	0,30
Running for 1000 meters (min)	4,22	4,44	4,31	0,07	0,01
Shuttle run 4x30 meters (s)	35,00	55,03	42,52	5,21	27,12
Pull-up (number)	3,00	11,00	6,17	2,50	6,27
Jump in length from the place (m)	1,45	2,43	1,67	0,26	0,07
Juggling ball (number)	20,00	144,00	39,17	32,63	1064,48
Shock on range (m)	11,00	44,00	16,83	8,48	71,97

Table 2

Total Variance Explained of test indicators for physical, technical preparedness and psychophysiological state of young football players 12-13 years old (n=48)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5,421	38,724	38,724	5,421	38,724	38,724	4,251	30,363	30,363
2	2,696	19,259	57,983	2,696	19,259	57,983	2,898	20,7	51,063
3	1,774	12,675	70,658	1,774	12,675	70,658	2,15	15,357	66,421
4	1,348	9,629	80,287	1,348	9,629	80,287	1,941	13,867	80,287
5	0,948	6,773	87,06	-	-	-	-	-	-
6	0,784	5,601	92,662	-	-	-	-	-	-
7	0,581	4,147	96,809	-	-	-	-	-	-
8	0,269	1,923	98,732	-	-	-	-	-	-
9	0,105	0,753	99,485	-	-	-	-	-	-
10	0,06	0,43	99,915	-	-	-	-	-	-
11	0,012	0,085	100	-	-	-	-	-	-
12	-3,60E-17	-2,57E-16	100	-	-	-	-	-	-
13	-2,54E-16	-1,81E-15	100	-	-	-	-	-	-
14	-3,78E-16	-2,70E-15	100	-	-	-	-	-	-

Notes: Extraction Method: Principal Component Analysis

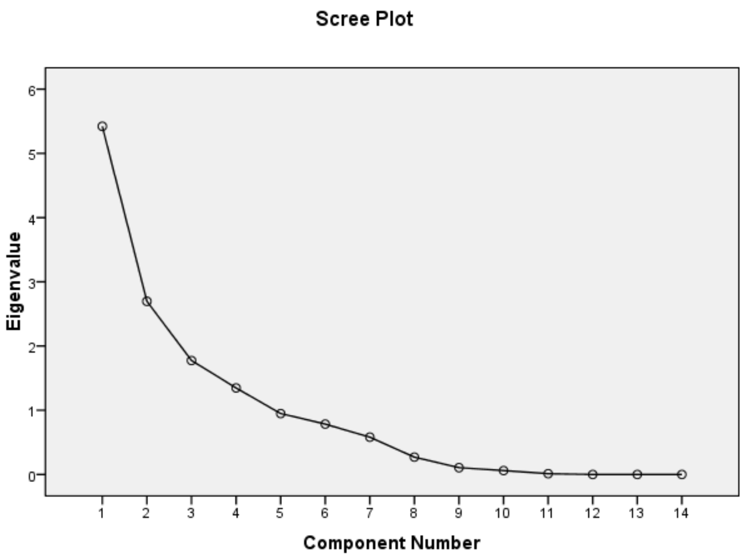

Fig. 1. Eigenvalues of factors: Scree Plot, "Rocky Rash" Kettel

The first factor (30.36% of the total dispersion) (Table 3) included the following indicators: Running 60 m (s) (r = -0.97), Juggling ball (number) (r = 0.93), Shock on range (m) (r = 0.91), Jump in length from the place (m) (r = 0.87), Running for 1000 meters (min) (r = -0.52). It should be noted that the first factor includes indicators that reflect the level of speed and strength training (Running 60 meters (s), Jump in length from the place (m)) technical readiness (Juggling ball (number), Shock on range (m)) and overall endurance (Running for 1000 meters (min)). Running 60 meters (s) and Running for 1000 meters (min) were included in the factor with negative correlation coefficients, all other indicators were included in the factor with positive correlation coefficients. The shorter the running time of different distances, the better the level of preparedness. The higher the scores in the tests Juggling ball (number), Shock on range (m) and Jump in length from the place (m), the higher the level of technical training and endurance. Thus, all indicators included in the first factor reflect the level of physical and technical fitness. It should be noted that running at 1000 m reflects the level of overall endurance, and other indicators of this factor in physical fitness reflect the level of speed and strength training. Indicators of endurance and speed-strength training were included in this factor with the coefficients of interrelation of different strength (Table 2). Running time per 1000 m was included in this factor with a correlation coefficient of -0.52 (average relationship), and Running 60 meters (s) and Jump in length from the place (m) were included in this factor according to the correlation coefficients -0 , 97 and 0.87 (high correlation with the factor) (Table 3). This reflects the physiological mechanisms of energy supply of muscular activity, as endurance and speed-strength training require different mechanisms of energy supply and inclusion of different muscle fibers. But football requires a comprehensive development of endurance and speed and strength. That is why the endurance index was included in this factor not with a small correlation coefficient, but with an average one. In addition, this factor included indicators of technical readiness (Shock on range (m) and Juggling ball (number)) with high correlation coefficients (Table 3). This is a reflection of the fact that in football, speed training and technical skills are closely linked. Based on the data obtained, the first factor was called "Speed and power and technical training."

The second factor (20.7% of the total variance) includes such indicators as Time of simple visual-motor reaction (ms) (r = -0.92), Shuttle run 4x30 meters (s) (r = -0, 86), Working time on the table 2 in the Schult test (s) (r = -0,66), Reaction of chosing a point in space: "Select a button" ('Ermakov test') (the number of correct touches) (r = 0.61) (Table 3). It is easy to note that the indicators included in the second factor mainly reflect the level of reaction rate (Time of simple visual-motor reaction (ms)), switching of attention (Working time on the table 2 in the Schult test (s), Reaction of choosing a point in space: "Select a button" ('Ermakov test') (the number of correct touches)) and dexterity (Shuttle run 4x30 meters (s)). It should be noted that the Time of simple visual-motor reaction also partially determines the level of attention switching. In addition, the Shuttle run time of 4x30 meters (s) is also determined by the speed of the simple reaction and the level of attention switching, because in this test you need to react quickly to the signal to move and quickly switch from one running direction to another. Based on the data obtained, the second factor was called "Attention Switching".

The third factor (15.36% of the total variance) included such indicators as Mistakes in the test of reaction of choice of 2 elements from 3 in the mode of feedback (number) (r = 0.93) and Time of reaction of choice of 2 elements from 3 (ms) (r = 0.78) (Table 3). Mistakes in the test of reaction of choice of 2 elements from 3 in the mode of feedback (number) is a reflection of the strength and sensitivity of the nervous system: the fewer errors, the higher the strength of the nervous system; the greater the number of errors, the higher the sensitivity of the nervous system. The reaction time of the choice of 2 elements from 3 (ms) is also an indirect reflection of the sensitivity of the nervous system. Since all these indicators were included in the third factor with positive correlation coefficients, we regarded the third factor as a reflection of the sensitivity of the nervous system, i.e. quality, the opposite of the strength of the nervous system. Therefore, the third factor was called "Sensitivity of the nervous system."

The fourth factor (13.87% of the total variance) includes the following indicators: Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms) (r = -0.93) , Pull-up (number) (r = 0.78) (Table 3). Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms) reflects the mobility of the nervous system. Pull-up (number) indicates the force. We took as a basis for the name of this factor indicator Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms), since the correlation coefficient with the factor Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms) is higher than the indicator Pull-up (number),. And so the fourth factor was called "Mobility of the nervous system."

Table 3

Rotated Component Matrix of test indicators for physical, technical preparedness and psychophysiological state of young football players 12-13 years old (n=48)

Indicators	Rotated Component Matrix(a)			
	Component			
	1	2	3	4
Running 60 meters (s)	-0,965			
Juggling ball (number)	0,925			
Shock on range (m)	0,908			
Jump in length from the place (m)	0,873			
Running for 1000 meters (min)	-0,518			
Time of simple visual-motor reaction (ms)		-0,916		
Shuttle run 4x30 meters (s)		-0,864		
Working time on the table 2 in the Schult test (s)		-0,655		
Reaction of choosing a point in space: "Select a button" ('Ermakov test') (the number of correct touches)		0,607	0,574	
Mistakes in the test of reaction of choice of 2 elements from 3 in the mode of feedback (number)			0,894	
Time of reaction of choice of 2 elements from 3 (ms)			0,874	
Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms)				-0,931
Pull-up (number)				0,782

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

Discussion

The purpose of this study to determine the structure of training of young football players aged 12-13, taking into account the indicators of the level of technical skills of physical qualities and psychophysiological condition was achieved. We determined the factor structure of complex training of young football players aged 12-13, in which the main factors in terms of quantity and quality of correlations formed indicators of speed and strength, attention switching, sensitivity and mobility of the nervous system.

We believe that such a structure of training of young football players aged 12-13 is provided by their age characteristics. This is consistent with current research. It is during this period that the intensity of physical development, reaction speed, and cognitive functions of children aged 12–13 increases.

Adolescence is the first transition period from childhood to adulthood. Qualitative changes taking place in the intellectual and emotional spheres of the adolescent's personality (intensive, uneven development and growth of the organism, personal characteristics, etc.) create a new level of self-awareness, the need for self-affirmation, equal and trusting communication with peers and adults.

This age is a sensitive period for the development of speed, agility. This is reflected not only in the development of physical qualities, but also psychophysiological functions. The results obtained by us on the peculiarities of the factor structure of training of young football players aged 12-13 confirm the position of the relationship of psychophysiological functions with the level of development of physical qualities and technical skills. The findings also confirm the results of studies that revealed the effects of various training programs on the level of physical and technical fitness of young football players [4, 23–25], as well as anthropometric indicators [4, 13].

In our study, young football players trained using standard programs for football players of the corresponding age. In both age groups, there was a positive dynamics of the relationship of psycho-physiological indicators with indicators of physical and technical readiness. However, in the age group of 15–16 years, a change in the quantity and quality of the interrelations studied during 3 months of training is more pronounced than in the age group of 12–13 years. This may be due to the age characteristics of young football players, since in 15-16 years there is some mismatch in the interaction of various functions due to puberty, the change in psycho-physiological functions occurs faster than in older ones [20, 21].

In studies Mikheev et. al. [26] it was shown that the development of speed abilities is associated with an increase in myelinization of nerve fibers and an increase in the amount of white matter in the brain, which contributes to an increase in the rate of impulse transmission along the nerve pathways. An increase in the reaction rate in various test modes is also due to an increase in the rate of impulse transmission through the nerve fibers. In this regard, we can conclude that by the age of 15-16 a specific neurodynamic type of football player is formed, which is characterized by a high level of neurodynamic processes in combination with a high level of development of speed and speed-power capabilities.

Due to the interrelationships between psycho-physiological indicators and indicators of physical and technical preparedness, in the training process of young football players should pay attention to the development of reaction speed, speed of switching attention, speed of thinking in combination with the development of speed and speed-power qualities in physical training. This leads to an intensification of the processes of conducting the impulse along nerve fibers, and increasing the speed of response to various signals [27–29].

Relatively new knowledge obtained in our study is the identification of hidden relationships between indicators of psychophysiological functions and indicators of physical and technical readiness.

Recommendations

Based on the obtained data, it is possible to give recommendations in the training process of young players to focus on the development of qualities that require the activation of psychophysiological functions, especially - the reaction rate, the speed of switching attention, mental performance, etc. Psychophysiological functions are largely hereditary, and their development is difficult, therefore, emphasis should be placed on their development, since in adults the level of psychophysiological functions is more difficult to develop that can play a decisive role in improving the athlete in football.

Conclusions

1. In the structure of complex training of young football players aged 12-13, 4 main factors were identified: 1 - "Speed-power and technical preparedness" (30.36% of the total variance); 2 -

"Attention switching" (20.7% of the total variance); 3 - "Sensitivity of the nervous system" (15.4% of the total variance); 4 - "Mobility of the nervous system" (13.9% of the total variance).

2. The first factor includes indicators: Running 60 m (s) (r = -0.97), Juggling ball (number) (r = 0.93), Shock on range (m) (r = 0.91), Jump in length from the place (m) (r = 0.87), Running for 1000 meters (min) (r = -0.52). The second factor included indicators: Time of simple visual-motor reaction (ms) (r = -0.92), Shuttle run 4x30 meters (s) (r = -0.86), Working time on the table 2 in the Schult test (s) (r = -0.66), Reaction of choosing a point in space: "Select a button" ('Ermakov test') (the number of correct touches) (r = 0.61). The third factor included indicators: Mistakes in the test of reaction of choice of 2 elements from 3 in the mode of feedback (number) (r = 0.93) and Time of reaction of choice of 2 elements from 3 (ms) (r = 0.78). The fourth factor includes indicators: Time of minimum signal exposure in the test of reaction of choice of 2 elements from 3 in the mode of feedback (ms) (r = -0.93), Pull-up (number) (r = 0,78).

3. The structure of complex training of young football players aged 12-13 is dominated by speed and strength, technical training in combination with switching of attention and mobility of the nervous system. The obtained data create conditions for recommendations in the training process of young football players aged 12-13 to increase the number of exercises that require the development of speed and strength, technical training in combination with exercises to switch attention.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Level of speed abilities of young football players in various training periods

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Abstract

Purpose: At the highest level of the competition, the players tend to have a comprehensive motor, technical-tactical and mental preparation. It is assumed that in the training process of young players, speed is an important factor determining sports success. Therefore, the aim of the study was to try to compare the speed abilities indicator of young footballers during the summer and winter preparatory period.
Material and methods: The research was conducted in July 2019 and January 2020 in Poznań. The research subject consisted of 23 young players of the Warta Poznań club in the age category of the junior football players (U14).
Results: The results were statistically processed, basic descriptive characteristics were made, the normality of the distribution of differences was checked using the Shapiro-Wilk test, and the collected results from two tests dates were compared using the Student's t-test for dependent samples. Based on the the conducted research, no significant change in the starting speed level was observed at the distance of 5 meters and 15 meters, while an improvement in the level of speed abilities in terms of locomotion at the distance of 30 meters was noted.
Conclusions. The level of running speed at a distance of 30 meters in the tested competitors changed in the six-month preparation cycle. There was no change in the starting speed level over the distance of 5 and 15 meters in the competition season between the preparatory period and the end of the autumn round in the competitors of the Poznań Warta club. On the basis of the conducted research, it is worth conducting experimental research based on individualized speed training on a group of 13 - 14 year old players.
Key words: training load, individualization, speed, football

Анотація

Калиновський П., Єршинський Д., Новаковська М. Рівень швидкісних здібностей юних футболістів у різні періоди тренувань

Мета: На найвищому рівні змагань гравці, як правило, мають комплексну рухову, техніко-тактичну та розумову підготовку. Передбачається, що у тренувальному процесі молодих гравців швидкість є важливим фактором, що визначає спортивний успіх. Тому метою дослідження було спробувати порівняти показник швидкісних здібностей молодих футболістів протягом літнього та зимового підготовчого періоду.

Матеріал і методи: Дослідження було проведено в липні 2019 року та січні 2020 року в Познані. Темою дослідження були 23 молоді гравці клубу Варта Познань у віковій категорії молодших футболістів (U14).

Результати: Результати були статистично оброблені, зроблені основні описові характеристики, перевірено нормальність розподілу відмінностей за допомогою критерію Шапіро-Вілька, а зібрані результати за дві дати тестів порівнювались за допомогою t-критерію Стьюдента для залежних зразків. На підставі проведеного дослідження не було помічено суттєвої зміни рівня стартової швидкості на відстані 5 метрів та 15 метрів, тоді як не було відзначено покращення рівня швидкісних здібностей в плані руху на відстані 30 метрів.

Висновки. Рівень швидкості бігу на відстані 30 метрів у випробуваних учасників змінювався протягом шестимісячного циклу підготовки. У змагальному сезоні між підготовчим періодом та закінченням осіннього раунду у стартовому рівні швидкості на дистанції 5 та 15 метрів у змагачів клубу Варта Познань не відбулося змін. На основі проведеного дослідження, варто провести експериментальне дослідження на основі індивідуального тренування швидкості на групі 13 - 14-річних гравців.

Ключові слова: тренувальне навантаження, індивідуалізація, швидкість, футбол

Аннотация

Калиновски П., Ершински Д., Новаковска М. Уровень скоростных способностей юных футболистов в разные периоды подготовки.

Цель: на высшем уровне соревнований игроки имеют тенденцию к всесторонней моторной, технико-тактической и психологической подготовке. Предполагается, что в тренировочном процессе юных футболистов скорость является важным фактором, определяющим спортивные успехи. Поэтому целью исследования было попытаться сравнить показатель скоростных способностей юных футболистов в летний и зимний подготовительный периоды.

Материал и методы: Исследование проводилось в июле 2019 г. и январе 2020 г. в Познани. Объектом исследования выступили 23 юных игрока клуба «Варта Познань» в возрастной категории юных футболистов (до 14 лет).

Результаты: результаты были статистически обработаны, составлены основные описательные характеристики, нормальность распределения различий проверена с помощью критерия Шапиро-Уилка, а полученные результаты по двум датам тестирования сравниваются с использованием t-критерия Стьюдента для зависимых выборок. По результатам проведенного исследования, существенного изменения уровня стартовой скорости на дистанции 5 и 15 метров не наблюдалось, а на дистанции 30 метров отмечено улучшение уровня скоростных способностей в части передвижения.

Выводы. Уровень скорости бега на дистанции 30 метров у тестируемых спортсменов изменился в шестимесячном цикле подготовки. Уровень стартовой скорости на дистанции 5 и 15 метров в сезоне соревнований между подготовительным периодом и концом осеннего тура у участников клуба «Варта Познань» не изменился. На основании проведенного исследования целесообразно провести экспериментальное исследование на основе индивидуализированной скоростной тренировки в группе игроков 13-14 лет.

Ключевые слова: тренировочная нагрузка, индивидуализация, скорость, футбол.

Introduction

The popularity of football in the world today is unquestionable [1-2]. The constant development of the discipline leads to looking for new solutions and increases the importance of comprehensive preparation of players [3]. Nowadays, there is no place for focusing on selected elements of the material structure. It should be noted that only comprehensive motor, technical-tactical and psychological preparation is a predictor for achieving high sports results [2]. Increasing requirements, changing conditions or other factors occurring during the game, direct the attention of sports practitioners and theorists to monitoring the players' work using modern technologies [4]. In addition to technical activities in specific systems, modern methods allow to determine energy expenditure, distances covered or determine the intensity of the players' efforts [5].

While earlier scientific reports informed about the volume of effort through the covered distance, which ranged from 10-13 km [6–7], nowadays it can be assumed that this information is insufficient. The specificity of the players' movement on the pitch is intertwined with low and high intensity running, taking into account a large number of jerks, starts, accelerations, brakes, jumps, turns, running on various sections, sudden changes of direction and performing motor tasks with the ball at the leg. Therefore, the intensity of movement seems to be important. Some authors consider high-intensity running values above 4 $m \cdot s^{-1}$ [8–9], while other authors take values above 5 m · s-1 [10-11]. In studies it is estimated that the ratio of low-intensity tasks to high-intensity tasks is 7: 1 or 5: 2 [5, 12]. Another important criterion for training footballers is the number of sprints, which, according to Di Salvo et al. [13], ranges from 3 to 40. Another criterion highlights the importance of speed requirements in modern football. Obviously, without proper aerobic preparation [14] and training of organisms, the maximum possibilities of anaerobic efforts are not possible. It is worth noting that speed plays a very important role in modern football [15].

According to this, it is worth considering when speed abilities can be shaped. When are there sensitive periods in human ontogenesis, during which there is an increase in the dynamics of the natural development of speed abilities? Osiński [16] indicates the second phase of acquiring new movements at the age of 12-13 by boys. During this period, the author indicates the ability to concentrate on a given activity and the willingness to undertake additional work on oneself. It should be emphasized here that motor skills do not develop simultaneously, they are characterized by high variability depending on age or experience [17]. In practice, there are various methods used to increase the speed level. Numerous authors point to the legitimacy of using resistance or isolated training [15, 18].

The influence of functional loads on the ability to speed was demonstrated in of e.g. Haycraft et al. [19] in the strudy on players of the Australian league in the U14 and U16 category and Köklüa et al. [20] in the study on players training in Turkey in a selected U16 team. In the study on Tunisian athletes conducted by Chaalali et al. [21], a positive effect of functional training on the improvement of speed abilities results based on the 5-0-5 test [22] was presented in a 6-week program aimed at changing direction and acceleration. All of these methods demonstrate the need for speed training. In response to numerous publications, it was decided to perform a diagnostic evaluation over the course of a 6-month macrocycle in the group of competitors without the use of additional classes aimed at additional speed training. Hence, the aim of the work is to try to compare the running and starting speed indicator at the beginning of the preparatory period of the 2019/2020 season and after the end of the autumn round of league games, at the beginning of the winter preparatory period of young players of the Poznań club.

Materials and Methods

The research was conducted in July 2019 and in January 2020 in Poznań. The research group consisted of 23 players of Warta Poznań U14 in the junior footballers category, playing at the highest league level. The team took first place in the 2019/2020 season. Warta Poznań club is a two-time Polish Champion. In the annual preparation cycle, the team was in the starting period with 5 training units in a microcycle and a championship match. Parents and trainers consent was obtained for the research. The players were subjected to tests aimed at assessing the level of motion speed on the distance of 5 m, 15 m and 30 m from a high start with a slope of 0.5 m [23]. Measurements were made using Microgate Witty photocells. The tested player covered the distance twice, and the better result was used for analysis. The obtained results were statistically processed in the Statistica 13.3 program, the mean (X), minimum (min) and maximum (max) values, standard deviations (SD), normality of the distribution of differences were determined using the Shapiro-Wilk test, and the collected results from two tests were compared using t - Student test for dependent samples.

Results

While measuring the starting speed at a distance of 5 meters, the average result was 1.04 seconds in the 1st test period, while after 6 months in the 2nd test period, the average result was 1.02 seconds. On the basis of the conducted research, no statistically significant differences were observed in the level of starting speed at a distance of 5 meters in the tests carried out in the six months training cycle (Table 1).

Table 1

Starting speed indicator at a distance of 5 meters in the preparatory summer period (stude I) and at the end of the autumn round of the 2019/2020 season (study II)

Variable	t – Student test for dependent samples; Warta Poznań club; 5 meters p < 0,05									
	Mean	Stand. Dev.	N	Difference	St. dev. Difference	t	df	p	Confidence -95,000%	Confidence +95,000%
Test I	1,04	0,06	23	-	-	-	-	-	-	-
Test II	1,02	0,06	23	-0,01	0,06	-1,11	22	0,28	-0,04	0,01

Based on the speed test at a distance of 15 meters, the average result in the 1-st test was 2.61 seconds, while after 6 months in the 2-nd test, the average result was 2.58 seconds. On the basis of the conducted research, no statistically significant differences were observed in the level of speed at a distance of 15 meters in the tests carried out in the six-month training cycle (Table 2)

Table 2

Speed indicators at a distance of 15 meters in the preparatory summer period (study I) and at the end of the autumn round of the 2019/2020 season (study II)

Variable	t – Student test for dependent samples; Warta Poznań club, 15 meters, p < 0,05									
	Mean	Stand. Dev.	N	Difference	St. dev. Difference	t	df	p	Confidence -95,000%	Confidence +95,000%
Test I	2,61	0,11	23	-	-	-	-	-	-	-
Test II	2,58	0,12	23	-0,03	0,09	-1,84	22	0,08	-0,07	0,004

Based on the speed test at a distance of 30 meters, the average result was 4.85 seconds in the 1st test, while after 6 months in the 2nd test, the average result was 4.72 seconds. On the basis of the conducted research, an improvement in the level of speed was noted at a distance of 30 meters in the tests carried out over a six months training cycle (Table 3).

Table 3

Speed indicators at a distance of 30 meters in the preparatory summer period (study I) and at the end of the autumn round of the 2019/2020 season (study II)

Variable	t – Student test for dependent samples; Warta Poznań club, 30 meters p < 0,05									
	Mean	Stand. Dev.	N	Difference	St.dev. Difference	t	df	p	Confience -95,000%	Confience +95,000%
Test I	4,85	0,23	23	-	-	-	-	-	-	-
Test II	4,72	0,24	23	-0,13	0,13	-4,87	22	0,000	-0,19	-0,07

Discussion

The latest scientific reports support the claims about the significant influence of speed on the actions taken on the pitch by players [12]. It is worth emphasizing the importance of the number of sprints performed during the entire meeting. These dependencies highlight the function of motor skills in football. Ekblom [24] noticed that it is the covered distance but the maximum speed of the covered distance that differentiates the players in certain levels. It can be assumed that speed will determine the final success [25]. Nevertheless, it is worth noting that it will depend on the level of the game. As the research of Kalinowski et al. [26] shows on a group of 83 players from Berlin clubs, at the regional level, they observed that speed was not related to efficiency. In this study, the players of a club aspiring to the highest league were tested.

Hence, it can be assumed that with a similar, very high level of skills, speed will be important for high sports results. There are many experimental studies informing about the advantages of using additional speed training [17]. In numerous studies, the authors indicate the advantages of using individualization. In own research on young players of Warta Poznań club, attempts were made to determine changes resulting from natural development during sensitive periods. The speed level only improved for the distance of 30 meters. It can be assumed that at this age it is the only distance that can be improved in training. Similar observations were demonstrated by Chmura et al. [27], who noted an improvement in speed thaks to training 30 and 40 meter distances. In his research, the author shows that the ball training used is more beneficial and increases the level of motor coordination skills in cooperation with a partner.

Hence, it can be assumed that the 6-month training period of young Warta Poznań players had a positive effect on the improvement of the speed level at the distance of 30 meters. In the future, It would be worth checking the changes using the experimental method by introducing elements of speed training. The research by Andrzejewski et al. [17] emphasized the great importance of individualization of training for speed training. In his work, the author divided the players according to the endurance and speed type. This is another confirmation of the individualized view on speed training, which confirms the validity of extending the research in the future. Andrzejewski et al. [17] noted an increase in the speed level in the same period of 6-month tests, both in speed and endurance athletes.

In own research on young players of the Poznań team, it was shown that in different starting periods in the 6-month cycle, the starting speed level at 5 meters and 15 meters did not differ from each other, while the speed level at a distance of 30 meters was improved. The competitors, in line with the assumptions of the training program, obtained better results after the autumn round, compared to the measurements from the preparatory summer period in one trial. Nevertheless, it is worth verifying whether in the same training period, after the introduction of the element of speed training, there would be a favorable change in the level at a distance of 5 and 15 meters? Based on the collected data, it can be concluded that the results obtained by the players in the 5-meter starting speed test compared to the research of 124 players aged 13 years participating in the Polisch Soccer Skills program, whose average level was 1.17 seconds, are high and they can predispose the players of Warta Poznań to play at the highest level in the senior categories. The comparison of the results is similar compared to the amateur team of KS

Vulcan Wólka Mlądzka [28].

A similar tendency was also found when comparing the results at 15 and 30 meters. Analyzing the results of the starting speed at 5 mmore precisely, we observe the average time of 1.02 seconds, which is a high level result, which only confirms that the competitors have high speed abilities. The results of own research and that of numerous authors confirm the validity of the use of systematic diagnostic tests in various training periods. Thanks to the results, it is possible to plan work in the annual training cycle more precisely, taking into account the sensitive periods which is so important for children. Nowadays, an average distance that players run during the match is about twice as long as it was in the 1950s, where a player ran about 5 km during the match [29] with increasing intensity. In the research of Kalinowski and Andryszak [30] on the players of Borusia Dortmund, the number of runs with high intensity was at the level of 47.68 per match [30]. The results of own research and the results of professional players are identical to the research of the outstanding physiologist Chmura [25], who claimed that a footballer "is a few centimeters closer to the ball, a few milliseconds faster than the opponent on the ball, he can score the decisive goal or stop the opponent from scoring one".

Based on the collected material, it can be assumed that effective diagnostics with the use of modern sports equipment in youth football is conducive to the optimization of sports training. This shows how dynamic changes football are. Motor skills play an important role not only during the recruitment of young footballers, but first of all in senior football at the highest level, which shows the need for proper diagnostics at all stages of training.

Conclusions

1. The level of running speed at a distance of 30 meters in the tested competitors changed in the six-month preparation cycle.
2. There was no change in the starting speed level over the distance of 5 and 15 meters in the competition season between the preparatory period and the end of the autumn round in the competitors of the Poznań Warta club.
3. On the basis of the conducted research, it is worth conducting experimental research based on individualized speed training on a group of 13 - 14 year old players.

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Conflicts of interest

The authors certify that there was no conflict of interest with any financial organization regarding the material discussed in this study.

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ORIGINAL ARTICLES. PHYSICAL THERAPY

Biomechanical technology of injury prevention in the training of specialists in physical education and sports

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Abstract

Purpose: to develop and experimentally test the biomechanical technology of injury prevention of future specialists in physical education and sports in the process of professional training (rock climbing for example).
Material and Methods. The participants of this study were 84 male students engaged in amateur climbing aged 18-19 years. All athletes were also students of physical education faculties of Ukrainian universities; 40 athletes were in the experimental group and 44 athletes were in the control group. The biomechanical technology for injury prevention in the training of specialists in physical education and sports has been developed on rock climbing for example. Developed biomechanical technology for injury prevention contains 3 areas: 1 - theoretical; 2 - analytical; 3 - practical. Injury risk (incidence) was defined as the number of injuries to the total number of athletes in the analyzed group. Relative risk (incidence rate ratio) was determined by the ratio of risk in the control group to the risk in the experimental group. The chance of injury was defined as the ratio of the number of injuries to the number of uninjured athletes in the analyzed group. The relative chance (Odds Ratio) was defined as the chances of injury in the control group to the chances of injury in the experimental group. These indicators were determined separately for low, medium and severe finger injuries.
Results. The applied technology of injury prevention significantly influences the reduction of the number of injuries of athletes – future specialists on the physical education and sports (on rock climbing for example). It is established that the application of the developed technology of injury prevention reduces the risk of finger injuries: low complexity – in 2.364 times (95% CI = 0.925-6.041, P> 0,05) times; medium complexity – in 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030); high complexity – in 8.182 times (95% CI = 1.084-61.749, P (Fisher) = 0.011).
Conclusions. The application of the developed biomechanical technology of injury prevention in the process of training specialists in physical education and sports significantly reduces the risk of injury to students.
Key words: injury, prevention, students, rock climbing, education

Анотація

Козін С.В. Біомеханічна технологія профілактики травматизму при підготовці спеціалістів з фізичного виховання і спорту

Мета: розробити і експериментально обґрунтувати біомеханічну технологію профілактики травматизму майбутніх фахівців з фізичної культури і спорту в процесі професійної підготовки (на прикладі скелелазіння).

Матеріал і методи. Учасниками дослідження були 84 студента чоловічої статі, що займаються скелелазінням на аматорському рівні, у віці 18-19 років. Всі спортсмени також були студентами факультетів фізичного виховання українських вузів. В експериментальну групу ввійшли 40 спортсменів, а в контрольну - 44 спортсмена. Була розроблена біомеханічна технологія профілактики травм при підготовці фахівців з фізичного виховання і спорту на прикладі скелелазіння. Розроблена біомеханічна технологія профілактики травм містить 3 напрямки: 1 - теоретичне; 2 - аналітичне; 3 - практичне. Ризик (інцидентність) отримання травми визначався як відношення кількості травм від загальної кількості спортсменів в аналізованої групі. Відносний ризик (коефіцієнт інцидентності) визначався ставленням ризику в контрольній групі до ризику в експериментальній групі. Імовірність отримання травми визначалася як відношення кількості травм до кількості нетравмованих спортсменів в аналізованої групі. Відношення шансів визначалося як шанси травми в контрольній групі до шансів травми в експериментальній групі. Ці показники визначалися окремо для травм пальців легкої, середньої та важкого ступеня.

Результати. Застосовувана технологія профілактики травм суттєво впливає на зниження травматизму спортсменів - майбутніх фахівців з фізичного виховання і спорту (на прикладі скелелазіння). Встановлено, що застосування розробленої технології профілактики травм знижує ризик травм пальців рук: низької складності - в 2,364 рази (95% CI = 0,925-6,041); середньої складності - в 3,333 рази (95% CI = 1,001-11,096, P (Fisher) = 0,030); високої складності - в 8,182 рази (95% CI = 1,084-61,749, P (Фішер) = 0,011).

Висновки. Застосування розробленої біомеханічної технології профілактики травматизму в процесі підготовки фахівців з фізичного виховання і спорту значно знижує ризик травматизму студентів.

Ключові слова: травми, профілактика, студенти, скелелазіння, освіта.

Аннотация

Козин С.В. Биомеханическая технология профилактики травматизма при подготовке специалистов по физическому воспитанию и спорту

Цель: разработать и экспериментально обосновать биомеханическую технологию профилактики травматизма будущих специалистов по физической культуре и спорту в процессе профессиональной подготовки (на примере скалолазания).

Материал и методы. Участниками исследования были 84 студента мужского пола, занимающихся скалолазанием на любительском уровне, в возрасте 18-19 лет. Все спортсмены также были студентами факультетов физического воспитания украинских вузов. В экспериментальную группу вошли 40 спортсменов, а в контрольную - 44 спортсмена. Была разработана биомеханическая технология профилактики травм при подготовке специалистов по физическому воспитанию и спорту на примере скалолазания. Разработанная биомеханическая технология профилактики травм содержит 3 направления: 1 - теоретическое; 2 - аналитическое; 3 - практическое. Риск (инцидентность) получения травмы определялся как отношение количества травм от общего количества спортсменов в анализируемой группе. Относительный риск (коэффициент инцидентности) определялся отношением риска в контрольной группе к риску в экспериментальной группе. Вероятность получения травмы определялась как отношение количества травм к количеству нетравмированных спортсменов в анализируемой группе. Отношение шансов определялось как вероятность травмы в контрольной группе к шансам травмы в экспериментальной группе. Эти показатели определялись отдельно для травм пальцев легкой, средней и тяжелой степени.

Результаты. Применяемая технология профилактики травм существенно влияет на снижение травматизма спортсменов - будущих специалистов по физическому воспитанию и спорту (на примере скалолазания). Установлено, что применение разработанной технологии профилактики травм снижает риск травм пальцев рук: низкой сложности - в 2,364 раза (95% CI = 0,925-6,041); средней сложности - в 3,333 раза (95% CI = 1,001-11,096, P (Fisher) = 0,030); высокой сложности - в 8,182 раза (95% CI = 1,084-61,749, P (Фишер) = 0,011).

Выводы. Применение разработанной биомеханической технологии профилактики травматизма в процессе подготовки специалистов по физическому воспитанию и спорту значительно снижает риск травматизма студентов.

Ключевые слова: травмы, профилактика, студенты, скалолазание, образование.

Introduction

The process of training specialists in physical education and sports is built in such a way that students have a large number of practical disciplines in various sports along with the chosen [1]. In practical classes, students learn technical skills, develop physical qualities, and learn to conduct classes not only in the chosen sport, but also in others. Therefore, the schedule of students - future specialists in physical education and sports is built in such a way that in one day there can be 2-3 pairs of practical classes in different sports, and in the evening - training in the chosen sport. This puts a heavy burden on the cardiovascular system, which overtraining creates the conditions for injury.

In addition, each sport has its own characteristics [2, 3]. When mastering the basics of a particular sport from childhood, the process of learning motor skills is easier compared to adulthood, when the sensitive periods of natural learning are over. And so the nervous system and musculoskeletal system of students with mastery of skills in various sports receive a heavy load. It should be noted that different movements in their biomechanical structure require the formation of different connections in the nervous system, and this is quite a difficult task. And the constant switching from one movement to another, which occurs when changing the type of activity, chaotic activity of the nervous system, and, accordingly, the musculoskeletal system. This creates the conditions for increased injuries. That is why the question of developing such learning technologies that will provide reliable prevention of injuries to students - future professionals in physical education and sports.

Currently, the role of physical culture and sports as the most powerful means of physical development, prevention of various diseases, recovery from illness. Sports contribute to the increase of motor intelligence, the development of psychological qualities that are necessary for building a career, the manifestation of individuality, success in all spheres of activity. Of particular importance is the importance of sports for students. However, sports are also accompanied by injuries of varying severity. This often leads to a large amount of time spent recovering from injuries, skipping classes, psychological problems [4–7].

In this regard, the problem of injuries to students in sports is widely covered in modern literature. The authors mainly pay attention to the registration of injuries of varying severity in different sports under different circumstances [8–11].

To analyze the number of students' injuries in the world, studies are carried out in various sports. For example, Asperti, et al. [12] found that Brazilian students engaged in amateur sports. traumatic impact was defined as the participation of one amateur student in one workout or game, and was expressed as the impact on the athlete (A-E). Injury rates are significantly higher in games (13.13 injuries per 1,000 student-athletes who participated in training or games (AE), 95% confidence interval = 10.3-15) than in training (4.47 injuries per 1,000 , 95% confidence interval = 3.9-5.1). The mechanisms that accounted for the most injuries in games and training were contact (52.9%) and non-contact (54.5%). Ankle sprains were the most common injury (18.2% of all reported injuries). There was also a relatively high incidence of anterior cruciate ligament injuries (0.16 injuries per 1,000 student-athletes who participated in training or games (A-E)). Asperti, et al. [12] concluded that Brazilian amateur students are at high risk for non-contact injuries such as ankle sprains and anterior cruciate ligament injuries. Also indicate the highest prevalence of injuries of the distal parts of the lower extremities (ankle joint and knee) during sports [13]. Burchard, et.al. [13] found that most school-related injuries occur in school sports, especially ball sports. The distal extremities were mainly injured.

In a study by Clifton, et al. [14] describes the epidemiology of injuries received in basketball by high school girls in the period from 2005-2006 to 2013-2014 school years and student women's basketball in the period from 2004-2005 to 2013-2014 school years. Injuries were recorded through an online sports surveillance program. The online high school reporting system documented 2,930 injuries with loss of working time over 24 hours during 1,609,733 workouts and games; The National University Sports Association's Injury Monitoring Program recorded 3,887 injuries with a loss of time of more than 24 hours during 783,600 workouts and games. Injury rates were higher in college than in high school (4.96 vs. 1.82 / 1000 training and games; injuries (IRR) = 2.73; 95% confidence interval (CI) = 2.60, 2.86) . The level of injuries was higher in competitions than in training, both for high school students (injury index (IRR) = 3.03; 95% confidence interval (CI) = 2.82, 3.26) and for students (injury index) IRR) = 1.99; 95% confidence interval (CI) = 1.86, 2.12). The most common injuries at both levels were sprains, concussions, and sprains of muscles and tendons. Most of the injuries affected the knees, head and face. These injuries were often caused by contact with another player or a non-contact mechanism. Clifton, D. R., et al. (2018) concluded that the level of injuries was higher in students than in high school students, higher in competitions than in training.

In a study by Fraser, et al. [15] described injuries from contact with the ball in 11 sports (men's soccer, women's field hockey, women's volleyball, men's baseball, women's softball, men's and women's basketball, men's and women's lacrosse, men's and women's football) National Student Sports Association (NCAA) for the period 2009-2010 to 2014-2015 academic years. As a result of the study, 1123 injuries from contact with the ball were registered. The highest scores were women's softball, women's field hockey (7.71 / 10,000 student-athletes who participated in training or games (AE)) and men's baseball (7.20 / 10,000 student-athletes who participated in training or games (AE)). The majority of ball-related injuries occurred on the hand / wrist (32.7%) and head / face (27.0%) and were diagnosed as strokes (30.5%), sprains (23.1 %) and concussion (16.1%). Among sexually comparable sports (eg, baseball / softball, basketball, and soccer), women had a higher rate of concussion diagnosed as concussion than men (ratio of injuries = 2.33; 95%). confidence interval (CI) = 1.63, 3.33). More than half (51.0%) of injuries from contact with the ball were associated with loss of time (ie time of restriction of participation, 24 hours), and 6.6% were severe (ie time of restriction of participation> = 21 days). The most frequent severe injuries in contact with the ball were concussions (n = 18) and fractures of the fingers (n = 10). Thus, the percentage of injuries from contact with the ball was highest in women's softball, women's field hockey and men's baseball. Although more than half were injuries without loss of time, serious injuries such as concussions and fractures were reported.

To prevent injuries, it is necessary to form rational movements in the most optimal way [16 – 18]. That is why the technology of preserving the health of students - future specialists in physical education and sports should contain universal approaches to the process of learning technical skills, which will ensure the prevention of injuries and, consequently, the preservation of health. First, it is necessary to form in students the concept of biomechanically rational movements in general [19 –21]. Secondly, it is necessary to create conditions for students to master modern means of self-analysis of movement techniques [19, 21]. Third, it is necessary to introduce into the learning process of students practical tools, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injuries [8, 9].

These provisions determine the great importance of research on the prevention of injuries of students - future professionals in physical education and sports, and based on these provisions, we can conclude that this work is timely and relevant.

Thus, in the analyzed works on traumatism of students, team sports were mainly investigated as the most susceptible to injuries. However, it is now also important to analyze injuries in other sports, which are increasing in popularity every year. Rock climbing can be chosen as such a sport for the following reasons: 1 – rock climbing is included in the program of the Olympic Games, it is becoming more and more popular among young people [22]; 2 – a large number of injuries are observed in rock climbing; 3 - there are currently no specific injury prevention programs in rock climbing [23–25].

The purpose: to develop and experimentally test the biomechanical technology of injury prevention of future specialists in physical education and sports in the process of professional training (rock climbing for example).

Material and Methods

Participants and randomization

The participants of this study were 84 male students engaged in amateur climbing in the cities of Ukraine (Kharkiv, Dnipropetrovsk, Lyuvov, Vinnytsia, Kamyanets-Podilsk, Kyiv) aged 18-19 years. All athletes were also students of physical education faculties of Ukrainian universities. All athletes gave written consent to participate in the experiment. The health of the athletes was checked during the first 2 weeks of the study with the help of regular medical examinations conducted by a doctor. Athletes were also observed for 6 months to assess baseline injury rates and baseline techniques of one-arm hang on one arm.

An independent statistician performed a parallel randomization of athletes into a control group and an intervention group using a random distribution method using an online random number generator program. As a result of randomization, 40 athletes were in the experimental group and 44 - in the control.

The groups were compared with indicators of body length, body weight, experience of rock climbing and the number of injuries during the observed period of 6 months before the experiment. For all these indicators, the groups did not differ significantly from each other.

The body length of athletes in the control group was 172.5 ± 8.5 cm, body weight - 65.2 ± 6.5 kg; the body length of the athletes of the experimental group was 173.4 ± 8.7 cm, body weight - 66.1 ± 6.6 kg ($p > 0.05$).. No significant differences in the injury index in the control and experimental groups were found ($p = 0.385$-0.729).

Both control and experimental groups consisted of novice athletes (amateurs), aged 18-19 years, males; body length of athletes of the control group was 172.5 ± 8.5 cm, body weight - 65.2 ± 6.5 kg; the body length of the athletes of the experimental group was 173.4 ± 8.7 cm, body weight - 66.1 ± 6.6 kg ($p > 0.05$). The groups trained according to the generally accepted plan 3-4 times a week, the number of training hours was the same in both groups. At the beginning and at the end of the pedagogical experiment, an analysis of the technique of performing the height on one arm was performed by experts in both groups. The number of injuries of the upper extremities in both groups was also recorded.

At the fourth stage of the study (August 2020 - December 2020) the analysis of the obtained data was carried out, the work was formalized.

Injury registration method

Cases of injuries and diseases of the upper extremities were registered during the year in the control and experimental groups. The following injuries were registered: injuries and diseases of the fingers, injuries and diseases of the elbow joint, injuries and diseases of the shoulder joint. Injuries were also registered by severity: minor, moderate, severe. Low complexity injuries include those that heal in less than 1 month, Medium complexity injuries that heal in 2-3 months, and High complexity injuries include those that heal within 6-12 months and can last a lifetime. Cases of injuries of the upper extremities were registered during the year in the control and experimental groups. Injuries of fingers were registered.

Method of determining the risk of injury

To determine the impact of the developed technology on the risk of injury, the following indicators were determined: risk (incidence) of injury, chance of injury, relative risk and odds ratio. Injury risk (incidence) was defined as the ratio of the number of injuries to the total number of athletes in the analyzed group. The relative risk (incidence rate ratio) was determined by the ratio of risk in the control group to the risk in the experimental group. The chance of injury was defined as the ratio of the number of injuries to the number of uninjured athletes in the analyzed group. The odds ratio was defined as the ratio of the chances of injury in the control group to the chances of injury in the experimental group.

Intervention program

As a result of analytical and creative work, a biomechanical technology for injury prevention in the training of specialists in physical education and sports was developed. The technology is developed, which contains 3 directions: 1 - theoretical and methodical (creation of bases for understanding by students of mechanisms of formation of movements without risk of injury, formation at students of concept of biomechanically rational movements in general); 2 - analytical (providing students with knowledge about modern means of self-analysis of the level of technical skills); 3 - practical (students' mastery of practical means of injury prevention, ie, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injuries).

Theoretical and methodological direction involved mastering the basic knowledge of dynamic anatomy, which is the basis of biomechanics, the basic laws of motion control, understanding the causes and means of injury prevention in physical culture and sports.

In order to form a theoretical foundation for students in the process of formation and improvement of technical skills, an author's video manual on the basics of biomechanics of the musculoskeletal system was developed. The author's video manual is an illustration with an explanation of the biomechanical patterns of proper motor skills and injury prevention.

The author's video manual is entitled: "Biomechanics of the musculoskeletal system" (A.C. №№ 100612-100616 from 17.11.2020) and consists of 5 parts:

Part 1. Biomechanics of the musculoskeletal system. Basic concepts in biomechanics (A.C. № 100612 from 17.11.2020) (Fig. 1).

Part 2. Biomechanics of the musculoskeletal system. Upper limb (A.C. № 100613 dated 17.11.2020) (Fig. 2).

Part 3. Biomechanics of the musculoskeletal system. Lower limb (A.C. № 100614 from 17.11.2020).

Part 4. Biomechanics of the musculoskeletal system. Torso and pelvis (A.C. № 100615 from 17.11.2020).

Part 5. Biomechanics of the musculoskeletal system. Head and neck (A.C. № 100616 from 17.11.2020).

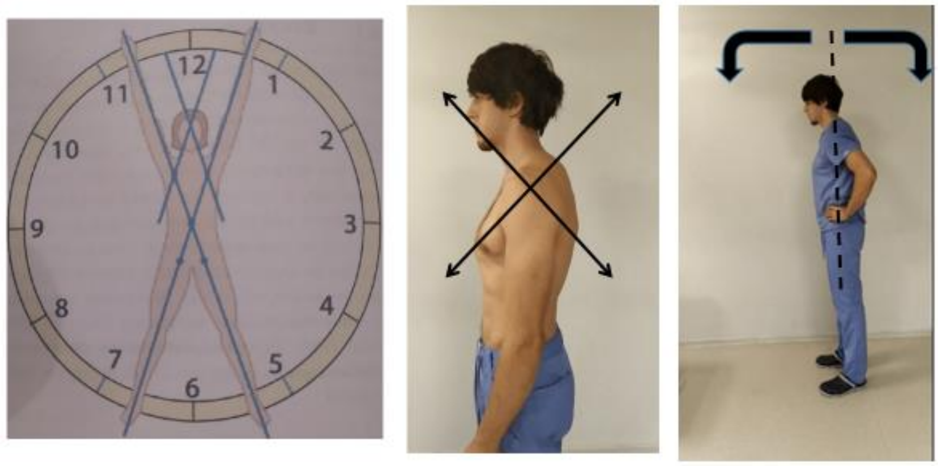

Fig. 1. Example of a slide of the first part of the author's textbook with an illustration of the pattern as part of the motor stereotype (source: the figure by the author)

Fig. 2. Example of a slide of the second part of the author's textbook with an illustration of manual therapy techniques for injury prevention and recovery from injuries of the upper extremity belt (source: the figure by the author)

Theoretical classes on sports and pedagogical improvement explained to students the main tasks of studying the biomechanical foundations of the process of mastering technical skills.

As a result, students were given the opportunity to get a lot of interesting, relevant information and applied techniques for work and independent training.

The first part of "Biomechanics of the musculoskeletal system. Basic concepts in biomechanics "contains information about the authors, the tasks of the manual, which are as follows:

• Study of basic and clinically significant concepts of biomechanics [26, 27].

• Study of functional anatomy in motion models.

• Mastering and practicing methods of manual and functional therapy

Next, students are invited to determine their goals in classes on sports and pedagogical improvement. This is a necessary condition and the first step to create a conscious attitude of students to their functional state and injury prevention in both the chosen sport and other physical activities.

The next stage provides a definition of biomechanics as a science of the laws of mechanical motion in living systems, which studies the features of movements in the process of motor activity and exercise. The general task of biomechanics is to find perfect ways of motor actions and to teach / learn to perform them more effectively. The following are partial problems of biomechanics:

• Study and explanation of the human movements in a particular area of his motor activity.

• Study of the results of the motor task.

• Study of the conditions in which they are carried out.

• Based on all this - the development of effective movements, through learning and training.

In the analytical direction the algorithm of revealing of the basic kinematic parameters of various models of technics characteristic of students with various level of possession of technics of sports movements is developed.

The analytical direction of biomechanical technology of injury prevention provided for the introduction of modern means of analysis of the effectiveness of mastering motor skills in the initial process of physical education and sports. In particular, students were asked to learn a modern tool for video analysis of movement techniques - the Kinovea program [28, 29]. The Kinovea sports video analysis program is now an effective, informative, easy-to-learn tool for improving the efficiency of students' acquisition of motor skills and injury prevention.

In the analytical classes, students were explained that for the prevention of injuries it is necessary to have modern tools not only qualitative but also quantitative analysis of movement technique. There are many different computer programs and video tools for this. One of the most common features is the Kinovea program.

In the future, students were invited to master working with this program.

In the practical direction the principles of application of means for prevention of traumatism are defined:

1 – strengthening of the muscles participating in performance of the movement;

2 – the formation of functional movement, coordinated work of the muscles of the torso, upper and lower extremities.

In this directions, developed and systematized tools to prevent injuries to students - future professionals in physical education and sports [30 –32].

All means are conditionally divided into two groups: means from a sport and means specific to physical therapy. Physical therapy is used in an unconventional way: to improve movement technique and to prevent injuries. We have applied following means of practical exercises for injury prevention in the process of training specialists in physical education and sports on the example of climbing.

The exercises were based on neuromuscular training [10, 19] with movements in a closed kinematic chain and exercises in an eccentric mode [33, 34].

Exercises specific to physical therapy were aimed at the formation of functional movements. The basis of physical therapy exercises was made up of movements aimed at coordinated interaction of the patterns of the shoulder, scapula, pelvis and trunk.

Statistical analysis

The values of the measured angles at the point of stable fixation of the height were compared on the basis of 20 measurements for each model of technology using the Student's method for odd samples.

To determine the impact of the developed technology on the risk of injury, the following indicators were determined: risk (incidence) of injury, chance of injury, relative risk and odds ratio using the computer program SPSS-17, Crosstabs option.

For the entire sample, we used the exact Fisher test and the Pearson χ-square test to compare the injury rate between the intervention groups and the control group. We calculated the number needed for training to prevent 1 injury as the inverse of the difference between the percentages of injured players in the control and experimental groups. We considered bilateral $P < 0.05$ statistically significant.

We presented the Injury rate indicates as the number of injuries per 1000 NPPs, and we defined the AE as the number of athletes multiplied by the number of all training sessions and competitions in which they participated (AE = athlete*exposure (training sessions, competitions)). In our case, the number of trainings and competitions was the same in the control and experimental groups and was 75 before the experiment and 150 during the experiment. The number of students - climbers in our case was 40 for the experimental group and 44 - for the control). The value of the Injury rate was defined as - the number of injuries 1000 AEs.

Significance of differences in the number and risk of injuries between the control and experimental groups was determined by the Fisher exact test and using the Pearson χ-square test.

Injury risk (incidence) was defined as the ratio of the number of injuries to the total number of athletes in the analyzed group. Relative risk (incidence rate ratio) was determined by the ratio of risk in the control group to the risk in the experimental group. The chance of injury was defined as the ratio of the number of injuries to the number of uninjured athletes in the analyzed group [35]. The relative chance (Odds Ratio) was defined as the ratio of the chances of injury in the control group to the chances of injury in the experimental group [35]. These indicators were determined separately for all analyzed types of finger injuries (low, medium and severe).

Results

The total number of all registered finger injuries during 1 year of the experiment was 33 in the control group and 9 in the experimental group. The number of AEs during 1 year of the experiment was 6600 in the control and 6000 in the experimental groups. Injury rate per 1000 AEs of all registered finger injuries in the control group during the 1 year of the experiment was 5.5 (95% Ci, 1.061; 9.267), in the experimental group - 1.364 (95% Ci, 0.032; 2.375), P <0.001.

The injury rate of mild finger injuries per 1000 AEs during 1 year of the experiment in the control group was 1.97 (95% Ci, 1.061; 2.303), in the experimental group - 0.83 (95% Ci, 0.068; 0.978). The incidence rate ratio for cohort (injuries = no) for mild shoulder injuries was 0.805 (0.643; 1.00). We also found that the Injury rate of moderate finger injuries per 1000 AEs during 1 year of the experiment in the control group was 1.67 (95% Ci, 0.247; 1.783), in the experimental group - 0.50 (95% Ci, 0.088; 1.182). The incidence rate ratio for cohort (injuries = no) for moderate finger injuries was 0.811 (0.669; 0.982; P = 0.030). Our study also showed that the Injury rate of severe finger injuries per thousand AEs during 1 year of the experiment in the control group was 1.36 (95% CI, 0.134; 1.685), in the experimental group - 0.17 (95% CI, 0.065; 1.225). The incidence rate ratio for cohort (injuries = no) for severe finger injuries was 0.816 (0.697; 0.955; P = 0.011) (Table 1).

The incidence (risk) of finger injuries of low complexity in the control group is 0.23, in the experimental - 0.10; the chances of getting a finger injury of low complexity in the control group is 0.419, in the experimental - 0.143. The relative risk (control group / experimental group) to get a injury of fingers of low complexity in the control group is higher in 2.364 (95% CI = 0.925-6.041, P> 0,05) times in comparison with experimental (tab. 1,). Relative risk - the probability of injury (experimental group / control group) is equal to 0.805 (95% CI = 0.643-1.008, P> 0.05). The relative chance of getting a finger injury of low complexity in the control group is 2.935 times higher (95% CI = 0.940-9.170, P> 0.05) compared with the experimental (Table 1).

The incidence (risk) of finger injuries of medium complexity in the control group is 0.250, in the experimental - 0.075; the chance of getting a finger injury of medium complexity in the control group is 0.333, in the experimental - 0.081. The relative risk (control group / experimental group) to get a finger injury of medium complexity in the control group is higher by 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030) compared to the experimental. Relative risk - the probability of injury (experimental group / control group) is equal to 0.811 (95% CI = 0.669-0.982, P (Fisher) = 0.030). The relative chance of getting a finger injury of medium complexity in the control group is 4,111 times higher (95% CI = 1.055-16.020, P (χ2) = 0.041) compared with the experimental (Table 1).

The incidence (risk) of finger injuries of high complexity in the control group is 0.205, in the experimental - 0.025; the chances of getting a finger injury of high complexity in the control group is equal to 0.257, in the experimental - 0.026. The relative risk (control group / experimental group) to get a finger injury of high complexity in the control group is 8,182 times higher (95% CI = 1.084-61.749, P (Fisher) = 0.011) compared to the experimental. Relative risk - the probability of injury (experimental group / control group) is 0.816 (95% CI = 0.697-0.955, P (Fisher) = 0.011). The relative chance of getting a finger injury of high complexity in the control group is 10,029 times higher (95% CI = 1.209-83.201, P (χ2) = 0.016) compared with the experimental (Table 1).

Discussion

As the analysis of the literature has shown, our study is one of the first to develop programs for the prevention of injuries for students - future specialists in the field of physical education and sports. In addition, our study is one of the first on injury prevention for climbers. Our technology for the prevention of injuries of students studying in the specialty "Physical Education and Sports" involves 3 directions: theoretical and methodological, analytical and practical. As the study showed, the application of the developed technology is effective for the prevention of injuries of students – rock climbers, future specialists in physical education and sports. Thus, the goal of the work was achieved: the technology of prevention of injuries of students - future specialists in physical education and sports - was developed and experimentally substantiated. In our study, we presented the results of the application of the developed technology for the prevention of finger injuries of rock climbers – students of the faculties of physical education and sports.

Table 1

Indicators of finger injuries in the control (n = 44) and experimental (n = 40) groups

Group	Low complexity				Medium complexity				High complexity			
	Yes*	No *	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury
C	13	31	0.23	0.419	11	33	0.250	0.333	9	35	0.205	0.257
E	5	35	0.10	0.143	3	37	0.075	0.081	1	39	0.025	0.026
IRR(CI) P^a	2.364 (0.925; 6.041)				3.333 (1.001; 11.096) P(Fisher)=0.030				8.182 (1,084; 61.749) P (Fisher)=0.011			
OR(CI) P^a	2.935 (0.940; 9.170)				4.111 (1.055; 16.020) $P(\chi^2)=0.041$				10.029 (1.209; 83.201) $p\ (\chi^2)=0.016$			

Notes: C-control group; E - experimental group; * - Yes - the number of people injured; No - the number of people who were not injured; IRR (incidence rate ratio) - the ratio of the value of the risk of injury in the control group to the value of risk in the experimental group; OR (Odds Ratio) - the ratio of the chances of injury in the control group to the value in the experimental group; CI - confidence interval (lower limit. Upper limit); and - only reliable values of P are presented; P (Fisher) - was determined by the exact Fisher test; P (χ2) was determined by the Pearson χ-square test

It should be noted that we have confirmed our previous studies on injury prevention for amateur climbers [32]. The work [32] showed that the use of neuromuscular training is effective for the prevention of finger injuries in climbers. The study presented in this work has shown a higher efficiency of the use of complex technology for the prevention of finger injuries of rock climbers - students. We believe that the great efficiency of the developed technology is due to its complex nature: it contains not only neuromuscular training, but also theoretical, methodological and analytical components. The educational component is very important for the students - climbers' conscious use of the proposed practical exercises [19]. In addition, the analytical component is important for the quantitative analysis of the technical features of the main elements of the sport. It is the integrated approach that determined the high efficiency of the use of biomechanical technology for preventing injuries of students - rock climbers, future specialists in physical education and sports. In addition, the study also confirmed our data presented in previous works on the effectiveness of the use of exercises in a closed kinematic chain and eccentric exercises for the prevention of shoulder injuries [30, 31]. In the study presented in this paper, technologies of a complex nature are shown. The theoretical, methodological and analytical aspects complement the practical, making up a coherent whole of understanding, application and ability to analyze. This, in our opinion, is especially important for students - future specialists in physical education and sports.

Our research has also confirmed the findings of other scientists dealing with the problem of student injuries. So, in many works it is shown that injuries received as a result of students' sports activities are a real problem. So, Jin [36] found a high number of injuries in college football students. Similar results were obtained by Kahlenberg, et al. [37]. It was found that every student is an athlete. on average engaged in 1.6 different sports. The average number of hours of sports per year was 504.3 and 371.6 hours, respectively. The average total number of sports injuries received by athletes was 1.7 per participant. 80.8% of respondents reported having suffered at least one sports injury. Thus, the number of injuries in students engaged in sports is high.

Kerr, et al. [38] data on injuries and impacts collected on 27 sports using the National Network for Sports Treatment, Injuries and

Outcomes (NATION). The results provided by certified sports coaches (AT) for the collection of data on injuries of athletes (AE) in training and competitions in 27 sports in the period from 2011/2012 to 2013/2014 were analyzed. It was found that most of the 47,014 injuries were injuries of the ankle and knee joints (82.8%). Among boys in sports, the injury rate was highest in football (3.27 / 1000 AE) and wrestling (2.43 / 1000 AE); The number of ankle and knee injuries was also highest in football (15.29 / 1000 AE) and wrestling (11.62 / 1000 AE). Among women's sports, the injury rate was highest in football (1.97 / 1000AE) and basketball (1.76 / 1000AE); The number of ankle and knee injuries was highest in field and lacrosse field hockey (both 11.32 / 1000 AE).

Our research has shown that rock climbing is also a dangerous sport in terms of upper limb injuries. Given its growing popularity among young people, the development and substantiation of a technology for the prevention of climbers' injuries is timely. This is especially true for students - future specialists in physical education and sports, since their task is not only to learn how to train without injuries, but also then to carry the knowledge gained to their future students.

Conclusions

1. The biomechanical technology for injury prevention in the training of specialists in physical education and sports has been developed on rock climbing for example. Developed biomechanical technology for injury prevention contains 3 areas: 1 - theoretical and methodological (creating a basis for students to understand the mechanisms of movement without risk of injury; concept of biomechanically rational movements in general); 2 - analytical (providing students with knowledge about modern means of self-analysis of the level of technical skills); 3 - practical (students' mastery of practical means of injury prevention, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injury).

2. The applied technology of injury prevention significantly influences both the reduction of the number of injuries of athletes – future specialists on the physical education and sports (on rock climbing for example). It is established that the application of the developed technology of injury prevention reduces the risk of finger injuries: low complexity – in 2.364 times (95% CI = 0.925-6.041, P> 0,05) times; medium complexity – in 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030); high complexity – in 8.182 times (95% CI = 1.084-61.749, P (Fisher) = 0.011).

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Conflict of interest

Authors state that there is no conflict of interest.

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