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According to the order of the Ministry of Education and Science of Ukraine No. 326 of 04.04.2018, the journal is included in the **List of scientific professional editions** of Ukraine in which the results of dissertation papers for obtaining the degrees of the doctor and candidate of sciences may be published from: **physical education and sport; pedagogy**. According to the Order of the Ministry of Education and Science of Ukraine dated 07/16/2018 No. 775, the magazine is included in the **group B of professional editions** of Ukraine. Specialties: physical education and sports (24.00.01, 24.00.02, 24.00.03); pedagogical sciences (13.00.02 (physical culture, basics of health), specialty with new ciphers: 017 physical culture and sports, 011, 014.

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

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 recreation, medical and recreational physical culture.

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Наказом МОН України № 326 від 04.04.2018 р. журнал внесено до **Переліку наукових фахових видань України**, в яких можуть публікуватися результати дисертаційних робіт на здобуття наукових ступенів доктора і кандидата наук з: **фізичного виховання та спорту; педагогіки**. Наказом МОН України від 16.07.2018 № 775 журнал включено в **категорію Б фахових видань** України. Спеціальності: фізичне виховання та спорт (24.00.01, 24.00.02, 24.00.03); педагогічні науки (13.00.02 (фізична культура, основи здоров'я); спеціальності за новими шифрами: 017 фізична культура і спорт, 011, 014.

Засновник:
Харківський національний педагогічний університет імені Г.С. Сковороди.
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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Приказом МОН Украины № 326 от 04.04.2018 г. журнал внесен в **Перечень научных профессиональных изданий Украины**, в которых могут публиковаться результаты диссертационных работ на соискание ученых степеней доктора и кандидата наук по: физическому воспитанию и спорту; педагогике. Приказом МОН Украины от 16.07.2018 № 775 журнал включен в **категорию Б специализированных изданий** Украины. Специальности: физическое воспитание и спорт (24.00.01, 24.00.02, 24.00.03) педагогические науки (13.00.02 (физическая культура, основы здоровья) специальности по новым шифрами: 017 физическая культура и спорт, 011, 014

Учредитель:
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Специализированное научное издание по проблемам физического воспитания, спорта, формирования здорового образа жизни, реабилитации, физической терапии.

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 реабилитации и рекреации, лечебной и оздоровительной физической культуры. 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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CONTENT

ЗМІСТ/СОДЕРЖАНИЕ

Physical therapy of middle-aged women after the hip joint replacement

Bezyazychna O.V., Manucharian S.V., Duhina L.V.

Kharkiv State Academy of Physical Education

DOI: https://doi.org/10.34142/HSR.2019.05.02.01

Abstract
Bezyazychna O.V., Manucharian S.V., Duhina L.V. Physical therapy of middle-aged women after the hip joint replacement
The purpose of the work: development and experimental substantiation of a physical therapy program for middle-aged women after the hip joint replacement.
Material and methods. 22 middle-aged women after hip joint replacement (the non-cement form of fixation of the prosthesis components) during the training period took part in the experiment; they were divided into two groups, experimental and control one, 11 people in each. Women in the experimental group underwent physical therapy measures according to the author's program, and women of the control group underwent it according to the physical therapy program for individuals after the hip joint replacement. Pedagogical and medico-biological studies were conducted for 3 months. Primary and repeated study involved clinical methods (history collection, physical examination); assessment of the quality of life, as well as medical and pedagogical observations in the process of remedial gymnastics and mathematical statistics methods.
Results. We present the program of physical therapy using remedial gymnastics based on step-down exercises with visual control and exercises with an elastic band on a healthy leg for balance training; therapeutic massage; physiotherapy according to conventional methods, namely: electromyostimulation; laser therapy.
Conclusion. In the course of the study conducted, we came to the conclusion that the program of physical therapy for middle-aged women after hip joint replacement in the training period, developed and implemented in the Utility Non-Profit Enterprise of Kharkiv Oblast Council "Oblast Clinical Hospital" has allowed to increase the efficacy of rehabilitation; it is available to all specialized rehabilitation centers, and deserves a wide-scale implementation into practice.
Key words: physical therapy, endoprosthesis replacement, quality of life.

Анотація
Без'язична О.В., Манучарян С.В., Дугіна Л.В. Фізична терапія жінок середнього віку після ендопротезування кульшового суглоба.
Мета роботи: розробити і експериментально обґрунтувати методику фізичної терапії для жінок середнього віку після ендопротезування кульшового суглоба.
Матеріал і методи. В експерименті брали участь 22 жінки середнього віку після ендопротезування кульшового суглоба (безцементний спосіб фіксації компонентів ендопротеза) у тренувальному періоді, які були розподілені на дві групи – експериментальну і контрольну, в кожній по 11 осіб. Жінкам експериментальної групи заходи фізичної терапії проводилися за авторською програмою, жінкам контрольної групи – за програмою фізичної терапії для осіб після ендопротезування кульшового суглоба. Педагогічні та медико-біологічні дослідження проводились протягом трьох місяців. При первинному і повторному дослідженні застосовувалися клінічні методи (збір анамнезу, зовнішній огляд), оцінка якості, а також лікарсько-педагогічні спостереження в процесі занять лікувальною гімнастикою і методи математичної статистики.
Результати. Представлена програма фізичної терапії із застосуванням лікувальної фізичної культури на основі степ-даун вправ з візуальним контролем та вправ з еластичною стрічкою на здоровій нозі для тренування балансу; лікувального масажу; фізіотерапії за стандартними методиками, а саме: електроміостимуляції; лазерної терапії.
Висновки. В ході проведеного дослідження ми прийшли до висновку, що розроблена і впроваджена в Комунальне некомерційне підприємство Харківської Обласної Ради «Обласна клінічна лікарня» програма фізичної терапії для жінок середнього віку після ендопротезування кульшового суглоба у тренувальному періоді дозволила підвищити ефективність відновного лікування, доступна для всіх спеціалізованих реабілітаційних центрів та заслуговує широкого впровадження в практику.
Ключові слова: фізична терапія, ендопротезування, якість життя.

Аннотация
Безъязычная О.В., Манучарян С.В., Дугина Л.В. Физическая терапия женщин среднего возраста после эндопротезирования тазобедренного сустава.
Цель работы: разработать и экспериментально обосновать программу физической терапии для женщин среднего возраста после эндопротезирования тазобедренного сустава.
Материал и методы. В эксперименте принимали участие 22 женщины среднего возраста после эндопротезирования тазобедренного сустава (бесцементный способ фиксации компонентов эндопротеза) в тренировочном периоде, которые были разделены на две группы – экспериментальную и контрольную, в каждой по 11 человек. Женщинам экспериментальной группы физическая терапия проводилась по авторской программе, женщинам контрольной группы – по программе физической терапии для лиц после эндопротезирования тазобедренного сустава. Педагогические и медико-биологические исследования проводились в течение 3 месяцев. При первичном и повторном исследовании применялись клинические методы (сбор анамнеза, внешний осмотр), оценка качества жизни, а также врачебно-педагогические наблюдения в процессе занятий лечебной гимнастикой и методы математической статистики.
Результаты. Представленная программа физической терапии с применением лечебной физической культуры на основе степ-даун упражнений с визуальным контролем и упражнений с эластичной лентой на здоровой ноге для тренировки баланса; лечебного массажа; физиотерапии по стандартным методикам, а именно: электромиостимуляции; лазерной терапии.
Выводы. В ходе проведенного исследования мы пришли к выводу, что разработанная и внедренная в Коммунальное некоммерческое предприятие Харьковского областного Совета «Областная клиническая больница» программа физической терапии для женщин среднего возраста после эндопротезирования тазобедренного сустава в тренировочном периоде позволила повысить эффективность восстановительного лечения, доступна для всех специализированных реабилитационных центров и заслуживает широкого внедрение в практику.
Ключевые слов а: физическая терапия, эндопротезирование, качество жизни.

Introduction

The hip joint holds a special place in the biomechanical connection of the lower extremity and the spine. It has three degrees of freedom and three axes of motion. With wide functionality, this joint assumes considerable dynamic and static loads, providing harmony of movement of the person. With the development of pathology in the joint, severe functional disorders occur throughout the lower extremity, which subsequently leads to disorders throughout the musculoskeletal system. Disability and pain make patients with disabilities. In recent years, one of the most effective and promising methods of surgical treatment is joint replacement [1, 2, 3].

According to the WHO expert group in 2012, 1 million 500 thousand total hip replacement is performed worldwide. The number of operations in the last 5 years has increased in Europe by 80%, which is 175 thousand a year in one Germany alone. That is, world statistics show that on average annually requires joint replacement of 500 - 1000 patients and injured per 1 million population, and given the population of Ukraine, annually in our country requires endoprosthesis 25-40 thousand patients and injured. Unfortunately, 10 times less than the estimated number of joint replacements is performed annually in Ukraine. As is known, osteoarthritis of the hip joint is almost inevitable consequence of any diseases and injuries of the hip joint. Therefore, any method of treatment other than total endoprosthetics cannot prevent its development, at best it can only slow the progression of osteoarthritis [4, 5].

An important and not completely resolved issue in endoprosthetics is the problem of recovery of patients after joint replacement. At present, there are few such centers in the country, and there are no accurate data on the total number of such patients, the results of their treatment, etc. At the same time, these patients require routine physical therapy, which should be performed in specially organized or specially equipped rehabilitation centers. Successful and biomechanically correct recovery of patients requires adequate pre- and postoperative physical therapy programs [6, 7, 8].

The purpose of the work: evaluate the impact of the author's physical therapy program on the quality of life of middle-aged women after hip replacement in the training period.

Tasks of work:

1. Based on the study of specialized literature to analyze the main approaches to physical therapy after hip replacement.
2. Improve and implement a program of physical therapy for middle-aged women after hip replacement in the training period.
3. To evaluate the effectiveness of the implemented physical therapy program on the basis of the quality of life assessment according to the Johanson questionnaire and Harris scale [7].

Material and methods

Participants

The study is based on the results of a survey of 22 women after hip replacement, who were arbitrarily divided into two groups - experimental (n=11) and control (n=11). The mean age in the experimental group was 49.09 ± 0.81 and in the control group was 51.00 ± 0.72. All patients with hip joint prosthetics were performed in the orthopedic-traumatology department of the Municipal non-profit enterprise of Kharkiv Regional Council "Regional Clinical Hospital", a cementless method of fixation of components of the endoprosthesis. In terms of the number of patients, age, presence of concomitant pathology, the groups were homogeneous (Tab. 1).

Experimental protocol

According to the analysis of medical histories in the hospital, physical therapy activities began from the first day after surgery: therapeutic exercises (breathing exercises, isometric exercises for the operated limb in the initial position lying on the back), for 2-3 days after endoprosthesis, the patient was verticalized and assigned to stroke. with additional support (walkers 1-2 days, then crutches). From the second week was prescribed electromyostimulation and mechanotherapy. Patients were in the hospital 7-10 days after surgical treatment (before removal of sutures).

The initial study was performed within 1-2 days of the training period, and the second study 3 months after the application of physical therapy measures at the Municipal Non-Profit Enterprise of Kharkiv Regional Council "Regional Clinical Hospital".

Part of them (11 patients) subsequently underwent physical therapy according to our author's program, and part (11 patients) were engaged in the program Epifanov [9] (department of the clinic in which they were treated).

Thus, the first (11 patients) was an experimental group and the second (11 patients) was the control group.

In the initial study, the quality of life indicators of patients on the Harris scale [7] in the

experimental and control groups were rated as "unsatisfactory". According to the Johanson questionnaire, the mean score in the experimental group was 44.45 ± 0.57, and in the control group 48.72 ± 0.63, which is below the mean.

When comparing indicators in patients of both groups, we found no statistically significant differences (p> 0.05) (Table 1).

Table 1

Indicators of quality of life of patients after endoprosthesis hip joint in the initial study ($\bar{X}$ ±m)

Questionnaire, scores	Experimental group, n=11	Control group, n=11	t	p
Harris Scale [7]	47,45±0,57	48,72±0,63	1,48	>0,05
Johanson System [7]	44,45±0,36	46,00±0,60	2,09	>0,05

The methodological bases of the developed physical therapy program included:

• selection and determination of rational orientation of physical rehabilitation means;

• justification of various means of physical rehabilitation and their dosage;

• defining the criteria for their effectiveness.

The program envisaged the use of the following measures:

• therapeutic physical education;

• therapeutic massage;

• physiotherapy by standard methods, namely: electromyostimulation; laser therapy.

Tasks of therapeutic physical culture:

• promotion of the condition of the musculoskeletal system;

• restoration of walking skills without additional support;

• adaptation to certain power and speed voltages, to long static and dynamic loads in daily life;

• restoration of statin dynamic balance, coordination of movements.

Forms of therapeutic physical culture:

• therapeutic gymnastics;

• therapeutic walking;

• independent classes.

Therapeutic gymnastics by individual or small group method (40-60 minutes, daily, № 30-40).

The basis of the medical gymnastics complexes were step-down exercises with visual control and exercises with an elastic band on a healthy leg for balance training.

Step-down exercises begin with a low step (10 cm high). The patient stands on the steppe and takes a slow step with a healthy leg forward, descending from the steppe. The body weight is kept on the sore leg, which will also train the balance.

There should be a mirror in front of the patient so that the patient can look at themselves from the side while controlling the position of the feet and thighs - it is very important to make sure that when stepping down from the steppe there is no blockage to the side of the patient's leg. They then return to the starting position and repeat the exercise.

The number of repetitions 12-18 times.

If the exercise is performed correctly, the height of the steppe is gradually increased (15 and 20 centimeters) (Fig. 1).

Fig. 1. Step-down exercise with visual control

Exercise with an elastic band on a healthy leg for balance training: the loose ends of an elastic band about 2 meters long are tied to a stationary object about 20 centimeters above the floor (for

example, the crossbar of a Swedish wall). Thus, a loop about 1 meter in length is obtained. Standing on a diseased leg, the patient puts this loop on a healthy leg so that the loop is at the level of the bone. The patient should stand about 60-70 centimeters from the wall. The knees should be slightly bent, but the torso should be kept straight. A healthy leg (on which a loop of elastic band is worn) starts to move sideways. This exercise trains the muscles of both legs, but first of all, the coordinated work of the muscles - the so-called balance training (Fig. 2). The number of repetitions 12-18 times.

Fig. 2. Exercise with an elastic band on a healthy one legs for balance training

Massage of the lumbosacral spine and lower extremity according to the method of Efimenko [10], daily, № 10-12.

In the training period after hip arthroplasty, it is recommended to massage the paravertebral zones - spinal segments S5 - S1, L5 - L1, as well as massage the operated limb.

Buttocks massage, techniques: stroking, squeezing, kneading, rubbing, shock techniques, shaking.

Thigh massage, techniques: stroking, surface grinding, kneading, deep rubbing, shock techniques, shaking.

Finish the massage with general broad stroke strokes of the diseased limb, passive and active movements. For contractures and stiffness in the joint, apply redressing movements.

To restore joint mobility, Efimenko [10] first recommends massaging his muscular antagonists, which move him, and carefully rub his muscle sinews and directly injured joint. First wide and superficial, then local and deep receptions. After such preparation, passive translational and elastic movements restore its flexibility in the necessary directions. periodically elastic movements alternate with motions at full amplitude. In order to eliminate the pain that occurs during these techniques, the joint is repeated surface rubbing and stroking.

Electromyostimulation of the operated limb muscles in order to increase their strength was performed using the 8-channel Mioritm 040 electromyostimulation apparatus (Russia), changing the frequency and procedure time individually according to the stimulation response of the muscles. Electromyostimulation was performed in the annular mode of the thigh muscles (anterior and posterior group) and the shin muscles of the operated limb in the following sequence: anterior thigh muscle group (4 seconds), posterior (4 seconds), tibia muscles: group flexors (4 seconds) and extensors (4 seconds). Pulse shape asymmetric bipolar without constant component, pulse duration 0.3 ms. Stimulation mode - 60 Hz, duration of the cycle "stimulation - relaxation" 4 seconds with an increase to 8 seconds with 5-6 procedures with positive dynamics and good transfer of procedures, duration of the procedure 5-10-30 minutes, daily, No. 12.

Laser therapy was performed once a day with the help of the laser therapy company "EME" (Italy) according to the standard method, the duration of the procedure - 1 minute for each point, 4 points for the procedure. The procedures were performed according to the zonal - point method: 1 minute per contact zone. On a course of 10 procedures daily [11].

Patients of the control group were prescribed physical therapy measures by Epifanov [9].

The program envisaged the use of the following measures:

- therapeutic physical education;
- therapeutic massage;
- physiotherapy by standard methods, namely: electromyostimulation; laser therapy.

Special tasks of therapeutic physical culture:

- recovery of hip function;
- normalization of trophic tissue of the joint;
- strengthening of muscles of a pelvic belt and extensors of a back, and also strengthening of muscular groups of a limb;
- restoration of their endurance to considerable static and dynamic loads in order to unload and stabilize the operated joint.

Forms of therapeutic physical culture:

- therapeutic gymnastics;

• therapeutic walking;
• independent classes.

In the gymnastics of physical exercises against the background of developmental and respiratory exercises used to restore and strengthen the muscles, eliminate stiffness and contractures in the injured lower extremity prescribe exercises with objects and without, on stretching, with resistance or counteracting, with exercise water, the simplest elements of occupational therapy, varieties of walking, exercise on simulators.

In the course of rehabilitation treatment varieties of therapeutic walking were used: walking sideways, walking types at a predetermined pace and with a predetermined length of stride.

The course of massage was divided into preparatory, main and final periods.

In the main period, a clearly differentiated method of massage was applied, taking into account the functional state of the patient. The intensity of the techniques was constantly increased, using 8-16 procedures.

Massage of the hip joint and hip muscles was performed according to the method of Epiphanes [9].

In each of the periods of rehabilitation, the methods of hardware physiotherapy were applied according to standard methods: electromyostimulation, laser therapy [11].

Results

When re-examining quality of life indicators, positive changes were identified. Significant differences were noted when comparing the results of the questionnaires in the dynamics. It was found that in the course of physical therapy there was a significant increase in quality of life indicators.

In the experimental group, the mean Harris score [7] increased by 31.54 points (1.7 times), in the control group - by 28.18 (1.5 times) ($p < 0.05$). However, it should be noted that in the experimental group in 55% the results were rated as "satisfactory", in 45% as "good" and in the control group - 82% and 18% respectively.

According to the Johanson questionnaire [7], in the experimental group the average score increased by 28.00 points (1.6 times), in the control group - by 20.27 (1.4 times) ($p < 0.05$). The figures in both groups are above average.

When comparing repeated measures in both groups, we found a statistically significant improvement in indicators in the experimental group compared with the control group ($p < 0.05$) (Table 2).

Table 2

Dynamics of quality of life indicators of patients of the main and control groups in the primary and re-examination ($\bar{x} \pm m$)

Questionnaire, scores	I research	II research	t	p
1	2	3	4	5
Experimental group (n=11)				
Harris Scale [7]	47,55±0,57	79,09±0,62	44,49	<0,05
Johanson System [7]	44,45±0,36	72,45±0,59	48,94	<0,05
Control group (n=11)				
Harris Scale [7]	48,72±0,63	76,09±0,83	24,20	<0,05
Johanson System [7]	46,00±0,60	66,27±0,87	32,73	<0,05

Comparing the quality of life of women in both groups, we came to the conclusion that when they were re-examined in the experimental group after the application of physical therapy measures under our advanced program, they were better, which positively affects the quality of life of this contingent of persons ($p < 0,05$) (Table 3).

Table 3

Comparative characteristics of quality of life of patients after hip replacement at repeated examination ($\bar{x} \pm m$)

Questionnaire, scores	Experimental group, n=11	Control group, n=11	t	p
Harris Scale [7]	79,09±0,62	76,09±0,83	2,87	<0,05
Johanson System [7]	72,45±0,59	66,27±0,87	5,84	<0,05

Discussion

Analyzing the programs of physical therapy after hip replacement, we can say that they are all based on the same statement, for the maximum restoration of motor functions and return to previous conditions of life, requires the early start of physical therapy. Physical therapy of individuals after hip replacement is important because it can reduce the recovery period of muscle strength that performs movements in the hip joint.

Therapeutic gymnastics is prescribed by the methods of Glinyana [12], Populakh [13], Glynyana [14], Mukhin [16], Babov [1, 4], Zamorsky [5], Gerasimenko [13], Roy [17, 18].

Gliniana [12, 14] offers several periods of physical rehabilitation: preoperative (14 days), early postoperative (1-7 days after surgery), late postoperative (5-7 to 17-21 days after surgery), recovery (from 17- 21 days to 10-12 weeks after surgery) and training (10-12 weeks to 24 weeks after surgery) periods.

Gliniana [12] proposes a physical therapy program for the elderly after cement arthroplasty and outlines the following principles:

1. A rational combination of methods and means of physical therapy at all periods, taking into account the features of surgery.

2. Differential use of physical therapy depending on concomitant diseases.

3. Consistent correction of functional disorders in accordance with the tasks of each period of physical rehabilitation. Also, for each of the periods listed there are defined their terms and physical activities that are characteristic of these periods.

Pollyakh [13] offers his work with patients who have had hip replacement. At admission to the hospital, first of all, appoint adequate analgesic therapy (ketalong, tramadol, dexalgin, dynastat, stadol, promedol, omnopon, morphine), assess the severity of concomitant diseases, and, if necessary, appoint consultations with relevant specialists. Conduct prevention of stagnation of the lungs and kidneys - training with an instructor exercise, breathing exercises and exercises for the upper and healthy extremities.

Pollyakh [13] also identifies periods of rehabilitation: preoperative and postoperative period, which in turn is divided into a period of relative rest (2-3 days), and a period of recovery of basic skills and functions. However, in general rehabilitation can be divided into two periods: preoperative and postoperative. In the first period, calmness prevails - the limb is placed in a derotation longette, passive limb exercises and turns in the bed are performed - after restoring the sensitivity of the patients, they return to the healthy side with a pillow between the knee joints and back to the back every 40 minutes - 1.5 hours depending on the condition and the wishes of the patient, perform breathing exercises. Exercise therapy is used in the form of therapeutic and morning hygienic gymnastics, independent classes. Complexes consist of approximately 75% of developmental and respiratory exercises in a 1: 1 ratio and up to 25% of special exercises. Perform them mainly from the starting position lying down. The intensity of the exercises was low and at the end of the period moderate. Duration of therapeutic gymnastics 5-12 minutes. The physiological load curve, which is an image of the change in pulse rate during a session, is a single peak in the middle of the main part of the session. Classes include breathing exercises (8-10 deep breaths at the end of each hour), static and dynamic exercises for the toes, isometric tension of the muscles of the forearm, hips and lower leg. Isometric muscle tension is of great importance for the restoration of limb strength. First, the instructor teaches to strain the muscles on a healthy limb, and then for two at a time. The exercise is performed as follows: 1) muscle tension for 3-4 seconds; 2) muscle relaxation for 8-10 seconds. The second period is dominated by exercises aimed at developing all muscle groups.

Classes with the instructor of therapeutic physical training after surgery 2-3 times a day for 15-20 minutes to teach patients to perform exercises to restore strength and function of muscles. Mobility in the hip joint depends on: large gluteal muscle - flexion, middle gluteal muscle - support function, quadriceps femur and iliac-lumbar muscle - flexion. For restoration of function of muscles of a limb appoint movements of fingers from a foot and in an ankle joint, circular movements of a foot and capture by fingers of a foot, movements in knee joints, bending and extensions, bringing and taking in hip joints, isometric tension of a muscle of a hip. 4-6 seconds with increasing number of repetitions and sessions [13].

Therapeutic massage is used in all periods of rehabilitation treatment after hip replacement. Use segmental reflex, drainage, healing and hardware types of massage. Therapeutic massage is prescribed by the methods of Eremushkin [15], Mukhin [16], Efimenko [10], Glynnaya [14], Zamorsky [5].

Roy et al [11, 17] summarized and systematized studies on the use of physiotherapy methods after hip replacement in various postoperative periods.

According to the Ukrainian authors [18], in the early postoperative period (4-7 days after endoprosthesis), patients are prescribed ultra-high

frequency therapy (UHF), amplitude or laser therapy, transverse or longitudinal electrophoresis, general ultraviolet radiation. The efficiency of application of the complex of magnetotherapy and ultra-phonophoresis (UFF) of chondroxide on both pre- and postoperative period at the action on the contralateral joint is substantiated.

Belarusian scientists apply physiotherapy treatment in the early rehabilitation period: electrophoresis of calcium-phosphorus preparations on the hip area, sinusoidal modulated currents (CMC) on the lumbosacral spine, laser therapy on the area of the operated joint5 and the paravertebral joint 1 area of the operated joint, acupuncture [19].

Russian authors recommend that in the early postoperative period, apply ultraviolet irradiation with small erythema doses to the area of postoperative sutures and ultra-high frequency therapy or magnetotherapy to the site of the operated joint for 2-3 days, calcium electrophoresis 12-12 days. After 10-12 weeks after surgery in an outpatient or sanatorium setting, heat therapy (therapeutic muds, paraffin, ozokerite) should be prescribed, with poor tolerability of the mud solution by constant or impulse (sinusoidal modulated currents and diadynamic therapy).

Electromyostimulation of the quadriceps and gluteal muscles of the operated limb is recommended for use by all authors both in the early (4 days) and in the late postoperative periods [20, 21, 22].

Conclusions

1. The program of use of the following measures was developed: medical physical education (the basis of the complexes of medical gymnastics were step-down exercises with visual control and exercises with an elastic band on a healthy leg for balance training); therapeutic massage by Yefimenko method; physiotherapy by standard methods: electromyostimulation; laser therapy.

2. In the experimental group, after the implementation of physical therapy measures under the advanced program, patients' quality of life scores were significantly higher ($p < 0.05$) compared to the control group.

3. The results of the study proved the effectiveness of the impact of physical therapy measures on an improved program on quality of life after hip replacement in the training period.

Prospects for further research are related to the development of an algorithm for physical therapy after hip replacement.

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Conflict of interest

Authors state n o conflict of interest.

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Methods of management and motivation in personnel management of the center of physical therapy and improving the quality of services for patients with orthopedic profile at the outpatient stage

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Abstrakt
Objective: to identify the main approaches in the management and motivation of the staff of the center to improve the effectiveness of physical therapy in orthopedic disorders, to form ways to take these features into account in managing the process of physical therapy. *Methods*: theoretical analysis and generalization of literary sources, method of systematization of scientific information. *Results*. It is advisable to use a fairly wide range of management techniques in the management of staff to provide physical therapy services, since it is about the impact on a rather complex system - the team of physical therapists, which in turn have a controlling influence on the not less complex systems - patients. The use of management methods can potentially contribute to a number of positive changes in the activities of the staff of physical therapists. The additional impact of these methods will be directed at the patient, in particular, in improving the quality of services. The work of a physical therapist is rather debilitating both from the physical side and from the psychological one. Therefore, the motivation of the staff is important in the management of physical therapists, as well as other employees of the Center for the provision of physical therapy services to patients with orthopedic profile. The study of the problem of motivation has a significant theoretical and practical significance, since the most valuable resource in the current conditions of the market of physical therapy services is personnel, not equipment. Therefore, the responsibility of the leader of a successful center for the provision of physical therapy services is that the motivational goals of the employees are largely correlated with the interests of the center and led to the final result to success, which can be characterized as achieving a useful result immediately to all participants in the system " the head is a physical therapist - a patient. " In a team of physical therapy center, as in any enterprise, there are different types of workers, and the choice of one concept of motivation is mainly determined by the majority of employees of a certain type in the team. The paper outlines the features of the selection and use motivational concepts for the staff center physical therapy. The theory of motivation is considered. Economic and non-economic motivational factors are allocated within the framework of the center for providing physical therapy services, the model of motivation of the personnel is given. *Conclusion*. The quality and performance of physical therapists in today's market conditions depends not only on professionalism and competence, but also on management, motivation, satisfaction of their needs and loyalty.
Key words: management, physical therapy, specialist, personnel, consumer, needs, motivation, quality.

Анотація
Вітомський В.В, Лазарєва О.Б., Федоренко С.М., Вітомська М.В. Методи менеджменту та мотивації в управлінні персоналом центру фізичної терапії та підвищенні якості послуг для хворих ортопедичного профілю на амбулаторному етапі.
Мета: визначити основні підходи в управлінні та мотивації персоналу центру для підвищення результативності фізичної терапії при ортопедичних порушеннях, сформувати шляхи врахування цих особливостей у керуванні процесом фізичної терапії. *Методи* дослідження: теоретичний аналіз та узагальнення літературних джерел, метод систематизації наукової інформації. *Результати*. У менеджменті персоналу для надання послуг фізичної терапії доцільно застосовувати досить широкий ряд методів менеджменту, оскільки мова йде про вплив на досить складну систему – колектив фізичних терапевтів, котрі у свою чергу здійснюють керуючий вплив на не менш складні системи – пацієнтів. Використання методів менеджменту потенційно може сприяти виникненню ряду позитивних змін у діяльності колективу фізичних терапевтів. Окрім того додатковий вплив цих методів буде спрямований і на пацієнта, а саме у вигляді підвищення якості послуг. Робота фізичного терапевта є досить виснажливою як з фізичної сторони, так і з психологічної. Тому важливим у менеджменті фізичних терапевтів, а також й інших працівників центру з надання послуг фізичної терапії пацієнтам ортопедичного профілю, є мотивація персоналу. Вивчення проблеми мотивації має вагоме теоретичне і практичне значення, оскільки найбільш цінним ресурсом у сучасних умовах ринку послуг фізичної терапії є персонал, а не устаткування. Тому обов'язок керівника успішного центу з надання послуг з фізичної терапії полягає у тому, щоб мотиваційні цілі працівників у значній мірі співвідносилися з інтересами центру і вели у заключному результаті до успіху, котрий можна охарактеризувати, як досягнення корисного результату відразу у всіх учасників системи «керівник – фізичний терапевт – пацієнт». *Висновок*. Якість та продуктивність роботи фізичних терапевтів у сучасних ринкових умовах залежить не тільки від професіоналізму та компетентності, але і від методів менеджменту, мотивації, задоволеності їх потреб та лояльності.
Ключові слова: управління, фізична терапія, фахівець, персонал, споживач, потреби, мотивація, якість.

Аннотация
Витомский В.В, Лазарева Е.Б., Федоренко С.Н., Витомская М.В. Методы менеджмента и мотивации в управлении персоналом центра физической терапии и повышении качества услуг для больных ортопедического профиля на амбулаторном этапе
Цель: определить основные подходы в управлении и мотивации персонала центра для повышения результативности физической терапии при ортопедических нарушениях, сформировать пути учета этих особенностей в управлении процессом физической терапии. *Методы исследования*: теоретический анализ и обобщение литературных источников, метод систематизации научной информации. *Результаты*. В менеджменте персонала для оказания услуг физической терапии целесообразно применять достаточно широкий ряд методов менеджмента, поскольку речь идет о влиянии на достаточно сложную систему - коллектив физических терапевтов, которые в свою очередь осуществляют управляющее воздействие на не менее сложные системы - пациентов. Использование методов менеджмента потенциально может способствовать возникновению ряда позитивных изменений в деятельности коллектива физических терапевтов. Кроме того дополнительное влияние этих методов будет направлено и на пациента, а именно в виде повышения качества услуг. Работа физического терапевта достаточно изнурительная как с физической стороны, так и с психологической. Поэтому важной составляющей в менеджменте физических терапевтов, а также и других работников центра по предоставлению услуг физической терапии пациентам ортопедического профиля, является мотивация персонала. Изучение проблемы мотивации имеет большое теоретическое и практическое значение, поскольку наиболее ценным ресурсом в современных условиях рынка услуг физической терапии является персонал, а не оборудования. Поэтому обязанность руководителя успешного цента по предоставлению услуг физической терапии заключается в том, чтобы мотивационные цели работников в значительной степени соотносились с интересами центра и вели в заключительном результате к успеху, который можно охарактеризовать, как достижение полезного результата сразу у всех участников системы «руководитель - физический терапевт - пациент». *Вывод*. Качество и производительность работы физических терапевтов в современных рыночных условиях зависит не только от профессионализма и компетентности, но и от методов менеджмента, мотивации, удовлетворенности их потребностей и лояльности.
Ключевые слова: управление, физическая терапия, специалист, персонал, потребитель, потребности, мотивация, качество.

Introduction

The purpose of management in the service sector is to ensure the profitability of the enterprise through the efficient use of human resources and rational organization of service process aimed at identifying and meeting the needs of the population [1, 2, 3].

The tasks of management in the service sector include the following [1, 2]:

- defining goals and identifying ways to achieve them;
- rallying people around common goals;
- organization of processes of development and provision of services;
- ensuring high quality of service;
- continuous training and development of staff;
- ensuring the effectiveness of communication between staff and the client;
- development and application of different ways of evaluating the activity of employees and the enterprise as a whole;
- the creation of their own traditions and the use of experience [1, 2].

The standard sequence of implementation of management functions is in the form of "goal definition" - "planning" - "decision" - "organization" - "motivation" - "control" [4, 5]. At the level of the physical therapy center, the first four functions will largely relate to the development of a business plan and the design of the institution, the creation of a management system. In the future, it is especially important to apply management methods to the function of "motivation" in order to adjust the work of the center and improve the quality of services.

The management of the staff providing physical therapy services plays an important role in improving the level of services provided and, accordingly, in improving the dynamics of the patient's condition.

Most executives recognize the fact that the productivity of staff depends not only on the professionalism and competence of employees, but also on how they relate to the work performed. The high level of satisfaction and loyalty encourages the employees to make more efforts for the qualitative and timely execution of their work, thereby increasing the productivity of the enterprise and contributing to the achievement of its strategic goals. Reducing the level of satisfaction and loyalty of staff on the contrary, slows down the development of the enterprise, reduces the productivity of employees and increases the likelihood of leaving valuable personnel from the organization [6]. Therefore, recognition of the role of methods of management and motivation of the workforce, timeliness of recognizing the first signs of negative changes, implementation of measures to remedy the situation, as well as introduction of a system of monitoring of satisfaction and loyalty of personnel are important in the work of the center for providing physical therapy services. This is the key to continuous growth in the quality of services and management system.

The purpose: to identify the main approaches in the management and motivation of the staff of the center to improve the effectiveness of physical therapy in orthopedic disorders, to form ways to take these features into account in managing the process of physical therapy.

Material and methods

В роботі було використано теоретичний аналіз та узагальнення літературних джерел, метод систематизації наукової інформації. Всього було проаналізовано 26 наукових джерел, на основі яких було визначено основні положення сучасних тенденцій вивчення проблематики з обраного напрямку досліджень.

Results

In management theory, the following features are distinguished for classifying management methods by the direction of influence on a managed object; a way of taking into account the interests of employees; the form of influence; the nature of the influence [2, 7, 8]. In the management of personnel for the provision of physical therapy services, it is advisable to apply a wide range of management methods, since it is an impact on a fairly complex system - a team of physical therapists, which in turn exert a controlling influence on equally complex systems - patients.

Thus, in the direction of influence on a managed object, there are methods of direct influence that directly affect the managed system, and methods of indirect influence that create the conditions for influence on the managed management system [7, 9, 10]. Thus, in the center for the provision of physical therapy services for patients with orthopedic profile, methods of direct impact can be represented by orders, orders, instructions, instructions and protocols of management, regulations, tariffs, and methods of indirect influence are implemented in practice in the selection of the team with different features and subsequent formation the general psychological climate.

The next group of management methods, which is very relevant in the field of physical therapy

services, is formed in a way that takes into account the interests of employees. According to this feature distinguish [7, 8]:

- material impact methods - take into account the property and financial interests of employees;
- methods of power influence - aimed at adjusting and organizing the functions, duties and rights of employees, instructing and normalizing their activities;
- methods of moral influence - aimed at increasing socio-economic activity.

In particular, the methods of material influence are applied in the form of economic incentives, financial responsibility. So in the center for the provision of physical therapy services for patients with orthopedic profile methods of power influence can be represented by staffing, instructions, protocols for the provision of individual services and procedures, orders, orders, reprimands. Methods of moral influence are also of great importance in the work of the center for physical therapy. So they include ethical standards, moral incentives to work with patients.

The form of influence distinguishes quantitative (costing, prices, material incentives, etc.) and qualitative methods (instructions, instructions, moral incentives, methods of selection of the team by psychophysiological factors) [7, 11].

According to the nature of the influence distinguish [4, 7, 12]:

- economic management methods. It is conditioned by various economic factors, by means of which the collective and individual satisfaction of needs at all levels is achieved;
- technological methods of management - floated on employees through the documents that determine the technology, in particular physical therapy for various pathologies of the musculoskeletal system;
- socio-psychological methods of management - a set of specific ways of influencing interpersonal relationships and relationships, social processes that arise in labor collectives. For the successful operation of the organization (the center of physical therapy) in the conditions of market relations, it is first of all necessary to activate the social activity of all workers by increasing initiative, creative purpose, self-discipline. This is achieved through interest management and through interest. Psychological and social management methods are aimed at creating this overall satisfaction.
- administrative (organizational and managerial) methods of management are mostly unambiguous, that is, they exclude variability of tasks and ways of their solution. Organizational influence is based on: organizational regulation, organizational normalization and organizational design.

The use of management methods promotes a number of positive changes in the activity of the team of physical therapists (Fig. 1). In addition, for the physical therapy process, the additional impact of these methods will also be directed to the patient, namely improving the quality of services.

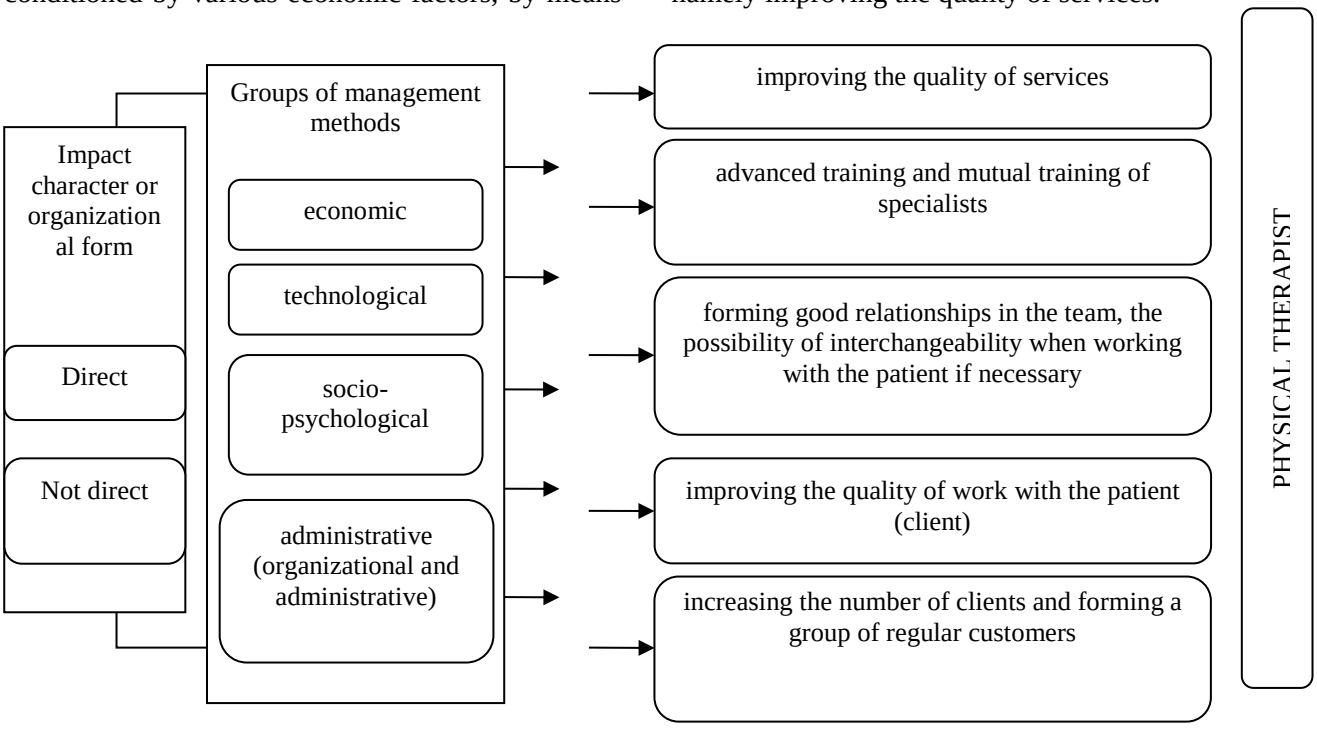

Fig. 1. The influence of management methods on the activity of physical therapist

The work of a physical therapist is quite exhausting, both physically and psychologically. This is due to the need to show exercise to the patient or to exercise at the same time as the patient, the need to assist the patient in load-fixing and resistance adjustment, as well as during, for example, massage procedures, myofascial release. The psychological burden is that working with patients in most cases involves the receipt, perhaps more than necessary, of complaints from the patient about his condition, information about the inability to perform even an easy motor task. Therefore, the motivation of the staff is important in the management of physical therapists, as well as other staff members of the center for providing physical therapy services to orthopedic patients.

On the other hand, the market for physical therapy services is in a state of constant competition. As a result, each specialist's value is increased in achieving the goals of the physical therapy center. An important task for the managerial part is to direct the team towards achieving the goals of the physical therapy center, since both the economic growth in general and the good dynamics of the patient's condition depend on the availability of highly skilled workers and the ability to encourage them to high productivity. In order to increase the efficiency of the employees of the center for the provision of physical therapy services, it is important to work on the motivation of employees, its effective practical application, as well as the improvement of methods. This is the responsibility of the management function of the same name "motivation".

The study of the problem of motivation is of considerable theoretical and practical importance, since the most valuable resource in the current conditions of the market of physical therapy services is staff, not equipment. That is why the staff is one of the most important factors in the progressive development and maximization of income in this field of activity.

The most common motivating factors include wage size, a sense of accomplishment, job advancement, creative and business growth, recognition of work performance and approval of work results, a high level of responsibility, good relationships with colleagues and a supervisor, opportunity or prospect solution of social and household problems. Therefore, the responsibility of a successful center for providing physical therapy services is that employees' motivational goals are closely aligned with the interests of the center and ultimately lead to success, which can be described as achieving beneficial results for all system members at once. - Physical therapist patient.

Motivation is one type of management activity that provides a process of encouraging oneself and other employees to pursue activities that are aimed at achieving personal or organizational goals [13, 14, 15].

The most effective implementation of the motivation function requires an understanding of what drives the employee to perform the work qualitatively. There are a number of concepts to consider: need, reward and motives.

Needs are what arise and are within a person and manifest in an individual form. This is a special state of the individual's psyche, an awareness of their dissatisfaction, a sense of lack of something, a reflection of the discrepancy between the internal state and external conditions. This is something that a person always wants to get rid of (satisfy their needs, muffle or not respond to them). There is a need for both the conscious and the unconscious, and most of them are periodically renewed [4].

Reward is all that a person considers valuable for himself. But the concept of value in people is specific, and therefore a different assessment of the reward and its relative value. A manager deals with two main types of remuneration: internal and external. The internal reward is given by the work itself. For example, this is a sense of achievement, meaningfulness and significance of the work performed, self-respect. External remuneration is given by the organization, for example: salary, promotion, symbols of status and prestige, praise and recognition, and additional payments [8].

The motive is the intrinsic desire of a person to satisfy his needs, which depends on many internal and external factors, as well as on the action of other motives that arise in parallel with this. The motive not only drives the person to act, but also determines what and how to do it. Thus, motive causes actions to eliminate problems, but in different people these actions can be completely different, even if they are caused by one problem. Motives are conscious: a person can influence their motives, suppress their influence, or even eliminate them [4].

The motivational potential of an employee is a component of the labor potential that characterizes the employee's willingness to maximize the work return, development of competitiveness, realization of the acquired knowledge, abilities, abilities and skills in work [14]. The literature presents different theories of motivation and interpretation of types of motivation of staff. Therefore, the basic theories of motivation need to be considered in order to develop the mechanisms of motivation of the employees of the center of physical therapy for patients with orthopedic profile.

The available substantive theories of motivation are based on the study of human needs, which is the main motive for his behavior and activity. They seek to explain that in a person or his or her environment, he or she shapes and supports a particular behavior or course of action. They are an attempt to identify and classify the needs of the people who drive them to act [4].

According to the theory of the hierarchy of needs of Abraham Maslow, the basis of behavior are human needs, which can be divided into primary (physiological, security needs) and secondary (needs for belonging and love, recognition, expression). According to Maslow's theory, all these needs can be arranged in a strict hierarchical sequence in the form of a pyramid, which is based on primary needs and the apex is secondary [13].

The value of the hierarchy of construction lies in the priority for the person of the needs of the lower levels, this affects its motivation [13, 16]. However, in K. Alderfer's theory, the set of human needs is regarded as a continuum - a set of equal, one-tier needs [17].

Based on the orientation of motivation in the subordinates in the theory of Mak-Gregor [4, 13, 14] ("X" and "Y"), two portraits of man, which are opposite to each other, were distinguished. Theory X forms the basis for the management and control of traditional management (through control) when the manager informs the subordinates of their obligations and applies penalties or rewards in the work process. The manager's actions are based on the fact that the person has to work immediately and avoids it whenever possible; most people should be forced to work, control and control them, emphasizing punishment; a person wants to avoid responsibility, does not have strong ambitions, prefers to be managed, and wants, first of all, safety and peace.

Theory "X" thus corresponds to negative motivation and considers only satisfaction of primary (basic) needs, without touching high ones [4].

The opposite theory is "Y" - the basis of so-called "complicity management" (management through motivation). This theory is based on the following assumptions [4, 13, 18, 19]:

- work is a natural process, and ordinary people do not feel hostility to work as much as they do in the process of playing or resting. A person may perceive work as a source of pleasure or punishment depending on working conditions;
- control and the threat of punishment - not the only way to get people to work diligently: when people are involved in organizational goals, they try to work hard, using self-control and self-government. Social needs and the desire to work well outweigh the human motives;
- a person's desire for a certain purpose depends on the reward, and the most important reward is the satisfaction of his self-love and the desire for self-expression;
- in certain conditions, a person is not only ready to take responsibility, but also strives for it. Most people want to use their knowledge and experience, to take responsibility;
- the ability to resourcefulness, imagination, creativity in solving problems of the organization is widespread among employees;
- in modern production, the potential of the average worker is not fully utilized and should be maximally disclosed.

Theory "Y" corresponds to positive motivation, concerns unmet and higher needs. It contributes to reducing the cost of staff control because it is focused on self-control and collaboration [4].

In practice, hired specialists who are represented in the theory of D. McGregor form opposite groups of people and require the use of different motives for behavior and stimulation to work [2, 13], as well as the recruitment of staff to work in a center for the provision of physical therapy services.

Clelland [4, 13, 14] argued that motivation should be based on the needs of achievement, participation, power. The need to achieve is the desire to achieve the goal more effectively than in the past. Employees with this need work a lot and qualitatively, but they do not like to share their work, they want to achieve goals and results personally. The need for participation is manifested in a person in the form of a sense of need for friendly relations with the team and the environment. Employees with this need strive to build and maintain good relationships, have support and a good appreciation for the work they have done on the part of the environment, and they are concerned about them. The desire of the authorities will manifest in the person in the desire to have control over the resources, processes and people in the organization. Such people are divided into two groups: "power for the sake of power" and "power for the sake of achieving the goal of the organization" [2, 9, 13].

This theory in the organization of the management of workers of the center for the provision of physical therapy raises the question of the need to determine the distribution of responsibilities and tasks (should there be one performer or group?), The distribution of power (who should increase the level of power? Also important is the theory of expectation (hope), which is based on

V. Vrum's writings and states that an active need is not the only indispensable condition for motivating an employee to fulfill the chosen goals. A person should hope that his or her type of behavior will actually lead to satisfying the need or getting what is desired. An employee's expectation is similar to an employee's assessment of the likelihood of an event occurring [13, 14, 21]. In the current conditions of market relations, the theory of justice has probably only increased its importance. This theory provides an alternative understanding of how people measure and channel their strength and energy to accomplish their goals and objectives. According to the theory of fairness, employees subjectively calculate the ratio of the remuneration they receive to the effort they spend, and then compare it with the remuneration of other employees who do similar work or spend the same amount of effort.

In the case of imbalance in comparison and injustice, there is a psychological strain. As a result, a situation arises in which, in order to establish fairness, it is necessary to eliminate the existing difference, which is performed by reducing the number of efforts or increasing the remuneration received [13, 21, 22].

There are all types of workers in the staff of the physical therapy services center, as in any enterprise, and the choice of one concept of motivation is the main one determined by the majority of workers of a certain type in the team. However, applying only one concept can lead to a mismatch between management methods and individual employees' motivation, in particular the retention of professionals with work experience and creativity in the physical therapy process. Therefore, the process of selecting and using motivational concepts for the staff of the center of physical therapy is quite complicated and creative (Fig. 2).

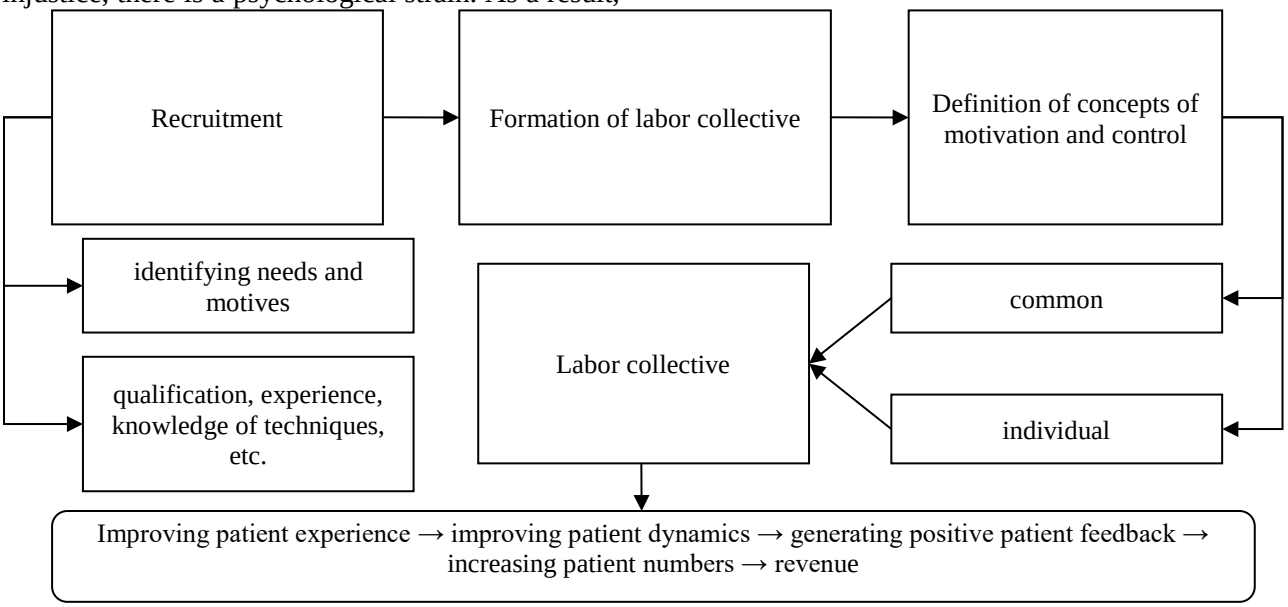

Fig. 2. The scheme of definition and use of motivational concepts in the center for the provision of physical therapy services for patients orthopedic profile

Generally speaking, in the aspect of a physical therapy center, motivation can be seen as a process of encouraging employees to perform effectively in order to achieve the goals of the center by meeting the needs of the center's staff and patients. And the choice of incentives for motivation will depend on the characteristics of specialists and the team as a whole. It should also be noted that motivation should be based on the following requirements [15]:

- providing equal opportunities for employment and job promotion;
- reconciliation of the level of remuneration for its results and recognition of personal contribution to the overall success;
- protection of health of workers;
- possibility of creative realization of the employee;
- maintaining an atmosphere of trust in the team.

In general, the motivational mechanism is a complex of organizational-economic, logistical and socio-psychological tools and methods of stimulating effective work to ensure the achievement of the goal of motivational policy [9, 15]. Considering the theories of motivation considered, the following motivational factors can be identified within the

physical therapy center - economic (Fig. 3) and not economic (Fig. 4). In particular, the following should be included in the economic category: pay, hourly wages, availability of bonuses for performing the largest number of procedures or over-fulfillment of the plan, payment for training, additional payments for absence of absenteeism for work, purchase of a course of rehabilitation services by the client, or active participation in shaping the patient's wish to switch to prevention and wellness use of physical therapy classes after meeting the goals set previously, preferential use of the center's equipment for workers and possibly their families ents expansion in load center. The need to develop and regulate these incentives is further emphasized by the following theories of motivation.

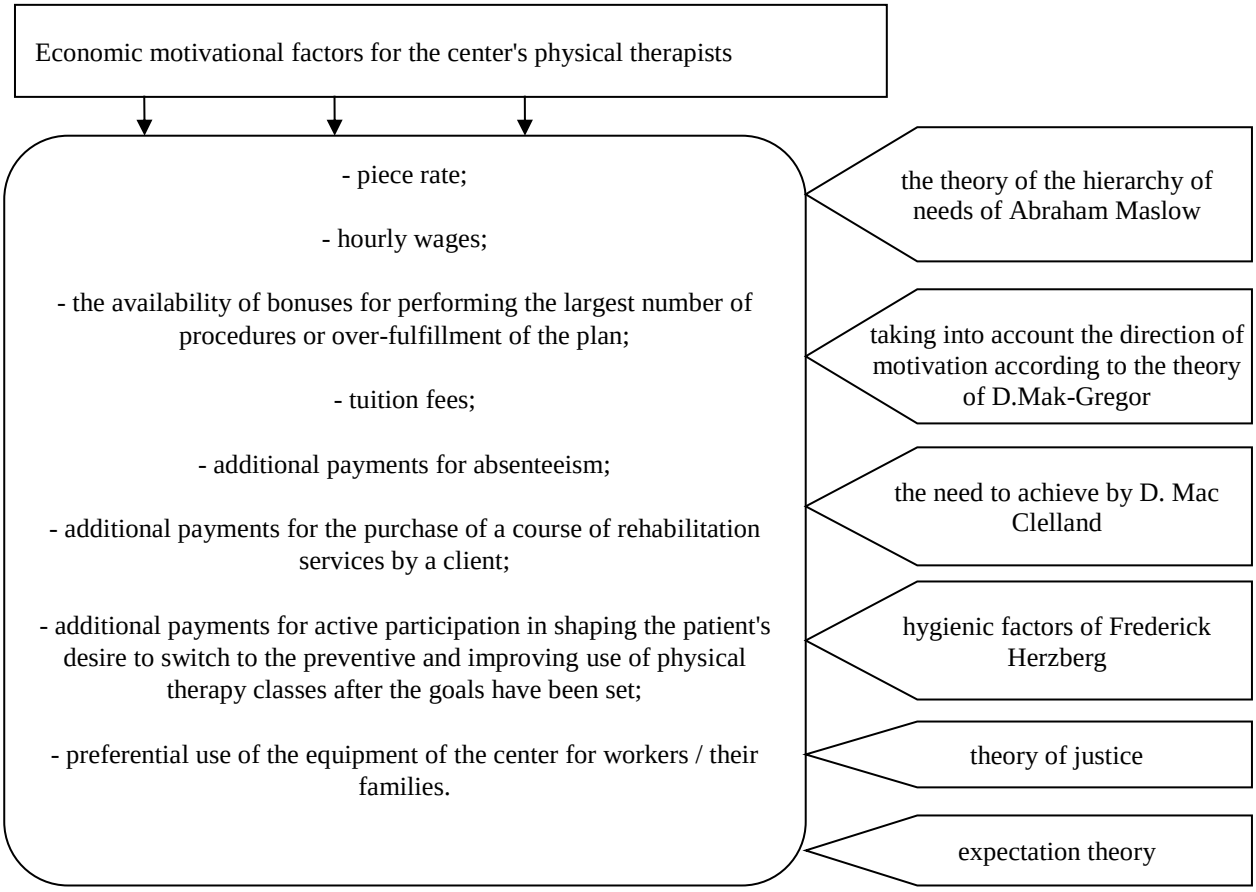

Fig. 3. Economic motivational factors for specialists of the center of physical therapy

We emphasize that an incentive (a motivating factor) becomes a motive only when it is realized by the person perceived by it. For example, for an incentive to motivate the behavior and activity of a particular employee, it is necessary that he or she be aware of it as a fair remuneration for the work. Then trying to earn a premium will help increase labor efficiency. However, for some employees who do not expect to receive a reward (low professional training, indiscipline, etc.), this possible reward does not translate into a motive, remaining at the level of potential incentive [14].

Non-economic measures include job enrichment, promotion, formulation of a convenient or flexible work schedule, a sense of accomplishment among employees (for example, on the basis of recognition of the patient's work efficiency and approval of work results), availability of self-improvement opportunities, availability of a high-level provision. responsibility for the patient's health, participation in decision-making regarding the content of the physical therapy program and decisions at the center level.

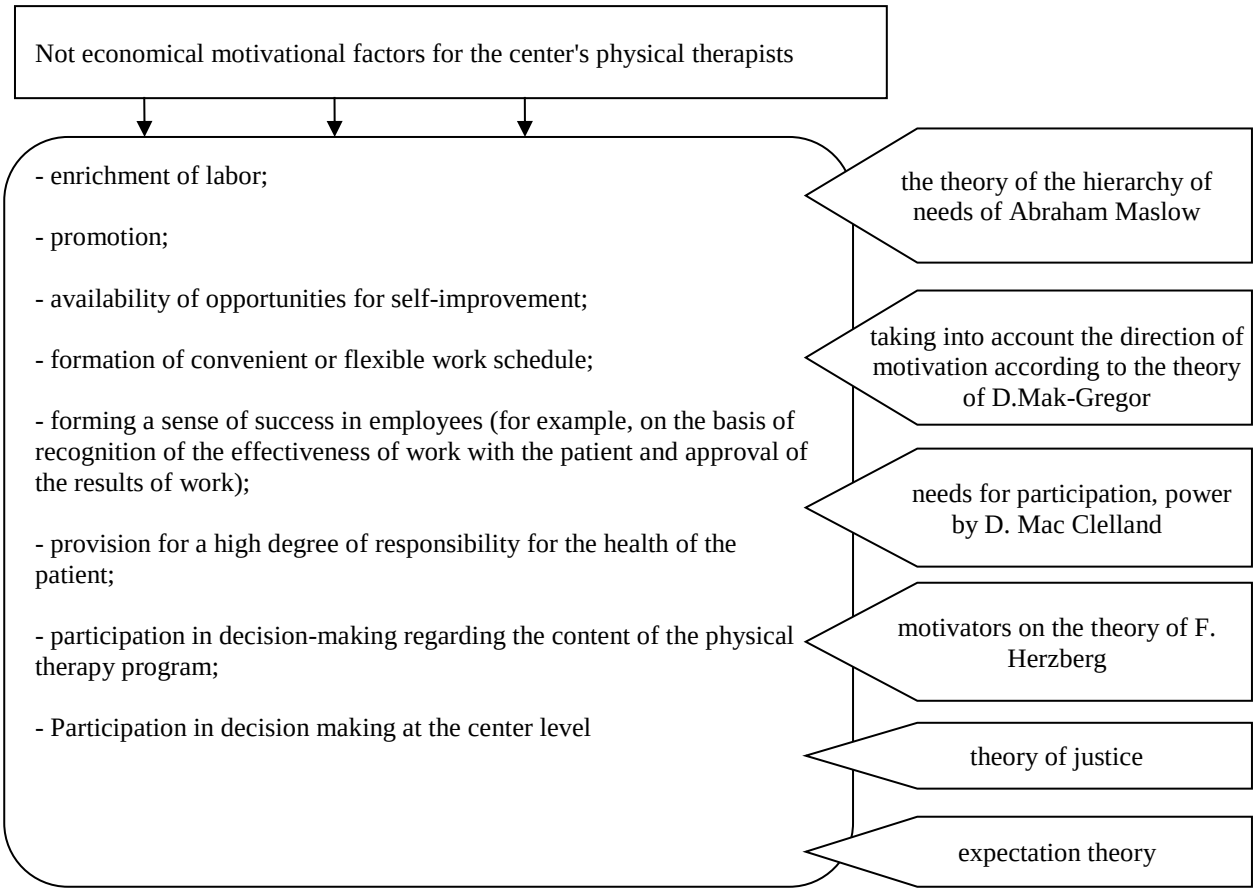

Fig. 4. Non-economic motivational factors for specialists of the center of physical therapy

Discussion

Note that the theory of enrichment of labor recommends to ensure that each worker has at least 6 factors, the courts together provide its attractiveness:

• responsibility for productivity;

• awareness of the importance and necessity of the work being done;

• possibility of independent allocation of resources in the process of work, control over resources;

• availability of feedback, possibility to receive information on the results of work;

• the possibility of professional growth, gaining new experience, advanced training (work should not be monotonous);

• the possibility of an employee's influence on working conditions [11, 12, 23].

Formulating a high level of responsibility for a patient's health is first and foremost an equivalence of the role of the physician and the physical therapist at the institution level, their survey results, the role in the development of the physical therapy program, and sometimes with regard to rehabilitation issues in general.

Thus, these measures eliminate the state of organization of work when the doctor examines and provides a fairly standard, rather than individualized, set of exercises for the patient, and the physical therapist performs only mechanical work. In addition, such activities also play a role in enriching the work of physical therapists. The role of the doctor diminishes in the aspect of selection of physical exercises, remains necessary in matters of making a team decision on contraindications, dosing of load.

Forming a sense of accomplishment and meeting the needs of self-improvement in employees is possible at the expense of:

- participation in conferences;
- continuous training;
- objective comparison of previous work with the past;
- recognition of even small achievements in the work of specialists (introduction of new physical exercises in protocol complexes; high assessment of patient's work results and his satisfaction);
- introduction along with material rewards and non-material ones (for example, honors, certificates, diploma, photo on the plaque of honor, the title of "employee of the month"; measures should be formed also taking into account the psychology of

personality, the collective, since for some people sincere gratitude from the manager may be more important than money).

The implementation of a number of economic and non-economic motivating factors is possible during collective meetings. In particular, it is correct to emphasize at the meeting the successful resolution of the tasks of a physical therapy program by a certain physical therapist, mastering a new method or technique of intervention by a physical therapist, availability of innovations from an employee or group, identifying colleagues' views on tactics for complex patient or administrative decisions.

Also important are peer learning meetings, which can be delivered in the form of lectures with presentations, hands-on workshops, with further discussion of key and unclear issues.

Thus, according to the results of the literature analysis [24, 25, 26], the model of the personnel motivation system can be represented as a sequence of actions (Fig. 5).

It should be noted that the use of both economic and non-economic motivational factors, incentives contributes to an increase in the wealth of motivation of the staff (diversity of motives as a result of the diversity of needs relevant to the employee, which induces him to work) [14].

This is the result of open interaction when an environmental subject (such as a manager) gives rise to motives that induce a person to act.

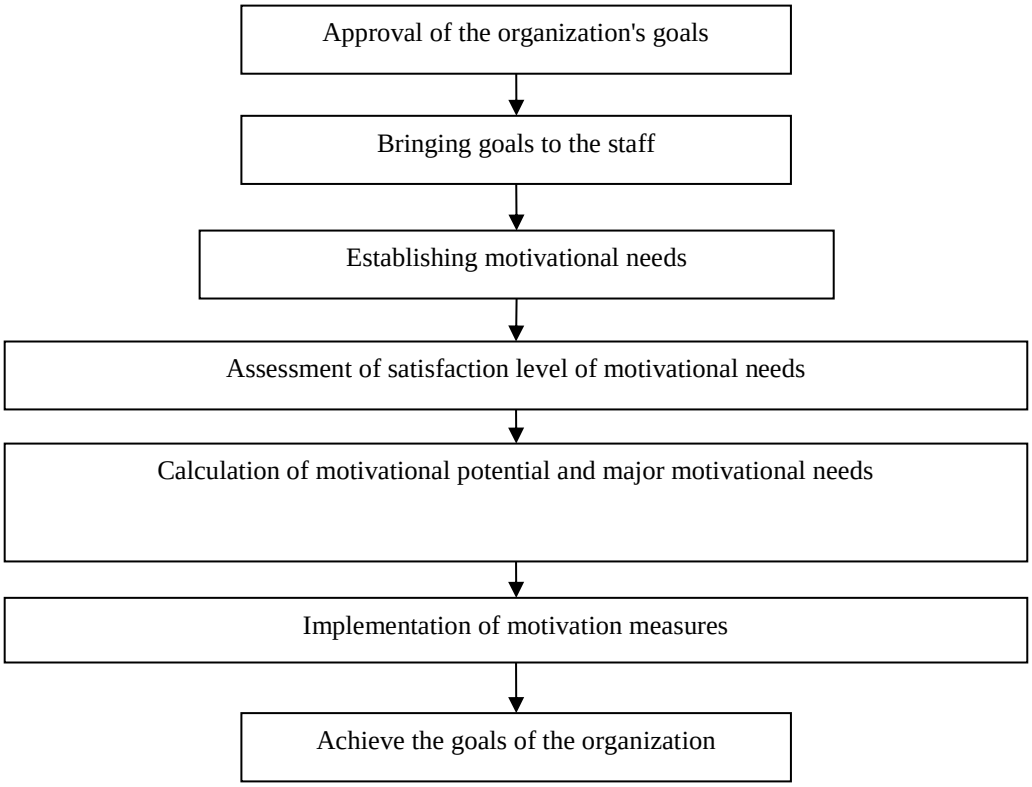

Fig. 5. Model of staff motivation

Conclusions

The quality and productivity of physical therapists in today's market conditions depends not only on professionalism and competence, but also on the level of satisfaction of their needs and loyalty. In addition, the work of a physical therapist is quite exhausting, both physically and psychologically. Therefore, the motivation of the staff is important in the management of physical therapists, as well as other staff members of the center for providing physical therapy services to orthopedic patients. The study of the problem of motivation is of considerable theoretical and practical importance, since the most valuable resource in the current conditions of the market of physical therapy services is staff, not equipment. The application of management methods and concepts of motivation can contribute to a number of positive changes in the activities of the team of physical therapists, which will reflect on the quality of services, the dynamics of the patient's

condition and the achievement of the goals of the physical therapy program.

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Conflict of interest

The authors state no conflict of interest.

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Influence of lower leg myofascial kinematic chains on flat feet development of children 7-14 years old

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Abstract
The aim of the work is to study the biomechanical properties of the myo-fascial kinematic chain "foot-shin" of children of 7-14 years old with non-fixed and clinically expressed flat-footedness.
Material and methods. The study involved 14 children with flat-footedness of grades I-II and 6 children with flat-foot deformity of the foot and 20 children who only had functional disorders of the foot. An anthropometric study of the foot was carried out, electrophysiological indicators of the muscles of the leg were determined, and plantograms were analyzed.
Results. The study found a correlation between the indicators of the anatomical and functional state of the foot and the imbalance of the frequency-amplitude indices of the ipsi and contralateral muscles within one link of the myofacial kinematic chain, may be important as one of the factors that contribute to the development of flatfoot. This is confirmed by other indicators and indicate a decrease in the height of the longitudinal arch, a decrease in the metatarsal and heel angles of the arch of the foot. Such changes have a pronounced relationship with age. The results of the work indicate that a possible cause of flattening of the vaulted apparatus of the foot is not only the weakness of its joint-ligament-muscular system, but also above the located kinematic segment - the tibia. The correlation analysis revealed the relationship between the indicators of the development of the anatomical and biomechanical components of the foot and the characteristics of the electromyographic indicators of the muscles of the leg in children 7-14 years old. As a result of a comprehensive study, it was found that during this period of ontogenesis in the formation of flatfoot such electromyographic indicators as frequency-amplitude characteristics of action potentials of motor units of the long and posterior tibial muscles, as well as their tone imbalance, take on major importance.
Conclutions. Experimental studies have established that the registered changes in the articular components of the foot of children 7-14 years old lead to a change in the electromyographic parameters of the muscles of the leg, which are involved in the formation of the initial sections of myo-fascial kinematic chains.
Key words: foot, electromyography, plantography, children of school age.

Анотація
Данищук А.Т. Вплив міо-фасціальних кінематичних ланцюгів гомілки на розвиток плоскостопості у дітей 7-14 років
Мета роботи – вивчити біомеханічні властивості міо-фасціального кінематичного ланцюга "стопа-гомілка" дітей 7-14 років з нефіксованою і клінічно вираженою плоскостопістю.
Матеріал і методи. У дослідженнях взяли участь 14 дітей, що мають плоскостопість I-II ступеня важкості і 6 дітей з плосковальгусною деформацією стопи і 20 дітей, у яких виявлені тільки функціональні порушення стопи. Проведено антропометричне стопи, визначали електрофізіологічні показники м'язів гомілки, аналізували плантограми. **Результати.** У дослідженні виявлений кореляційний взаємозв'язок між показниками анатомо-функціонального стану стопи і дисбалансом частотно-амплітудних показників іпсі- і контрлатеральних м'язів в межах однієї міо-фаціальної кінематичної ланки, що може мати значення як один з факторів, який сприяє розвитку плоскостопості. Це підтверджується іншими показниками, що свідчать про зниження висоти поздовжнього склепіння, зменшенням плеснового і п'яткового кутів склепіння стопи. Такі зміни мають яскраво виражений взаємозв'язок з віком. Результати роботи вказують, що можливою причиною сплощення склепінчастого апарату стопи є не тільки слабкість її суглобово-зв'язково-м'язового апарату, але й вище розташованого кінематичного сегменту – гомілки. Проведений кореляційний аналіз виявив залежність між показниками розвитку анатомо-біомеханічних компонентів стопи та особливостями електроміографічних показників м'язів гомілки у дітей 7-14 років.
Висновки. Експериментальними дослідженнями встановлено, що зареєстровані зміни суглобових компонентів стопи дітей 7-14 років призводять до зміни електроміографічних показників м'язів гомілки, які приймають участь у формуванні початкових ділянок міо-фасціальних кінематичних ланцюгів.
Ключові слова: стопа, електроміографія, плантографія, діти шкільного віку.

Аннотация
Данищук А.Т. Влияние мио-фасциальных кинематических цепей голени на развитие плоскостопия у детей 7-14 лет
Цель работы – изучить биомеханические свойства мио-фасциальной кинематической цепи "стопа-голень" детей 7-14 лет с нефиксированной и клинически выраженным плоскостопием.
Материал и методы. В исследованиях приняли участие 14 детей, имеющих плоскостопие I-II степени тяжести и 6 детей с плосковальгусною деформацией стопы и 20 детей, у которых обнаружены только функциональные нарушения стопы. Проведено антропометрическое исследование стопы, определяли электрофизиологические показатели мышц голени, анализировали плантограммы.
Результаты. В исследовании обнаружена корреляционная взаимосвязь между показателями анатомо-функционального состояния стопы и дисбалансом частотно-амплитудных показателей ипси- и контрлатеральных мышц в пределах одного звена мио-фациальной кинематической цепи, может иметь значение как один из факторов, который способствует развитию плоскостопия. Это подтверждается другими показателями и свидетельствуют о снижении высоты продольного свода, уменьшением плюсневого и пяточного углов свода стопы. Такие изменения имеют ярко выраженную взаимосвязь с возрастом. Результаты работы указывают, что возможной причиной уплощения сводчатого аппарата стопы является не только слабость ее суставно-связочно-мышечного аппарата, но и выше расположенного кинематического сегмента - голени. Проведенный корреляционный анализ выявил зависимость между показателями развития анатомо-биомеханических компонентов стопы и особенностями электромиографических показателей мышц голени у детей 7-14 лет.
Выводы. Экспериментальными исследованиями установлено, что зарегистрированные изменения суставных компонентов стопы детей 7-14 лет приводят к изменению электромиографических показателей мышц голени, которые принимают участие в формировании начальных участков мио-фасциальных кинематических цепей.
Ключевые слова: стопа, электромиография, плантография, дети школьного возраста.

Introduction

The first place among the pathologies of the lower extremities in children is occupied not by the flat foot itself, but by various functional disorders of the foot, the frequency of which, according to a number of authors [1, 2], ranges from 35.1 to 63.8%. Many researchers have found that non-fixed foot disorders or mobile flat feet over time can lead to serious changes throughout the body and cause flat feet and flat feet, as a separate nosological unit [3].

First of all, flat feet and flat-footed foot are characterized by pronounced deformation of the foot, which is manifested in a decrease in the height of the longitudinal arch, combined with pronation of the heel and supination contracture of the anterior foot [4]. Violations of the support-depreciation function of the foot in children 7-12, it is very difficult to detect because these changes are hidden and do not cause pain for some time. At the same time, a slight aching or mild character remains only a subjective feature, which is often left unattended by parents [5].

One of the reasons for the flattening of the longitudinal arch of the foot is the weakness of the musculoskeletal system, not only the foot itself, but also the muscles of the shin [6]. Together, they form the first link in the so-called myo-fascial kinematic chains (IFLC). The theory of their existence and decisive role in the biomechanics of the human body has recently become widespread relevance and is the subject of much attention, especially in the preparation of physical therapists [7].

Experimental studies [8] found that in violation of the vaulted apparatus of the foot in parallel there is a decrease in the depreciation properties of the lower extremity and impaired spinal function of the spine. This is due to the biomechanical features of the foot-spine kinematic pair, as one of the three existing elastic segments of the human body (the third element is myo-fascial kinematic chains [7]). Each of them provides mechanical shock absorption in at least two mutually perpendicular planes [9]. The importance of correct and consistent, in space and time, the functioning of these three elements of the musculoskeletal system is difficult to overestimate, since the violation of at least one of them on the one hand causes a direct proportional exhaustion of the reserve capacity of the other two, and on the other - is the cause of pathology above and below the kinematic links of the human body. Therefore, it is very important to study the first components of the myo-fascial kinematic chains (in our case, these are the tibia muscles), the development of which will largely depend on the condition of the vaulted foot apparatus [8].

The above was the basis for an in-depth study of the biomechanical properties of the skeletal muscles of the tibia of children of all ages who have I-II degree of flat feet or flat-mouth deformity of the foot compared with children who have only found functional changes in the foot, which are located in SA.

The aim of the study is to study the biomechanical properties of myo-fascial kinematic chain of the foot-tibia of children 7-14 years with unfixed and clinically pronounced flat feet.

Material and methods

The analysis and theoretical generalization of the specialized scientific literature, pedagogical observation, anthropometry [10], electromyography, video computer foot analysis, statistical data processing ("Statistics 6") have been carried out.

Electromigraphy was performed using the Neuro-EMG-Micro computer-based electromyrographic complex manufactured by Neurosoft (Russia). The muscles involved in the lateral (long tibia) and dorsal (posterior tibia) of the myo-fascial kinematic chains of the right and left tibia were examined.

Video-computer analysis was performed with the help of the system for determining the functional state of the locomotor system "DIERS FAMUS" (Germany), which allowed to perform quantitative analysis of the planograms of the foot in static position and dynamic load during walking (Fig. 1). The study involved 14 children with flat feet I-II severity and 6 children with flat-foot deformity of the foot (experimental group 1) and 20 children with functional disorders of the foot (experimental group 2).

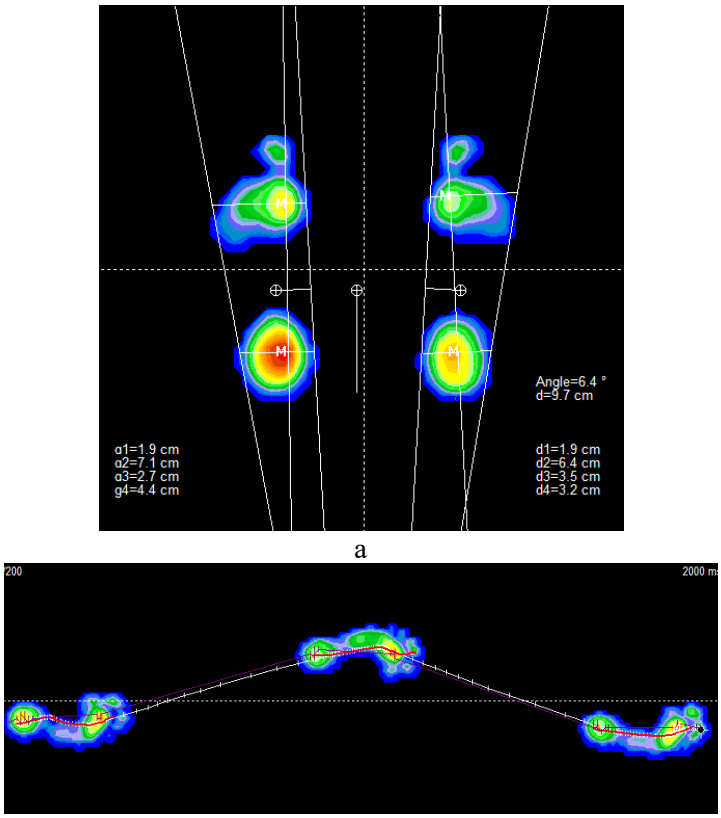


Fig. 1. General view of the computer planogram analysis page in static (a) and dynamic (b) planograms using DIERS FAMUS (Germany)

All children are engaged in the Taekwon-to-Ivano-Frankivsk section for 2-7 years. In the images of the foot in different planes, using the ImageJ program (USA), in addition to the linear dimensions, the angular characteristics of the CAC were measured: the mold angle α (characterizing the spring properties of the foot associated with the retention of the active components of the muscles) and the heel angle β (characterizes the spring properties associated with the passive components, due to the peculiarities of bone junction and the ligamentous apparatus of the foot).

Results

As a result of comparative examination, it was found that the children of the first experimental group had statistically significant differences ($p < 0.05$) in height of the vaulted apparatus of the foot (Fig. 1).

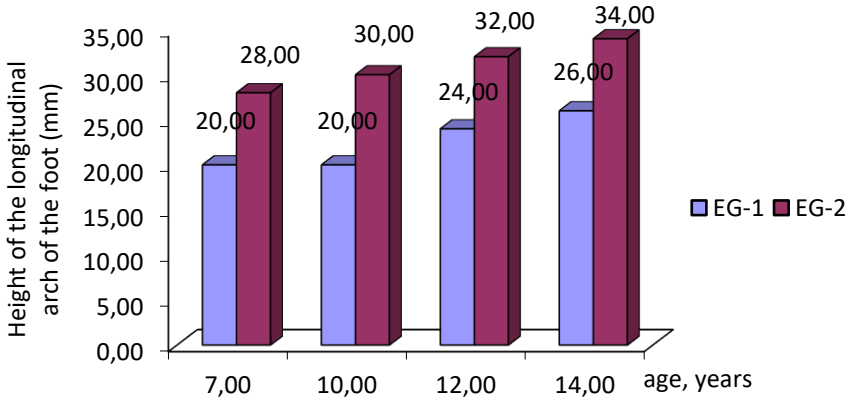


Fig. 1. The height of the longitudinal arch of the foot in children with fixed flat feet and flat feet of the I-II degree at the age of 7-14 years:
EG-1 is experimental group 1
EG-2 is experimental group 2

The analysis of the results showed that the decrease in the musculoskeletal properties of the feet of schoolchildren is accompanied by a decrease in the performance of the motor units of the muscles under study according to electromigraphy. Against this background, the asymmetry of muscle tone, which belongs to one myo-fascial kinematic chain, is revealed. This was reflected in the higher values of the frequency-amplitude characteristics of the action potentials of the motor units of the long tibial muscle and the decrease in the electromigraphic indices of the posterior tibial muscle (Fig. 2).

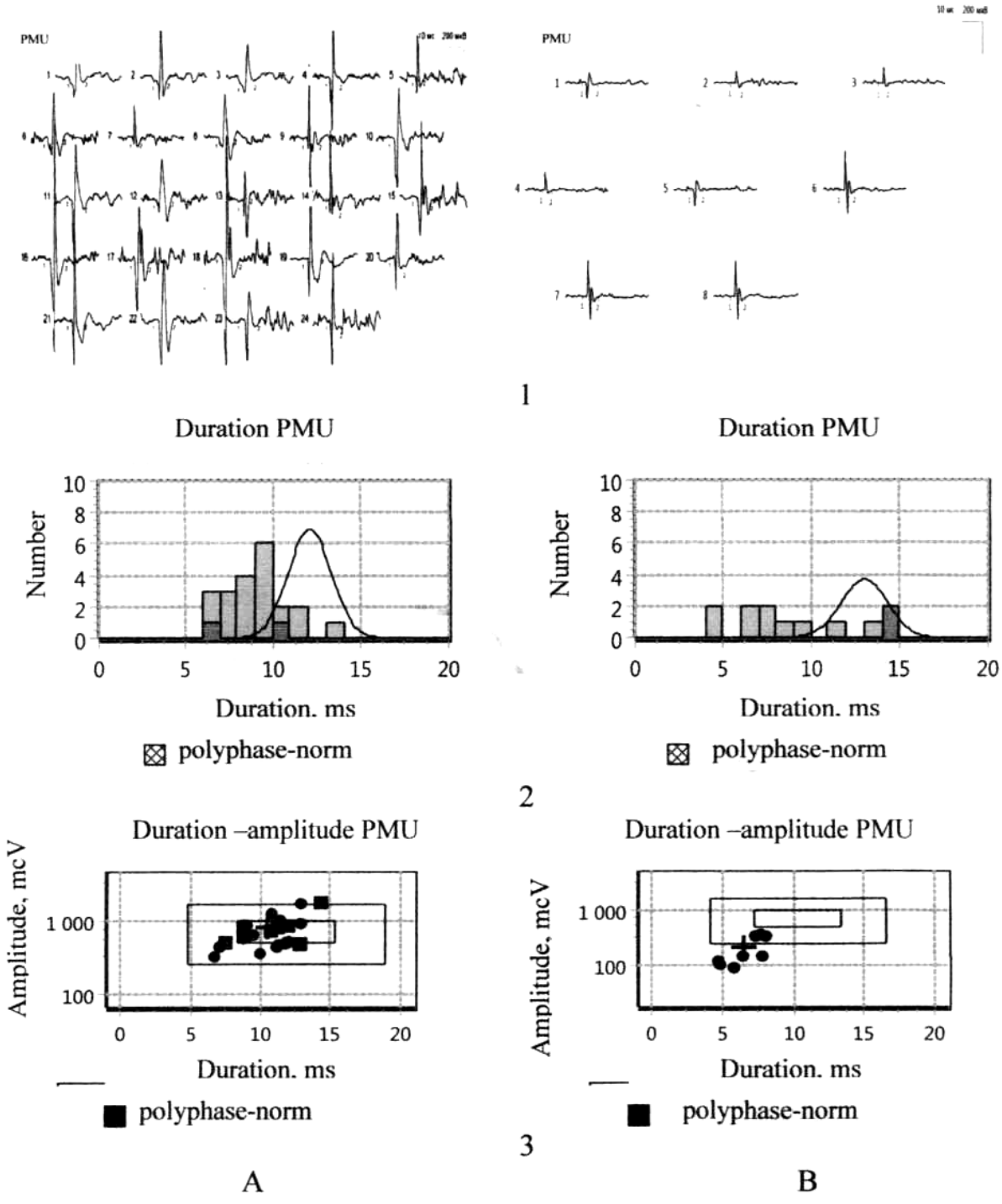
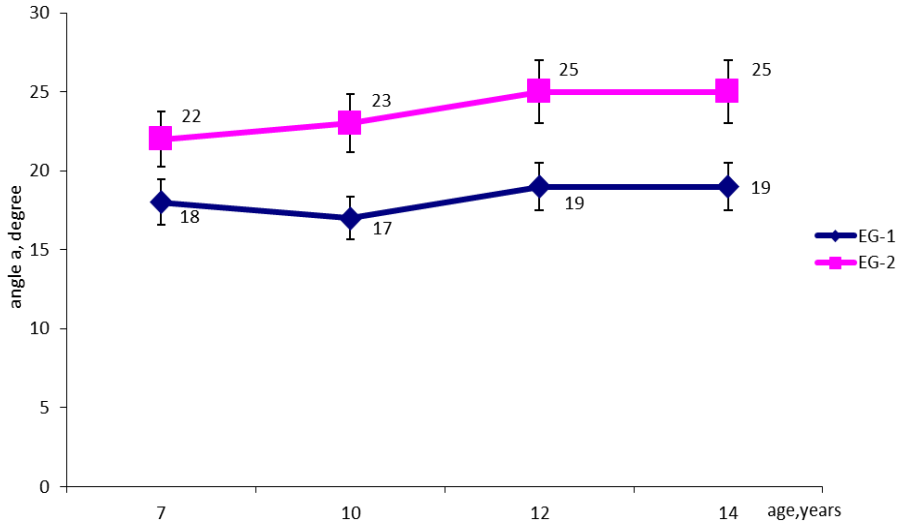
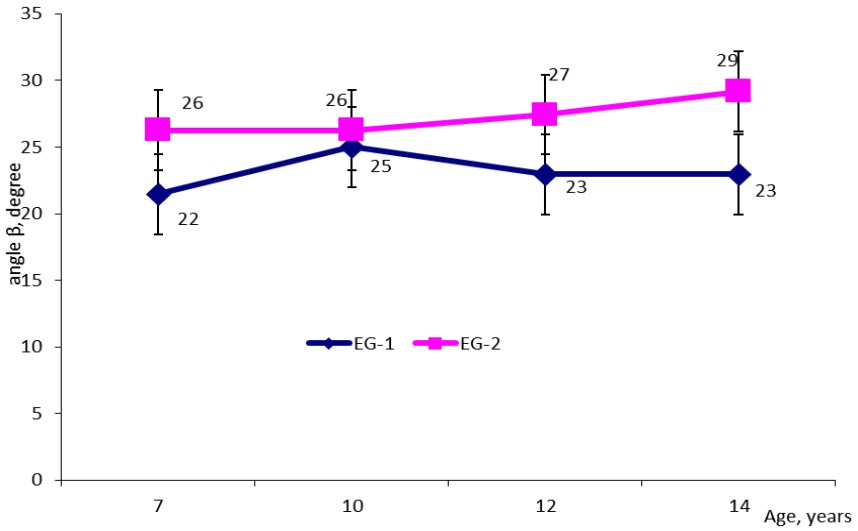


Fig. 2. Qualitative (1) and quantitative (2, 3) electromyographic indexes of the long tibial muscle (A) and posterior tibial muscle (B) in a 10-year-old child with flat-footed I-II severity

Significant differences were observed when comparing the angular characteristics of the foot. In all children, experimental group-1 mean mold angle was 1.1-1.5 ° less than in experimental group 2 (Fig. 3).



a



b

Fig. 3. The magnitude of the angle α (a) and the angle β (b) in children with unfixed flat feet (EG-2) and flat feet I-II severity (EG-1), depending on age:
EG-1 is experimental group 1
EG-2 is experimental group 2

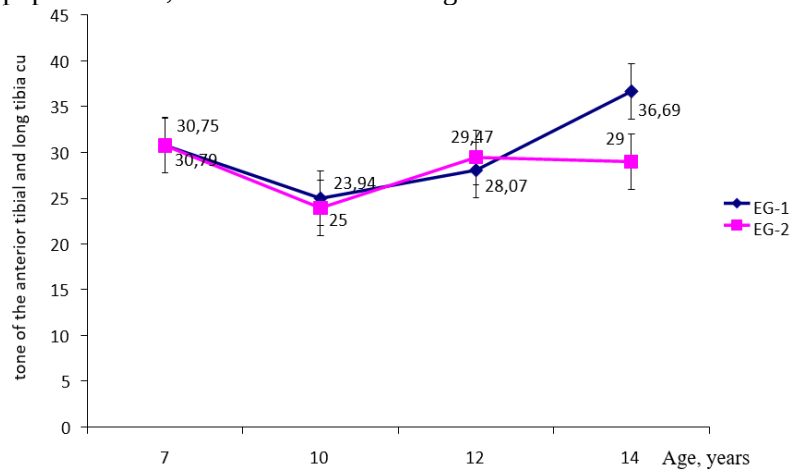
Changing the height of the vaulting device of the foot as the age of children in both groups, as a rule, is accompanied by a significant increase in the tone of the long tibial muscle by an average of 4.0% and the anterior tibial muscle - by 6.8% per year, which is manifested first of all, by increasing the amplitude of the action potential of the motor unit (Fig. 3). The dynamics of change in tone of the studied muscles of the lower extremities is wavy. The greatest increase in the tone of the muscles under investigation is from 7 to 8 years and from 10 to 12 years.

As a result of correlation analysis it is established that the index of the height of the arch of the foot has a certain relationship with the linear dimensions of the foot itself and the geometry of its articular formations: the length of the foot ($r = 0,58$, $p < 0,05$), the length of the supporting part of the arch of the foot ($r = 0.56$, $p < 0.05$), the height of the arch of the foot ($r = 0.75$, $p < 0.05$), the height of the rise of the foot ($r = 0.83$, $p < 0.05$), as well as the value of the metatarsus ($r = 0.80$, $p < 0.05$) and heel ($r = 0.84$, $p < 0.05$) angles.

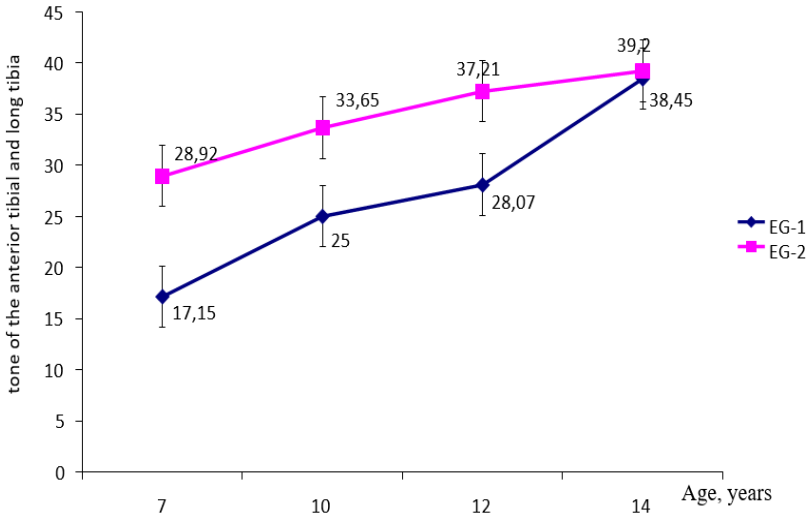
Discussion

Features of biomechanics of the foot, which is the most important link in the general myo-fascial kinematic chains, largely determine the biomechanics of movements of the lower extremities, spine and human body as a whole [11, 12, 13].

One of the main features of this fairly sophisticated design is that the cushioning ability of the foot, contrary to popular belief, is determined not so much by tendons and ligaments, but by the dynamic performance of a large group of foot and leg muscles [3, 14, 15] . However, according to many authors [5, 16, 17], the most effective correction of flatfoot is possible only at the age of 12 years, since by this age the vaulted apparatus of the foot is finally formed. Therefore, in our study, we chose the age range of children under 14 to test the effectiveness of physical therapy after 12 years and to identify or deny their effectiveness at that age.



A



B

Fig. 4. Indices of anterior tibial and long tibial muscle tone of children 7-14 years: A - children with flat-foot deformity of the foot; B - children with not fixed flat feet:
EG-1 is experimental group 1
EG-2 is experimental group 2

To date, the causes and mechanisms of development (etiopathogenesis) of flat foot and flat foot in children have not been sufficiently studied [2]. There are many theories about the occurrence of this pathology, each of which has the right to exist. However, the only theoretical basis characterizing these stato-dynamic disturbances has not yet been formed [11, 18, 19].

Therefore, we propose our own vision of this problem, which is based on a theoretical and practical basis on the unity of anatomic-biomechanical factors, which is clearly presented in the theory of myo-fascial kinematic chains. According to this theory [7, 20, 21], all groups of the leg muscles and their own muscles of the foot are involved in the formation and retention of the vaulted apparatus of the foot [2].

Together they represent the first link of myo-fascial kinematic chains. Prevents valgus (deviation of the foot outward) deformation of the foot, mainly the posterior group of the leg muscles. Conversely, the lateral group of the tibiae muscle raises the lateral edge of the foot (pronation), while participating in the formation of flat-valvular (combination of valgus and flatfoot) deformity of the foot [4]. Therefore, in our work we investigated the EMG activity of the muscles of these two groups. The revealed asymmetry of the amplitude-frequency characteristics of these muscles in DG-1 children confirms the opinion of some authors [1, 3, 6], about the significant role of the initial links of IFLC in the formation of the correct SAS. On the other hand, he argues that the lag in their development (primarily power characteristics) against the background of the tonic imbalance of these muscle groups plays the function of a trigger factor for the development of flat foot and flat-foot deformity of the foot. This approach will allow you to review the views on the treatment and prevention regimens of such foot defects and to apply non-traditional physical exercises for the development of power, while restoring the symmetry of muscle tone in the ipsi and contralateral structures of one myo-fascial kinematic chain. Such exercises can be a training complex and taekwon-do, which has movements that simultaneously develop the flexibility, coordination and strength of the muscles of the lower extremity.

The quantitative changes we found in the anthropometric parameters of the vaulted apparatus of the foot indicate a significant difference, especially in relation to the height of the arch and its angular characteristics, between children with severe pathology and functional disorders of the foot. Therefore, they should be used to monitor the effectiveness of physical therapy, as they objectively reflect the real condition of the osteoarticular component of the vault of the foot.

In addition, we also found age dependence between changes in various indicators, indicating a greater sensitivity of the vaulting device of the foot in 7-8 years, compared with older age. This is probably due to the fact that, at a younger school age, his reserve capacity is determined more by a ligament than by a muscular element [2, 6]. Then, as the latter naturally develops at an older age. It is this pattern that explains the presence of a large group of surveyed children with functional disorders of the foot and substantiates the need for early development of reserve capabilities to prevent the development of flat feet.

Conclusions

1. The analysis of the scientific literature shows that with age, the percentage of cases of violation of the vaulting apparatus of the foot of different types decreases: from 53.7 to 72.9% - in boys 7-9 years, from 46.2 to 59.1% - in 10-12 years and from 40,1 to 55,3% - 13-14 years. The possible reason for flattening of the foot vault is not only the weakness of its articular-ligamentous-muscular apparatus, but also the tibia above the kinematic segment.

2. The correlation analysis revealed a correlation between the development of the anatomic-biomechanical components of the foot and the features of the electromyographic parameters of the tibia muscles in children 7-14 years. As a result of a comprehensive study it was found that during this period of ontogeny in the formation of flatness of the leading value such electromyographic parameters as the frequency-amplitude characteristics of the action potentials of the motor units of the long tibial ($r = 0.87$, $p < 0.05$) and posterior tibial ($r = 0.81$, $p < 0.05$), as well as imbalance in their tone.

3. Experimental studies have found that recorded changes in the joint components of the foot of children 7-14 years lead to changes in the electromyographic parameters of the tibia muscles, which are involved in the formation of the initial sections of the myo-fascial kinematic chains.

The prospects of further research should be directed to the study of other problems of the influence of myo-fascial kinematic chains on the biomechanical properties of the foot and their role in forming conditions for the development of flat feet and other deformities of the foot.

Conflict of interest

Authors declare that there is no conflict of interest.

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Identify patterns of individual dynamics of competitive performance of athletes as a basis for predicting results (qualified basketball players for example)

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Abstract
The aim of the work wos to develop an algorithm and determine the patterns of the individual dynamics of the competitive performance of qualified basketball players.
Material and methods. The study involved the players of the main composition of the men's basketball team of Ukraine. It was analyzed 12 games of the national team of Ukraine in games with equal rivals - teams of other countries. The research was conducted from June 2018 to September 2018. Technical logging of games, which was carried out using a modified formula of Yu.M. Portnov. Mathematical modeling was used to describe the patterns of individual dynamics of competitive performance using sinusoidal regression models.
Results. The process of changing competitive performance should be considered in terms of oscillatory processes. The most acceptable function to describe this pattern is the sinusoidal function. The regression model of the individual dynamics of the effectiveness of competitive activity of the players of the Ukrainian basketball national team obeys a sinusoidal relationship, which is described by the sinusoidal regression equation.
Conclusions. The data obtained may be useful for predicting the individual game performance of athletes, determining the individual characteristics of players and adjusting training programs.
Keywords: basketball; dynamics; game; effectiveness; function; sinewave; individualization

Анотація
Козіна Ж.Л., Гущин С.А., Сафронов Д.В., Храпов С.Б., Васильєв Ю.К. Виявлення закономірностей індивідуальної динаміки змагальної результативності спортсменів як основа для прогнозування результатів (на прикладі кваліфікованих баскетболістів)
Мета роботи - розробити алгоритм і визначити закономірності індивідуальної динаміки змагальної результативності кваліфікованих баскетболістів.
Матеріал і методи. У дослідженні взяли участь гравці основного складу молодіжної чоловічої збірної команди України з баскетболу. Було проаналізовано 12 ігор збірної команди України в іграх з рівними суперниками - збірними командами інших країн. Дослідження проводилося в період з червня 2018 року по вересень 2018 року. Технічне протоколювання ігор, яке проводилося за модифікованою формулою Ю.М. Портнова. Застосовувалося математичне моделювання для опису закономірностей індивідуальної динаміки змагальної результативності за допомогою синусоїдальних регресійних моделей.
Результати. Процес зміни змагальної результативності доцільно розглядати з точки зору коливальних процесів. Найбільш прийнятною функцією для опису даної закономірності є синусоїдальна функція. Регресійна модель індивідуальної динаміки ефективності змагальної діяльності гравців збірної команди України з баскетболу підпорядковується синусоїдальної залежності, яка описується сінусоідальним рівнянням регресії.
Висновки. Отримані дані можуть бути корисні для прогнозування індивідуальної ігрової результативності спортсменів, визначення індивідуальних особливостей гравців і коректування тренувальних програм.
Ключові слова: баскетбол; динаміка; гра; результативність; функція; синусоїда; індивідуалізація

Аннотация
Козина Ж.Л., Гущин С.А., Сафронов Д.В., Храпов С.Б., Васильев Ю.К. Выявление закономерностей индивидуальной динамики соревновательной результативности спортсменов как основа для прогнозирования результатов (на примере квалифицированных баскетболистов)
Цель работы – разработать алгоритм и определить закономерности индивидуальной динамики соревновательной результативности квалифицированных баскетболистов.
Материал и методы. В исследовании приняли участие игроки основного состава молодежной мужской сборной команды Украины по баскетболу. Было проанализировано 12 игр сборной команды Украины в играх с равными соперниками - сборными командами других стран. Исследования проводилось в период с июня 2018 года по сентябрь 2018 года. Техническое протоколирование игр, которое проводилось по модифицированной формуле Ю.М. Портнова. Применялось математическое моделирование для описания закономерностей индивидуальной динамики соревновательной результативности с помощью синусоидальных регрессионных моделей.
Результаты. Процесс изменения соревновательной результативности целесообразно рассматривать с точки зрения колебательных процессов. Наиболее приемлемой функцией для описания данной закономерности является синусоидальная функция. Регрессионная модель индивидуальной динамики эффективности соревновательной деятельности игроков сборной команды Украины по баскетболу подчиняется синусоидальной зависимости, которая описывается синусоидальным уравнением регрессии
Выводы. Полученные данные могут быть полезны для прогнозирования индивидуальной игровой результативности спортсменов, определения индивидуальных особенностей игроков и корректировки тренировочных программ.
Ключевые слова: баскетбол; динамика; игра; результативность; функция; синусоида; индивидуализация

Introduction

"To foresee is to control" [1], - Pascal's aphorism applies to all controlled systems, including the process of sports training. Foresight involves making forecasts and adjusting training programs according to the results obtained, since the prediction of the future is a chance to change it, it is "the choice of those who want to win time" [1], i.e. rise to a higher level in any kind of activity. It is not by chance that, as long as humankind exists, so much does people have a passionate desire to look into the future. Existed and there are a huge number of predictors and ways to predict the future [2, 3]. There are also scientific methods of forecasting, the algorithms of which are applicable to many types of human activity, including the process of sports training [4, 5].

Forecasting is an integral part of managing any process, including the process of preparing athletes, since the goal in sports is to overcome one's own limitations, raising one's functional state to a new level.

What is needed to make high-quality forecasts? Turn to the classics to answer this question. For example, Belinsky [1] wrote: "Without knowing the past, it is impossible to understand the present and it is impossible to foresee the future", thereby emphasizing the need for a detailed analysis of current events in order to manage any process in the present and in the future. This statement coincides with the opinion of Gurdjieff [1]: "If a person has thoroughly studied what happened yesterday, the day before yesterday, a week, a year, ten years ago, he will be able to accurately say what will happen and what will not happen tomorrow."

It should be noted that the methods of scientific forecasting are closely intersected with the statements of the classics of culture. For compiling scientific forecasts in economics and sociology, many authors [2, 3] recommend the following algorithm: 1. Collect data on similar events in the past. 2. Search for patterns in the events that have occurred. 3. Extrapolation of the obtained laws to the future and making forecasts. 4. Preparation of recommendations to adjust the alleged events.

The basis of sports forecasts is also the analysis of patterns of similar events of the past, therefore, in order to predict an individual competitive performance of an athlete, it is necessary to find patterns of the dynamics of his competitive performance in the past.

In this regard, the definition of patterns of individual dynamics of competitive performance will allow you to optimize the training process through the regulation of the level of load and recovery activities according to the obtained laws.

The aim of the work is to develop an algorithm and determine the patterns of the individual dynamics of the competitive performance of qualified basketball players.

Material and methods

Participants

The study involved the players of the main composition of the men's basketball team of Ukraine. It was analyzed 12 games of the national team of Ukraine in games with equal rivals - teams of other countries.

Research organization

The research was conducted from June 2018 to September 2018. Technical logging of games, which was carried out using a modified formula of Portnov [6]. Mathematical modeling was used to describe the patterns of individual dynamics of competitive performance using sinusoidal regression models.

Statistical analysis

To describe the patterns of individual dynamics of competitive performance was applied sinusoidal regression analysis.

The use of a regression sinusoidal model is effective in practical work, since it allows you, quite quickly, using only data from technical reports, to predict the time of "ups" and "recessions" of individual game performance. This helps to adjust training programs, for example, by reducing the level of physical exertion before the expected "recession" or paying more attention to the means of recovery.

The main indicator in the sinusoidal formula for practical work is the period of oscillation. Knowing the period of individual fluctuations of the athlete's functional state, which determines the game performance, the coach can foresee the "ups and downs" of the competitive performance of each player.

Results

Theoretical substantiation of the sinusoidal model of individual dynamics of competitive performance. From the classical theory of sports [7, 8, 9] it is known that the development of sports form is carried out in waves, with certain limited periods of linear development. For practical work and prediction of results over short time intervals, linear regression models are used [10, 11, 12]. However, it

is already difficult to describe the longer periods of development of sports by the linear regression equation, for this it is necessary to apply other functional patterns.

One of such functional patterns is oscillatory processes [13, 14]. According to physical laws, oscillations are motions or processes that have one or another frequency in time. For living systems, harmonic oscillations are most characteristic, in which the oscillating quantity x varies with time according to the law of sine or cosine (Fig. 1):

$$x(t) = A \cdot \mathrm{Cos}(\omega t + \alpha), \quad (1)$$

or

$$x(t) = A \cdot \mathrm{Sin}(\omega t + \alpha), \quad (2)$$

where:
A - the amplitude;
ω - the circular frequency;
α - the initial phase;
(ωt + α) - phase.

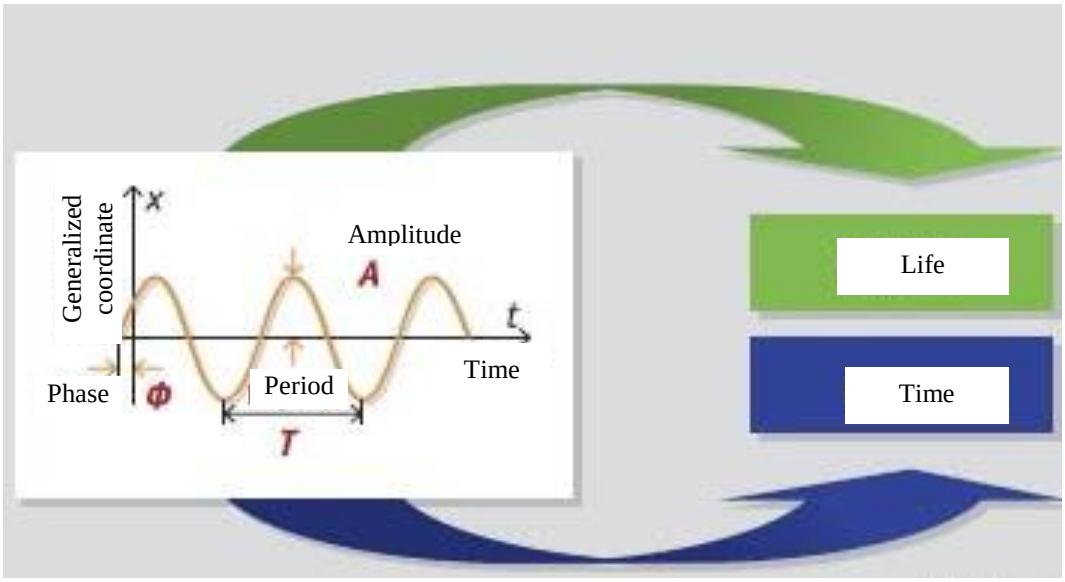

Fig. 1. Graph of harmonic oscillations in living systems [14]

Oscillatory processes occurring in nature, determine the biological time. In nature, there are countless various oscillatory processes. There are oscillatory processes that occur at the cell level, the time of which is measured from 0.5 minutes to an hour.

There are oscillatory processes that occur at the level of individual body systems. For example, heartbeat, breathing, changing phases of sleep and wakefulness, fluctuations in body temperature (higher in the day), muscle function of the intestines, metabolic rate, degree of activity and speed of reactions, mood, etc. Even the size of the cells themselves have different periods of oscillation.

Part of this kind of oscillatory processes has a circadian (near-day) cycle. Another part of the processes occurring at the level of individual systems has cycles corresponding to the change of the phases of the moon. These are either lunar-monthly cycles equal to about 29.5 Earth days, or lunar-diurnal cycles equal to lunar days (approximately 24.8 Earth hours). There are also fluctuations with a frequency equal to the cycles of sea tides (24.8 or 12.4 hours). There are oscillatory processes with an annual cycle of functional activity of the organs [14].

Oscillatory processes occurring in nature are the main condition for the preservation of life on Earth, and the existence of biological time is a tough necessity: outside of its own biological time, all life could neither exist nor reproduce [14].

In this regard, the process of changing competitive performance, which is one of the aspects of biological processes, it is advisable to consider in terms of oscillatory processes. Therefore, if we consider the dynamics of competitive performance of athletes, then the most acceptable function to describe this pattern is a function that reflects harmonious oscillatory processes, i.e. - sinusoidal.

Sinusoidal models of individual dynamics of competitive performance. As shown by our experimental studies [11, 12, 13, 15], the most adequate model for describing the individual characteristics of the dynamics of competitive performance is the sinusoidal function, since the changes in these indicators are harmonious, i.e. are described by sinusoidal functions with a period of 25–30 days for women and 33–37 days for men and

have a significant correlation (r = 0.53–0.71, p <0.05) with the values of the emotional biological rhythm for women and intellectual biorhythm in men [eleven]. The use of these patterns in the training process had a positive impact on the performance of individual competitive performance and functional state of athletes [11].

The use of a regression sinusoidal model is effective in practical work, since it allows you, quite quickly, using only data from technical reports, to predict the time of "ups" and "recessions" of individual game performance. This helps to adjust training programs, for example, by reducing the level of physical exertion before the expected "recession" or paying more attention to the means of recovery.

The main indicator in the sinusoidal formula for practical work is the period of oscillation. Knowing the period of individual fluctuations of the athlete's functional state, which determines the game performance, the coach can foresee the "ups and downs" of the competitive performance of each player.

In our previous works [11, 12, 13], we performed identification of sinusoidal regression coefficients using the MathCAD program, however, for practical work of a trainer, work in the MathCAD program is not always available, therefore we applied the sinusoidal regression building algorithm in the ECXEL program ", Which is described in detail in [12, 13, 15].

It should be noted that the identification of patterns of individual competitive performance is appropriate only for qualified athletes, since the higher the level of qualification, the more ordered is the pattern of changes in individual competitive performance.

For example, we want to know whether any individual patterns are subject to the individual dynamics of the competitive performance of the players of the Ukrainian national team. To do this, you can use the data of the technical reports on games with the main rivals of the Ukrainian team for a certain period of time (the minimum period is 3-4 months). Modern technical reports in teams of the highest league, super league and national teams of the country are usually compiled using computer programs, which facilitates data processing [16].

To determine the individual patterns of the dynamics of competitive performance, we recommend using such an indicator as "the sum of positive points in the game", which most accurately reflects the level of the player's "positive" contribution to the result of the meeting. You can also use any other indicator, the most significant for a particular player, for example, the indicator of the total number of points brought by the player, or the number of rebounds.

In our case, we analyzed the dynamics of the index of individual game performance of individual players of the Ukrainian team in 12 games during the 3 months of 2018 (June-August). As a result of the analysis of the obtained sinusoidal model, it was revealed that the regression model of the individual dynamics of the effectiveness of competitive activity of the players is subject to sinusoidal dependence. For example, for player 1, this pattern is described by the regression equation (Fig. 2):

$$S+=12+11\sin((2\pi/28)(T-27)), \quad (3)$$

where:

S+ - the number of "positive" points;

T – time interval, that is, the day in a row from the first game to be analyzed.

Coefficient 12 means the average performance of the player, the coefficient 11 means the amplitude of the game performance fluctuations of the athlete, factor 28 - the period of the game performance fluctuations of player 1, coefficient 27 - the value of the period at the time of the first game being analyzed.

For the practical work of the coach, the most important is the indicator of the fluctuation period of the game performance of each player. In this case, the oscillation period of the game performance of a basketball player is 28 days. This means that if this athlete has a pronounced rise in game performance for a certain period of time, a similar rise can be expected after about 28 days, and after 14 days we can expect a relative decline in the player's functional state. By reducing the load before the expected "recession" or using adequate means of restoring performance, it is possible to significantly reduce the "recession" and increase the "rise" [11, 15]. In our case, player 1 should have had a "boost" of competitive performance (or functional state) 28 days after the last "lift" according to a sinusoidal function, i.e. 3.09.2018, 1.10.2018, which is confirmed by the results of its competitive activity. At more remote intervals, the forecast may not work due to the large number of influencing factors. You can check the results of the forecast by analyzing the game performance (or functional state) of the athlete at these intervals of the time [11, 15].

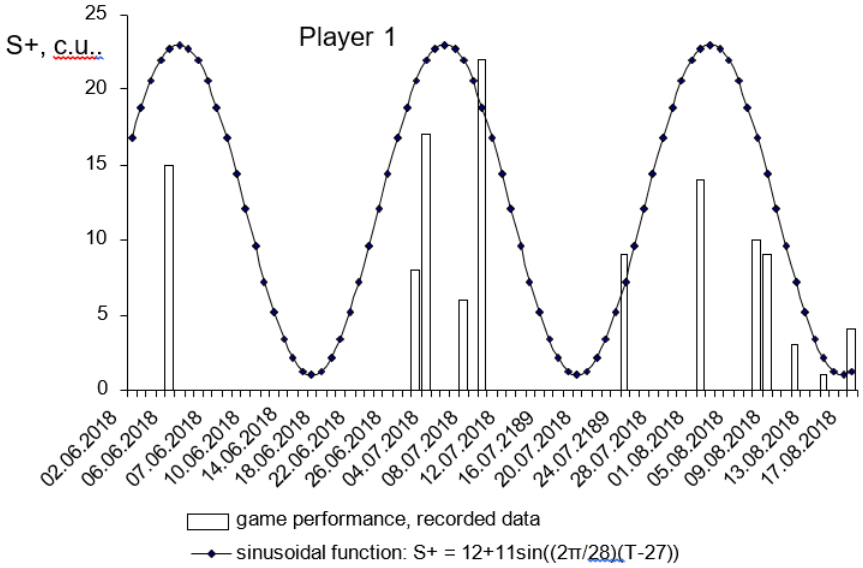

Fig. 2. Dynamics of individual game performance of a basketball player of the Ukrainian team (player 1)

Consider the patterns of individual dynamics of the competitive performance of another player of the Ukrainian team, player 2. The regression model of the individual dynamics of the competitive activity of this athlete is also subject to a sinusoidal relationship (Fig. 2), which is described by the regression equation

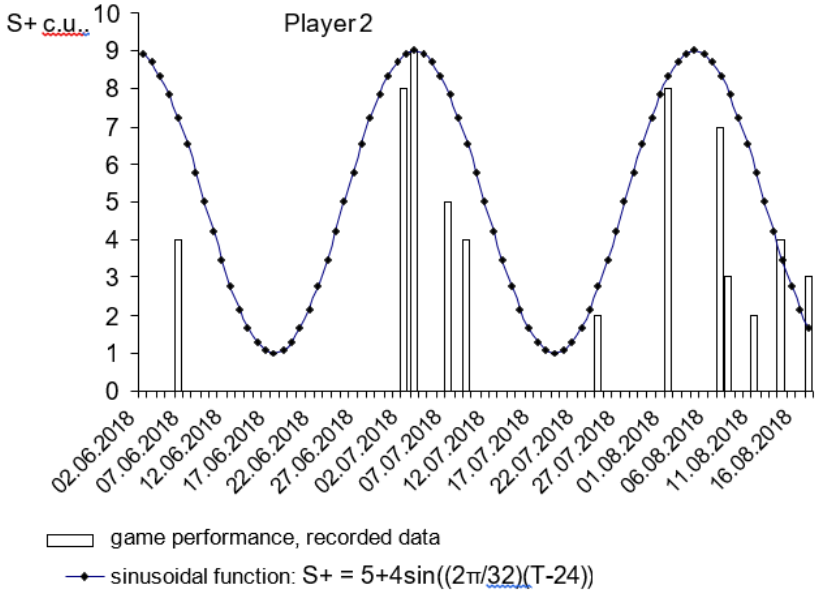

Fig. 3. Dynamics of individual game performance of a basketball player of the Ukrainian team (player 2)

$$S+=5+4\sin((2\pi/32)(T-24)), \quad (3)$$

where:

S+ - the number of "positive" points;

T – time interval, that is, the day in a row from the first game to be analyzed.

Coefficient 5 means arithmetic average value of the game performance of this player, coefficient 4 means the amplitude of the game performance fluctuations of the athlete, coefficient 32 - the period of fluctuations of the game performance of the athlete 2, coefficient 24 - the value of the period at the time of the first analyzed game.

The period of fluctuations in the game performance of a basketball player 2 is 32 days. Extrapolating the data obtained, we find that player 1 had to have a "rise" of competitive performance (or functional state) 32 days after the last "lift" according to a sinusoidal function, i.e. 09/06/2018, 10/8/2018, which is also confirmed by the results of his competitive activities in this period.

Discussion

Based on the obtained results and literature data [2, 3, 4], it is possible to determine the individual characteristics of the analyzed players and, accordingly, of similar types of players.

For example, for an athlete, 1 period of fluctuations in game performance is 28 days. Based on the literature data on the psycho-physiological features of people with different biorhythm periods [17, 18, 19], it can be concluded that this athlete's general condition, and, consequently, his competitive performance, depends on the physical biorhythm [20, 21, 22]. As shown by our previous studies [15], for many qualified basketball players, the dynamics of game performance is determined by the psychological state, but player 1 is distinguished by the fact that its game performance determines precisely the physical state. The decisions that a player makes on the court and in life are also determined by his physical condition. In this regard, it is logical to conclude that for this player the best means of recovery will be massage, including - vibratory massage, sauna. As a means of recovery for player 1 can also be used funds from other sports and activities, such as fast dancing, such as Hispanic, downhill skiing, which, however, requires caution. Athlete 1 may have a tendency to hypertension, therefore, due attention must also be paid to natural relaxation means, such as medicinal plants, such as peppermint (*Méntha piperíta*), coltsfoot (*Tussilágo*), and oak (*Quércus róbur*), yarrow (*Achilléa millefólium*), blood-red hawthorn (*Crataégus sanguínea*), heart-leaved linden (*Tília cordáta*), etc. [26, 27].

Player 2 has a period of fluctuations in game performance of 32 days. Based on the literature data on the psycho-physiological features of people with different biorhythm periods [23, 24, 25], it can be concluded that this athlete's general condition, and, consequently, his competitive performance, depends on the psychological state, on his inner world. The obtained data are in line with our previous studies [15], which showed that in qualified basketball players, the game performance correlates with the values of the intellectual biological rhythm. In this regard, this player first needs to understand the meaning of the proposed exercises, "play" in the mind various technical and tactical actions. For player 2, independent installations for activating recovery processes and increasing mutual understanding with partners and coaches are also very effective. In addition, for player 2, being in a nature zone is useful. This player is suitable as a means of recovery for calm music, such as "relax" or "trance" with video accompaniment. Of all other sports, everything that is connected with the need to think is suitable: other sports games, martial arts. As a medicinal plant, it is possible to use toning and strengthening the nervous system to increase and restore working capacity: Ginseng (*Pánax*), Cornflower (*Centauréa jacéa*), Chamomile (*Matricária chamomílla*), Origanum Orientanum (*Oríganum vulgáre*), British Devilsil (*Pentanéma británnicum*), Inula hirta (*Ínula*), Calamus (*Ácorus cálamus*), and others [26, 27].

Conclusions

1. The process of changing competitive performance should be considered from the point of view of oscillatory processes. The most acceptable function to describe this pattern is the sinusoidal function.

2. The regression model of the individual dynamics of the effectiveness of competitive activity of the players of the Ukrainian basketball national team obeys a sinusoidal dependence, which is described by the regression equation $S+=a+b\sin((2\pi/t)(T-c))$,, where S + is the number of "positive" points, T is the time interval, that is, the day in a row from the first game being analyzed, the coefficient a means the average value of the game performance of a given player, the coefficient b means the amplitude of fluctuations of the game performance of an athlete, the coefficient t is the period k oscillations gaming performance athlete coefficient c - meaning a period of time of the first analyzed games.

3. The use of a regression sinusoidal model is effective in practical work, as it allows quite quickly, using only the data from technical reports, to predict the time of "rises" and "recessions" of individual game performance, which helps to adjust training programs and determine some psycho-physiological individual characteristics of players.

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Conflict of interest

The authors state no conflict of interest.

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Comparative characteristics of anthropometric indicators, level of physical and technical readiness of young players of 12 and 15 years of different playing fields

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Abstract
Purpose: To develop model characteristics of physical and technical fitness of players of 12 and 15 years of different playing roles.
Material and methods. The study was attended by football players of 12 and 15 years of sport school "Areal" Kharkiv, in which the developed technologies were applied in the educational process. In total, 23 forvards, 28 midfielders, 30 defenders and 15 goalkeepers were invited for the survey. Indicators of the running time of segments of 15 m from the course, 30 m from the course and 60 m from the course were determined; shuttle running time 5 to 20 m. Determined the length and weight of the body; Heart rate at rest and heart rate after a shuttle run. From the technical readiness indicators were determined: the time of holding the soccer ball on the foot; juggling, that is, the number of shots of the ball with the foot without losing the ball; time to run a soccer ball on a mission; goal kicks for accuracy; strikes the ball at flight range.
Results. Young players of 12 and 15 years of different game specializations differ in terms of physical and technical fitness. The largest number of significant differences were found in the technical readiness of football players for 15 years. Field players at speed capabilities are significantly superior to goalkeepers. Goalkeepers, on the contrary, have lower running speeds. The level of speed endurance is relatively high for defenders and midfielders, as opposed to goalkeepers. The obtained data allowed us to build models of physical development, physical and technical readiness of players of 12 and 15 years of different playing fields, on the basis of which training programs for representatives of different playing roles can be developed.
Conclusions. The data obtained indicate the need for a differentiated approach in the training process of young football players, taking into account their playing role. The differentiated approach is more relevant at the age of 15 compared to the age of 12.
Keywords: football; game play; physical fitness; technical readiness; anthropometric indicators

Анотація
Козіна Ж.Л., Ліманс А., Маріно Ю., Круз Х., Голенков А.А., Дубич В.В. Порівняльна характеристика антропометричних показників, рівня фізичної та технічної підготовленості юних футболістів 12 та 15 років різних ігрових амплуа
Мета: розробити модельні характеристики фізичної та технічної підготовленості футболістів 12 та 15 років різних ігрових амплуа.
Матеріал і методи. У дослідженні узяли участь футболісти 12 та15 років ДЮСШ «Ареал» м. Харкова, в навчально-тренувальному процесі яких застосовувалися розроблені технології. Всього для обстеження було запрошено 23 нападаючих, 28 півзахисників, 30 захисників і 15 воротарів. Визначалися показники часу пробігання відрізків 15 м з ходу, 30 м з ходу та 60 м з ходу; час човникового бігу 5 по 20 м. Визначали довжину та масу тіла; ЧСС спокою та ЧСС після човникового бігу. З показників технічної підготовленості визначали: час тримання футбольного м'ча на стопі; жонглювання, тобто кількість набивань м'яча стопою без втрати м'яча; час виконання ведення футбольного м'яча за завданням; удари по воротам на точність влучення; удари м'яча на дальність польоту.
Результати. Юні футболісти 12 і 15 років різних ігрових спеціалізацій розрізняються між собою за показниками фізичної і технічної підготовленості. Найбільша кількість достовірних відмінностей виявлена у показниках технічної підготовленості футболістів 15 років.
Польові гравці по швидкісних можливостях істотно перевершують воротарів. Воротарі, навпаки, мають нижчі показники швидкості бігу. Рівень швидкісної витривалості відносно високий у захисників і напівпівзахисників на відміну від воротарів. Отримані дані дозволили побудувати моделі фізичного розвитку, фізичної та технічної підготовленості футболістів 12 та 15 років різних ігрових амплуа, на основі яких можуть бути розроблені програми тренувань для представників різних ігрових амплуа.
Висновки. Отримані дані свідчать про необхідність диференційованого підходу в тренувальному процесі юних футболістів з урахуванням їх ігрового амплуа. Диференційований підхід набуває більшу актуальність у 15 років у порівнянні з віком 12 років.
Ключові слова: футбол; ігрові амплуа; фізична підготовленість; технічна підготовленість; антропометричні показники

Аннотация
Аннотация
Козина Ж.Л., Лиманс А., Марино Ю., Круз Х., Голенков А.А., Дубич В.В. Сравнительная характеристика антропометрических показателей, уровня физической и технической подготовленности юных футболистов 12 и 15 лет разных игровых амплуа.
Цель: разработать модельные характеристики физической и технической подготовленности футболистов 12 и 15 лет разных игровых амплуа.
Материал и методы. В исследовании приняли участие футболисты 12 та15 лет ДЮСШ «Ареал» г.. Харькова, в учебно-тренировочном процессе которых применялись разработаны технологии. Всего для обследования были приглашены 23 нападающих, 28 полузащитников, 30 защитников и 15 вратарей. Определялись показатели времени пробегания отрезков 15 м с ходу, 30 м с ходу и 60 м с хода; время челночного бега 5 по 20 м. Определяли длину и массу тела ЧСС покоя и ЧСС после челночного бега. Из показателей технической подготовленности определяли: время содержания футбольного мяча на стопе; жонглирование, то есть количество набивок мяча стопой без потери мяча; время выполнения ведения футбольного мяча по заданию; удары по воротам на точность попадания; удары мяча на дальность полета.
Результаты. Юные футболисты 12 и 15 лет разных игровых специализаций различаются между собой по показателям физической и технической подготовленности. Наибольшее количество достоверных различий обнаружено в показателях технической подготовленности футболистов 15 лет.
Полевые игроки по скоростным возможностям существенно превосходят вратарей. Вратари, наоборот, имеют более низкие показатели скорости бега. Уровень скоростной выносливости относительно высокий у защитников и полузащитников в отличие от вратарей.
Выводы. Полученные данные свидетельствуют о необходимости дифференцированных устных подхода в тренировочном процессе юных футболистов с учетом их игрового амплуа. Дифференцированных устных подход приобретает большую актуальность в 15 лет по сравнению с возрастом 12 лет.
Ключевые слова: футбол; игровые амплуа; физическая подготовленность; техническая подготовленность; антропометрические показатели

Introduction

The problem of training young football players is becoming more urgent nowadays [1, 2, 3]. Effective functioning of the system of sports reserve, improving the quality of training and training process for young athletes can be ensured only with rigorous scientific substantiation of both the system as a whole and its individual components [4, 5, 6]. Optimal design of the training process technology, the formation of training programs, the selection of adequate training methods and methods of purposeful recovery and purposeful recovery is possible only on the basis of the laws of age-related development of information on the functional features of athletes [7, 8, 9].

In the literature, aspects of this problem are fragmented [10, 11, 12] and mainly concern skilled adult football players. At the same time, special attention should be paid to managing the development of adaptation, functional readiness, optimization of the training process of young footballers at the stage of advanced specialization. This is due to the fact that this stage of long-term sports training coincides with powerful ontogenetic processes, the beginning of the manifestation of individual features of the mechanisms of regulation of functions and adaptation processes, on the basis of which, in particular, the game specialization of young football players is determined [13, 14, 15].

Improving the efficiency of the training process is associated with the development and implementation of various means and methods of training athletes. One of the most effective approaches to optimize the training process, taking into account trends in the development of a particular sport, is the use of readiness indicators that allow you to individualize the training process [1].

But there is practically no information in the literary data regarding the model characteristics of the readiness of players of 12 and 15 years of different playing fields. The future of sports, including football, in the individualization of the training process [4, 5]. Football is also a unique feature of combining in one team as players with different anthropometric and functional indicators. Of course, the construction of the training process is greatly complicated by the need to study and apply an individual approach to each player of the team, but it is a basic requirement of modern sports.

Individual approach is needed not only for players of different roles, but also for players of the same game functions. Modern scientific methods allow to give an accurate description of the individual characteristics of athletes and to build "ideal" models of athletes. However, such methods are rarely used, from which the effectiveness of the training process is significantly reduced.

Individual approach to the players is necessary at all stages of sports training, including - at 12 and 15 years, since in these age groups there is a qualitative leap in the level of physical development, which is reflected in the indicators of physical and technical fitness [16, 17, 18]. In basketball, during this period there is a more rigorous distribution of athletes in terms of functions (which are not always clearly defined in athletes at this stage of preparation), their individual playing profile is determined, and therefore this period plays an important role in becoming a high-class athlete [19, 20, 21]. That is why the pressing issue is to determine the features of physical development, physical and technical preparedness of players of different game roles in these age groups.

Based on the above, this study hypothesized that at the age of 12 years there can already be significant differences in the indicators of physical development, physical and technical fitness, which become more significant at the age of 15 years.

The purpose of the study is to develop model characteristics of physical and technical fitness of players of 12 and 15 years of different playing fields.

Material and methods

Participants

The study was attended by football players of 12 and 15 years of school "Areal" Kharkiv, in which the developed technologies were applied in the educational process. A total of 23 forwards (12 players 12 years and 11 players 15 years), 28 midfielders (14 players 12 years and 14 players 15 years), 30 (15 players 12 years and 15 players 15 years), defenders and 15 goalkeepers were invited for the survey (8 players 12 years and 7 players 15 years).

Experimental protocol

To achieve this goal, a comprehensive testing of physical performance and basic indicators of functional fitness in young players of 12 and 15 years of different playing roles was carried out. In the course of the researches the indicators of speed qualities were determined by the time of running of segments of 15 m from the course, 30 m from the course and 60 m from the course (the test participant makes a run up to 10 meters, at the maximum speed crosses the starting line and overcomes the distance of 15 meters, 30 m, 60 m); high speed endurance (shuttle running time 5 to 20 m).

From indicators of physical development the length and weight of the body were determined; from indicators of functional readiness - resting heart rate and heart rate after shuttle running.

From the indicators of technical readiness determined the following:

- time to hold the soccer ball on the foot: the test participant locks the ball on the foot and holds it for as long as possible. It is impossible to stuff and jump on a support leg;

- juggling, that is, the number of shots of the ball with the foot without losing the ball;

- the time of running a soccer ball on a mission. There is a ball on the line. From the line there are three skittles, a distance of 3 m, 6 m, 9.5 m. According to the examiner's whistle, the test participant runs the skittles "snake" on the right side;

- shots on goal for accuracy of hit. The gates are divided into 6 equal squares. We set the ball at 11m. The task of the test participant is to get the ball into these squares, at the bottom - at most one touch of the ball to the ground, three balls per square. Number of hits - 18. One hit - 1 point.

- Ball strikes on flight range. Set the ball on the line. The test taker's job is to hit the ball as far as possible. The result is recorded at the first touch of the ball to the ground.

Statistical analysis

In the mathematical processing of primary materials of this study, in addition to the calculation of primary statistics, a comparative analysis of the averages by t - Student's t test was conducted. Indicators were processed using modern computer programs - EXEL and SPSS.

Results

Comparing the indicators of physical development (length and body weight) (Tables 1, 2), it can be seen that according to these parameters the players of different game roles practically do not differ from each other ($p>0.05$). This provision applies to both 12-year-olds and 15-year-olds. The average length of goalkeepers 12 years is 157.67 cm, of defenders 12 years is 152.0 cm, of midfielders 12 years is 155.6 cm, of forwards 12 years is 155.6 cm The average values of the length of goalkeepers 15 years is 166.33 cm, of defenders 15 years is 172.75 cm, of midfielders 15 years is 168.2 cm, of forwards 15 years is 170.8 cm.

Table 1

Indicators of physical development, physical and technical readiness of football players of 12 years of different playing fields (goalkeepers, n = 8, defenders, n = 15, midfielders, n = 14, forwards, n = 12)

Indexes	Playing fields		$\bar{x}$	S	m	t		p
1	2	3	4	5	6	7	8	9
Body length (cm)	1	goalkeepers	157.67	0.58	0.33	1-2	1.74	0.14
	2	defenders	157.67	0.58	0.33	1-3	0.66	0.54
	3	midfielders	155.60	5.27	2.36	1-4	0.94	0.38
	4	forwards	155.61	3.65	1.63	2-3	-1.00	0.35
	-	-	-	-	-	2-4	-1.19	0.27
	-	-	-	-	-	3-4	0.00	1.00
Body weight (kg)	1	goalkeepers	43.67	1.15	0.67	1-2	1.20	0.29
	2	defenders	42.00	2.16	1.08	1-3	-0.05	0.96
	3	midfielders	43.80	4.32	1.93	1-4	-0.38	0.72
	4	forwards	44.60	4.04	1.81	2-3	-0.75	0.48
	-	-	-	-	-	2-4	-1.15	0.29
	-	-	-	-	-	3-4	-0.30	0.77
Heart rate rest (beats·min^{-1})	1	воротарі	76.00	3.46	2.00	1-2	-0.09	0.93
	2	захисники	76.50	9.00	4.50	1-3	-0.05	0.96
	3	напівзахисники	79.60	7.27	3.25	1-4	-2.04	0.09
	4	нападники	82.80	5.02	2.24	2-3	-0.57	0.58
	-	-	-	-	-	2-4	-1.34	0.22
	-	-	-	-	-	3-4	-0.81	0.44

Continuation of table 1

1	2	3	4	5	6	7	8	9
Heart rate after a shuttle run (beats·min^{-1})	1	goalkeepers	178.00	3.46	2.00	1-2	0.21	0.85
	2	defenders	177.00	7.75	3.87	1-3	-0.79	0.46
	3	midfielders	178.80	5.02	2.24	1-4	0.87	0.42
	4	forwards	174.00	7.35	3.29	2-3	-0.42	0.69
	-	-	-	-	-	2-4	0.60	0.57
	-	-	-	-	-	3-4	1.21	0.26
Shuttle Run (s)	1	goalkeepers	27.67	0.44	0.25	1-2	0.85	0.43
	2	defenders	27.35	0.51	0.26	1-3	-0.24	0.82
	3	midfielders	27.46	0.11	0.05	1-4	1.16	0.29
	4	forwards	27.44	0.10	0.05	2-3	-0.46	0.66
	-	-	-	-	-	2-4	-0.39	0.71
	-	-	-	-	-	3-4	0.27	0.80
Running 30 m (s)	1	goalkeepers	6.80	0.10	0.05	1-2	1.88	0.12
	2	defenders	6.49	0.26	0.13	1-3	1.06	0.33
	3	midfielders	6.53	0.21	0.10	1-4	1.49	0.19
	4	forwards	6.56	0.26	0.12	2-3	-0.25	0.81
	-	-	-	-	-	2-4	-0.38	0.72
	-	-	-	-	-	3-4	-0.17	0.87
Running 15 m (s)	1	goalkeepers	5.07	0.07	0.04	1-2	3.52	0.02
	2	defenders	4.73	0.15	0.08	1-3	1.97	0.10
	3	midfielders	4.78	0.38	0.17	1-4	2.46	0.05
	4	forwards	4.67	0.26	0.12	2-3	-0.21	0.84
	-	-	-	-	-	2-4	0.39	0.71
	-	-	-	-	-	3-4	0.49	0.64
Keeping the Ball on the Foot (s)	1	goalkeepers	5.86	1.41	0.82	1-2	1.03	0.35
	2	defenders	5.00	0.82	0.41	1-3	1.27	0.25
	3	midfielders	6.95	1.88	0.84	1-4	-0.35	0.74
	4	forwards	6.14	0.82	0.37	2-3	-1.91	0.10
	-	-	-	-	-	2-4	-2.06	0.08
	-	-	-	-	-	3-4	0.88	0.40
Ball juggling (quantity)	1	goalkeepers	25.33	5.51	3.18	1-2	-0.66	0.54
	2	defenders	31.00	13.76	6.88	1-3	1.32	0.23
	3	midfielders	20.00	5.52	2.47	1-4	0.32	0.76
	4	forwards	23.60	8.20	3.67	2-3	1.65	0.14
	-	-	-	-	-	2-4	1.01	0.35
	-	-	-	-	-	3-4	-0.81	0.44
Keeping the Ball (s)	1	goalkeepers	13.63	0.45	0.26	1-2	1.26	0.26
	2	defenders	13.02	0.74	0.37	1-3	-0.49	0.64
	3	midfielders	13.89	0.82	0.37	1-4	-0.52	0.62
	4	forwards	13.78	0.36	0.16	2-3	-1.65	0.14
	-	-	-	-	-	2-4	-2.05	0.08
	-	-	-	-	-	3-4	0.27	0.79
Running 60 m (s)	1	goalkeepers	9.85	0.29	0.17	1-2	0.89	0.42
	2	defenders	9.67	0.27	0.13	1-3	1.37	0.22
	3	midfielders	9.62	0.19	0.09	1-4	0.96	0.38
	4	forwards	9.55	0.49	0.22	2-3	0.27	0.80
	-	-	-	-	-	2-4	0.42	0.69
	-	-	-	-	-	3-4	0.31	0.76
Shots on goal (balls)	1	goalkeepers	6.60	3.61	2.08	1-2	0.26	0.80
	2	defenders	6.50	1.29	0.65	1-3	0.17	0.87
	3	midfielders	6.60	3.13	1.40	1-4	0.20	0.85
	4	forwards	7.00	2.07	0.93	2-3	-0.06	0.95
	-	-	-	-	-	2-4	-0.08	0.94
	-	-	-	-	-	3-4	0.00	1.00
Ball strikes for range (m)	1	goalkeepers	27.00	1.73	1.00	1-2	1.46	0.20
	2	defenders	25.50	1.00	0.50	1-3	2.30	0.06
	3	midfielders	23.20	2.49	1.11	1-4	4.13	0.01
	4	forwards	21.60	1.82	0.81	2-3	1.72	0.13
	-	-	-	-	-	2-4	3.82	0.01
	-	-	-	-	-	3-4	1.16	0.28

The average body weight of goalkeepers 12 years is 43.67 kg, of defenders 12 years is 42 kg, of midfielders 12 years is 43.8 kg, of forwards 12 years is 44.6 kg. The average body weight of goalkeepers 15 years is 55.43 kg, of defenders 15 years is 52.25 kg, of midfielders 15 years is 54.4 kg, of forwards 15 years is 53.4 kg. The findings differ somewhat from the results of studies by other authors [1], who found that goalkeepers have the greatest weight and body length. These differences with the results of other authors can be explained by the low football experience of the surveyed children and the need to improve the system of distribution of players by function.

Regarding the indicators of functional readiness, it can be noted that in terms of heart rate, the representatives of different game roles, both 12 and 15 years, do not have significant differences (Tables 1, 2). But it should be noted that there is a tendency to the lowest values of resting heart rate at goalkeepers and increasing resting heart rate at defenders, midfielders and the greatest values of resting heart at attackers.

The obtained data can be explained by the greater emotional endurance of the goalkeepers and the least by the attackers, which affects the resting heart rate. This trend is more pronounced in football players 15 years old compared to football players 12 years old. The average resting heart rate at goalkeepers 12 years is 76 beats·min^{-1}, for defenders 12 years is 76.5 beats·min^{-1}, for midfielders 12 years is 79.6 beats·min^{-1}, for forwards 12 years is 82.8 beats·min^{-1}. The average resting heart rate at goalkeepers 15 years is 68 beats·min^{-1}, at defenders 15 years is 72 beats·min^{-1}, at midfielders 15 years is 70.8 beats·min^{-1}, at forwards 15 years is 75.6 beats·min^{-1}.

The average heart rate after shuttle running at goalkeepers 12 years is 178 beats·min^{-1}, at defenders 12 years is 177 beats·min^{-1}, at midfielders 12 years is 178.8 beats·min^{-1}, at forwards 12 years is 174 beats·min^{-1}.

Table 2

Indicators of physical development, physical and technical readiness of football players of 15 years of different playing fields (goalkeepers, n = 7, defenders, n = 15, midfielders, n = 14, forvards, n = 11)

Indexes	Playing fields		$\bar{x}$	S	m	t		p
1	2	3	4	5	6	7	8	9
Body length (cm)	1	goalkeepers	166.33	8.08	4.67	1-2	-1.61	0.17
	2	defenders	172.75	1.26	0.63	1-3	-0.38	0.72
	3	midfielders	168.20	6.10	2.73	1-4	-0.77	0.47
	4	forwards	170.80	7.89	3.53	2-3	1.45	0.19
	-	-	-	-	-	2-4	0.48	0.64
	-	-	-	-	-	3-4	-0.58	0.58
Body weight (kg)	1	goalkeepers	55.00	6.25	3.61	1-2	0.82	0.45
	2	defenders	52.25	2.50	1.25	1-3	0.11	0.92
	3	midfielders	54.40	7.99	3.57	1-4	0.49	0.64
	4	forwards	53.40	3.21	1.44	2-3	-0.51	0.62
	-	-	-	-	-	2-4	-0.59	0.58
	-	-	-	-	-	3-4	0.26	0.80
Heart rate rest (beats·min^{-1})	1	goalkeepers	68.00	3.46	2.00	1-2	-0.60	0.58
	2	defenders	72.00	10.95	5.48	1-3	-0.84	0.43
	3	midfielders	70.80	5.02	2.24	1-4	-1.23	0.26
	4	forwards	75.60	10.04	4.49	2-3	0.22	0.83
	-	-	-	-	-	2-4	-0.51	0.62
	-	-	-	-	-	3-4	-0.96	0.37
Heart rate after a shuttle run (beats·min^{-1})	1	goalkeepers	132.00	6.00	3.46	1-2	-1.97	0.11
	2	defenders	142.50	7.55	3.77	1-3	-2.00	0.09
	3	midfielders	151.20	15.53	6.95	1-4	-2.88	0.03
	4	forwards	163.20	17.70	7.91	2-3	-1.02	0.34
	-	-	-	-	-	2-4	-2.16	0.07
	-	-	-	-	-	3-4	-1.14	0.29
Shuttle Run (s)	1	goalkeepers	24.24	0.17	0.10	1-2	4.83	0.01
	2	defenders	23.19	0.34	0.17	1-3	2.63	0.04
	3	midfielders	23.29	0.27	0.12	1-4	4.17	0.01
	4	forwards	23.46	0.29	0.13	2-3	-1.02	0.34
	-	-	-	-	-	2-4	-1.28	0.24
	-	-	-	-	-	3-4	-0.93	0.38

Continuation of table 2

1	2	3	4	5	6	7	8	9
Running 30 m (s)	1	goalkeepers	5.93	0.06	0.03	1-2	2.39	0.06
	2	defenders	5.49	0.31	0.16	1-3	2.63	0.04
	3	midfielders	5.41	0.33	0.15	1-4	2.63	0.04
	4	forwards	5.78	0.09	0.04	2-3	0.35	0.73
	-	-	-	-	-	2-4	-2.07	0.08
	-	-	-	-	-	3-4	-2.45	0.04
Running 15 m (s)	1	goalkeepers	3.97	0.81	0.47	1-2	1.28	0.26
	2	defenders	3.41	0.34	0.17	1-3	1.23	0.27
	3	midfielders	3.54	0.15	0.07	1-4	0.99	0.36
	4	forwards	3.57	0.36	0.16	2-3	-0.76	0.47
	-	-	-	-	-	2-4	-0.70	0.51
	-	-	-	-	-	3-4	-0.21	0.84
Keeping the Ball on the Foot (s)	1	goalkeepers	7.04	2.65	1.53	1-2	-2.68	0.04
	2	defenders	12.10	2.35	1.17	1-3	-0.26	0.81
	3	midfielders	7.36	1.03	0.46	1-4	-0.57	0.59
	4	forwards	8.27	3.10	1.39	2-3	4.10	0.01
	-	-	-	-	-	2-4	2.04	0.08
	-	-	-	-	-	3-4	-0.62	0.55
Ball juggling (quantity)	1	goalkeepers	35.33	6.81	3.93	1-2	-0.43	0.69
	2	defenders	38.75	12.28	6.14	1-3	-1.25	0.26
	3	midfielders	43.40	9.71	4.34	1-4	-2.52	0.05
	4	forwards	46.40	5.59	2.50	2-3	-0.64	0.55
	-	-	-	-	-	2-4	-1.26	0.25
	-	-	-	-	-	3-4	-0.60	0.57
Keeping the Ball (s)	1	goalkeepers	9.77	0.25	0.15	1-2	-0.08	0.94
	2	defenders	9.81	0.76	0.38	1-3	-0.08	0.94
	3	midfielders	9.81	0.88	0.39	1-4	-0.01	0.99
	4	forwards	9.06	0.24	0.11	2-3	-0.01	0.99
	-	-	-	-	-	2-4	2.08	0.08
	-	-	-	-	-	3-4	1.83	0.11
Running 60 m (s)	1	goalkeepers	8.65	0.08	0.04	1-2	-0.56	0.60
	2	defenders	8.28	0.46	0.23	1-3	-2.62	0.04
	3	midfielders	8.12	0.33	0.15	1-4	3.91	0.01
	4	forwards	8.16	0.15	0.07	2-3	-1.40	0.21
	-	-	-	-	-	2-4	0.54	0.61
	-	-	-	-	-	3-4	2.99	0.02
Shots on goal (balls)	1	goalkeepers	6.60	0.58	0.33	1-2	-0.19	0.85
	2	defenders	9.00	3.59	1.80	1-3	0.76	0.48
	3	midfielders	10.33	2.92	1.30	1-4	2.68	0.04
	4	forwards	10.75	2.30	1.03	2-3	0.81	0.45
	-	-	-	-	-	2-4	2.11	0.07
	-	-	-	-	-	3-4	1.45	0.19
Ball strikes for range (m)	1	goalkeepers	48.33	4.51	2.60	1-2	2.39	0.06
	2	defenders	41.00	3.65	1.83	1-3	4.80	0.00
	3	midfielders	37.00	2.35	1.05	1-4	5.04	0.00
	4	forwards	35.60	2.79	1.25	2-3	2.00	0.09
	-	-	-	-	-	2-4	2.52	0.04
	-	-	-	-	-	3-4	0.86	0.42

The average heart rate after shuttle running at goalkeepers 15 years is 132 beats·min^{-1}, at defenders 15 years is 142.5 beats·min^{-1}, at midfielders 15 years is 151.2 beats·min^{-1}, at forwards 15 years is 163,2 beats·min^{-1}. Differences between goalkeepers and forwards 15 years are significant at $p<0.05$ (Tab. 1, 2). The findings can be explained by the fact that forwards are more emotionally reactive compared to the midfielders, defenders and goalkeepers, as well as the better shuttle performance in the attackers, midfielders and defenders compared to the goalkeepers.

Thus, the average value of shuttle running time for goalkeepers 12 years are 27.67 s, for defenders 12 years is 27.35 s, for midfielders 12 years is 27.46 s, for forwards 12 years is 27.44 s. The average time of shuttle running for goalkeepers 15 years is 24.24 s, for defenders 15 years is 23.19 s, for midfielders 15 years is 23.29 s, for forwards 15 years is 23.46 s. Differences between goalkeepers and

attackers 15 years old, goalkeepers and midfielders 15 years old, goalkeepers and defenders are significant at $p<0.05$ (Tab. 1, 2).

A similar trend is observed in 15 meters running. Forwards, defenders and midfielders are better than goalkeepers. So, the average value of running for 15 m at goalkeepers 12 years is 5.06 s, for defenders 12 years is 4.73 s, for midfielders 12 years is 4.77 s, for forwards 12 years is 27.44 s. The average running distance of 15 m for goalkeepers of 15 years is 4.67 seconds, for defenders of 15 years is 3.97 s, for midfielders 15 years is 3.4 s, for forwards 15 years is 3.57 s (Tab. 1, 2) .

A similar trend is observed in 30 meters running. Forwards, defenders and midfielders, these indicators are better than goalkeepers. Thus, the average values of running for 30 m at goalkeepers 12 years is 6.79 s, for defenders 12 years is 6.49 s, midfielders 12 years is 6.53 s, forwards 12 years is 6.55 s. The average running distance of 30 m for goalkeepers 15 years is 5.93 s, for defenders 15 years is 5.48 s, for midfielders 15 years is 5.4 s, for forwards 15 years is 5.78 s. Differences between goalkeepers and forwards 15 years, goalkeepers and midfielders 15 years, goalkeepers and defenders 15 years are significant at $p<0,05$ (Tab. 1, 2).

The detected pattern is also observed in the indicators of running at 60 m. Forwards, defenders and midfielders, these indicators are better than for goalkeepers. Thus, the average values of running at 60 m for goalkeepers 12 years is 9.85 s, for defenders 12 years is 9.66 s, for midfielders 12 years is 9.62 s, for forwards 12 years is 9.55 s. The average running distance of 60 m for goalkeepers 15 years is 8.64 s, for defenders 15 years is 8.27 s, for midfielders 15 years is 8.12 s, for forwards 15 years is 8.16 s. Differences between goalkeepers and forwards 15 years, goalkeepers and midfielders 15 years, goalkeepers and defenders 15 years are significant at $p<0,05$ (Tab. 1, 2).

The biggest differences between the representatives of different game roles are found in the technical readiness, especially concerning the indicators of juggling, keeping the ball on the foot, accuracy of the range of strikes. The average goal time of a goalkeeper 12 years is 13.63 s, for defenders 12 years is 13.01 s, for midfielders 12 years is 13.88 s, for forwards 12 years is 13.78 s. Goalkeepers of 15 years have a median time at 9.77 s, defenders - at 9.8 s, midfielders - at 9.81 s, forwards - at 9.06 s. Differences between goalkeepers and forwards 15 years are significant at $p <0.05$ (Tab. 1, 2).

The average juggling value for goalkeepers 12 years is 25.3 times, for defenders 12 years is 31 times, for midfielders 12 years is 20 times, for forwards 12 years is 23.6 times. The average value of juggling for goalkeepers 15 years is 35.3 times, for defenders 15 years is 38.75 times, for midfielders 15 years is 43.4 times, for forwards 15 years is 46.4 times. Differences between goalkeepers and forwards 15 years are significant at $p<0.05$ (Tab. 1, 2).

Mean goalkeeping time for goalkeepers 12 years is 5.86 s, for defenders 12 years is 5.00 s, for midfielders 12 years is 6.94 s, for forwards 12 years is 6.13 s. Differences between midfielders and forwards 12 years and quarterbacks and midfielders 12 years are significant at $p<0.05$ (Tab.1, 2). Mean goalkeeping time for goalkeepers of 15 years is 7.03 s, for defenders 15 years is 12.09 s, for midfielders 15 years is 7.36 s, for forwards 15 years is 8.26 s. Differences between all representatives of different gaming specializations of 15 years were significant at $p<0.05$ (Tab. 1, 2).

The average values of the accuracy of shots of the ball on goal at goalkeepers 12 years make 6,6 points, at defenders 12 years make 5 points, at midfielders 12 years make 6,6 points, at forwards 12 years make 7 points. The average values of the accuracy of shots of the ball on goal at goalkeepers 15 years make 6,6 points, at defenders 15 years make 9 points, at midfielders 15 years make 10,3 points, at forwards make 15 years 10,75 points. Differences between goalkeepers and forwards 15 years are significant at $p<0.05$ (Tab.1, 2).

The average value of the ball strikes at goalkeepers 12 years is 27 m, at defenders 12 years is 25.5 m, at midfielders 12 years is 23.2 m, at forwards 12 years is 21.6 m, at goalkeepers 15 years is 48.3 m, at defenders 15 years is 41.25 m, at midfielders 15 years is 37 m, at forwards 15 years is 35.6 m. Forwards and midfielders for 15 years are significant at $p<0.05$ (Tab.1, 2).

Thus, the field players at speed capabilities are significantly superior to goalkeepers. Goalkeepers, by contrast, have lower running speeds (Fig. 1).

The level of speed endurance is relatively high for defenders and midfielders, as opposed to goalkeepers. The obtained data allowed us to build models of physical development, physical and technical readiness of players of 12 and 15 years of different game roles, on the basis of which training programs for representatives of different game roles can be developed (Fig. 1).

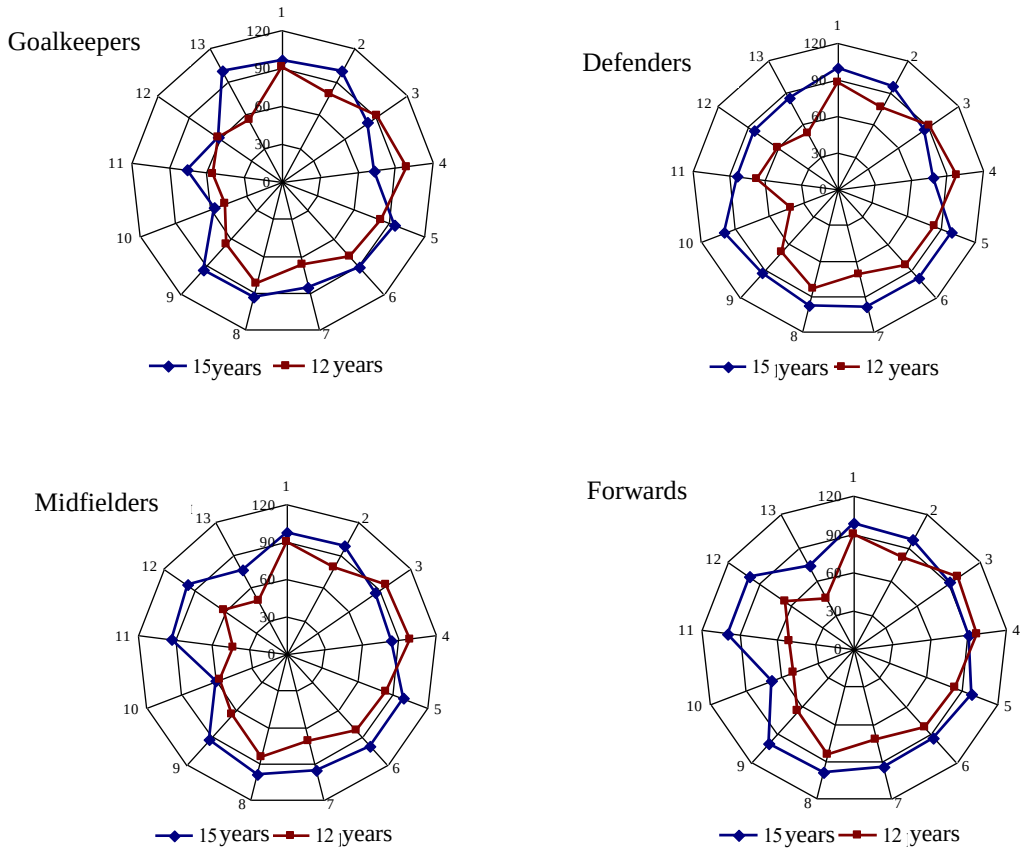

Fig. 1. Basic models of physical development, physical and technical readiness of players of 12 and 15 years of different playing roles:
1 - Body length (cm); 2 - Body weight (kg); 3 - resting heart rate (beats·min^{-1}); 4 - heart rate after a shuttle run (beats·min^{-1}); 5 - Shack running (s); 6 - Running 30 m (s); 7 - Run 15 m (s); 8 - Keeping the ball on the foot (s); 9 - Ball juggling (quantity); 10 - Ball management (s); 11 - Running 60 m (s); 12 - Shots on goal (balls); 13 - Ball strikes (m)

Discussion

The study confirmed the hypothesis of the presence of significant differences in the indicators of physical development, the level of physical and technical readiness of young players of different playing fields. These discrepancies are already observed at the age of 12 years and are exacerbated at the age of 15 years. The data obtained indicate the need for a differentiated approach to the training of young players of age groups.

As is well known, modern youth football develops by increasing the requirements to all sides of the training of young athletes [1, 6, 7]. In the process of competitive activity on the body are significant in magnitude and duration of loading, requiring the maximum mobilization of the body of young athletes and make high demands on their readiness. Therefore, for the proper construction of the training process, it is necessary to identify the features of the physical and technical readiness of the players of different game roles [9,17].

The results of our study complement the results of the authors [1, 19] who believe that in the preparation of football players of this age the coach should take into account their morpho-functional capabilities [4,6]. Comparing the indicators of physical development of football players, it can be seen that in these parameters the players of different playing roles are practically no different from each other. The findings differ somewhat from the results of studies by other authors [21], who found that goalkeepers have the greatest weight and body length. These differences with the results of other authors can be explained by the low football experience of the surveyed children and the need to improve the system of distribution of players by function.

In football, as in other sports games, each game position poses certain requirements to the level of manifestation of different qualities and properties of athletes, which must be taken into account in their evaluation [4, 5]. Therefore, in our study, we compared players of different game roles with each other. Goalkeepers have been found to have virtually low technical and physical fitness scores in virtually all testing results, as opposed to hitters, defenders, and midfielders. We explain this by the fact that the goalkeeper is a highly specialized player of defense and trains on a separate program. As a result of comparing most indicators of physical and technical preparedness of the strikers, defenders and

midfielders, no significant differences were found. This is due to the fact that in the training process the coach often changes the playing role of young athletes, in order to train and find the optimal playing role of each football player, depending on the competitive period. After all, the main feature of adolescence is associated with the process of puberty, resulting in significant changes in the psyche, there is high emotionality, mood imbalance, inflammation, exaggeration of their capabilities. Very often the manifestation of the so-called sense of adulthood is reflected in the behavior of the players in the game. At the same time, the body of adolescents is quickly adjusted to work and easily readjusted to another type of activity, due to the great mobility of nervous processes [19]. Therefore, in the practical work of the coach actively put players of 12 and 15 years in different zones of the playing field, thereby teaching them the specifics of different playing roles.

Thus, when choosing training loads for goalkeepers, trainers need to take into account the data obtained, which will allow to develop optimal programs for the development of flexibility, speed, strength, agility, as well as for improving technical skill. When selecting funds in the training process of representatives of other game roles, it is necessary to pay special attention to the implementation of the techniques of football players 12 and 15 years.

Conclusions

1. Young players of 12 and 15 years of different game specializations differ in terms of physical and technical fitness. The largest number of significant differences were found in the technical readiness of football players for 15 years.

2. Field players at speed capabilities are significantly superior to goalkeepers. Goalkeepers, on the contrary, have lower running speeds. The level of speed endurance is relatively high for defenders and midfielders, as opposed to goalkeepers. The obtained data allowed us to build models of physical development, physical and technical readiness of players of 12 and 15 years of different playing fields, on the basis of which training programs for representatives of different playing roles can be developed.

3. The data obtained indicate the need for a differentiated approach in the training process of young football players, taking into account their playing role. The differentiated approach is more relevant at the age of 15 compared to the age of 12.

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Conflict of interest

The authors state no conflict of interest.

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The model of prediction of changes in the functional state of athletes engaged in hand-to-hand combat under the influence of the training load

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Abstract
The purpose of the work is to develop a model for predicting changes in the functional state of athletes engaged in hand-to-hand combat, under the influence of a training load using psychophysiological indicators.
Material and methods. The study involved 24 male athletes who are professionally engaged in hand-to-hand combat with full contact with the opponent (full contact), and 20 athletes. The average age of the athletes was 19-26 years. Research methods: analysis of scientific and methodological sources, psychophysiological, mathematical statistics, fuzzy logic.
Results. The conducted studies proved the presence of significant differences in the values of psychophysiological indicators and the reaction to the training load of athletes with different levels of fitness, which made it possible to use these indicators to build a model for predicting the dynamics of a functional state. Changes in the functional state, determined by psychophysiological indicators, confirmed by corresponding changes in indicators of heart rate variability. The developed forecast model allows using two psychophysiological indicators (the time of a complex visual-motor reaction and the response index to a moving object), received to the load, to predict a change in the functional state of athletes engaged in hand-to-hand combat, with an overall accuracy of 95.5%. The forecast of changes in the functional state provides the trainer with the opportunity to timely adjust the volume of training loads and training regimen.
Conclusions. Significant differences between groups of trained athletes and beginners in terms of the state of nervous processes (the time of a complex visual-motor reaction and the response index to a moving object) to the load were revealed, which allowed developing a model for predicting the functional reaction to the load in athletes with different levels of sportsmanship. Using the obtained model allows predicting changes in the functional state of athletes that will take place under the influence of the test load, according to psychophysiological indicators without using the load with an overall accuracy of 95.5%.
Key words: hand-to-hand combat; psychophysiological indicators; fuzzy logic; forecast model

Анотація
Кочина М.Л., Чернозуб А.А., Адамович Р. Г., Кочін О.В., Фірсов О.Г. Модель прогнозу зміни функціонального стану спортсменів, що займаються рукопашним боєм, під впливом тренувального навантаження
Мета роботи – розробка моделі прогнозу зміни функціонального стану спортсменів, що займаються рукопашним боєм, під впливом тренувального навантаження з використанням психофізіологічних показників.
Матеріал і методи. В дослідженні взяли участь 24 спортсмени чоловічої статі, які професійно займаються рукопашним боєм з повним контактом з супротивником (фул-контакт), та 20 спортсменів-початківців. Середній вік спортсменів становив 19-26 років. *Методи дослідження*: аналіз науково-методичних джерел, психофізіологічні, математичної статистики, нечітка логіка.
Результати. Проведені дослідження довели наявність достовірних відмінностей у значеннях психофізіологічних показників та реакції на тренувальне навантаження спортсменів з різним рівнем тренованості, що дозволила використати ці показники для побудови моделі прогнозу динаміки функціонального стану. Зміни функціонального стану, визначені за психофізіологічними показниками, підтверджені відповідними змінами показників варіабельності серцевого ритму. Розроблена моделі прогнозу дозволяє за двома психофізіологічними показниками (часом складної зорово-моторної реакції та індексом реакції на рухомий об'єкт), одержаними до навантаження, прогнозувати зміну функціонального стану спортсменів, що займаються рукопашним боєм, з загальною точністю 95,5%. Прогноз зміни функціонального стану надає тренеру можливість своєчасно корегувати обсяги тренувальних навантажень та режими тренувань.
Висновки. Виявлені достовірні відмінності між групами тренованих спортсменів та початківців за показниками стану нервових процесів (часом складної зорово-моторної реакції та індексом реакції на рухомий об'єкт) до навантаження дозволили розробити модель прогнозу функціональної реакції на навантаження у спортсменів з різним рівнем спортивної майстерності. Використання отриманої моделі дозволяє прогнозувати зміни функціонального стану спортсменів, які відбудуться під впливом тестового навантаження, за психофізіологічними показниками без використання навантаження з загальною точністю 95,5%.
Ключові слова: рукопашний бій; психофізіологічні показники; нечітка логіка; модель прогнозу

Аннотация
Кочина М.Л., Чернозуб А.А., Адамович Г. Г., Кочин А.В., Фирсов О. Модель прогноза изменения функционального состояния спортсменов, занимающихся рукопашным боем, под влиянием тренировочной нагрузки
Цель работы - разработка модели прогноза изменения функционального состояния спортсменов, занимающихся рукопашным боем, под влиянием тренировочной нагрузки с использованием психофизиологических показателей. **Материал и методы**. В исследовании приняли участие 24 спортсмена мужского пола, которые профессионально занимаются рукопашным боем с полным контактом с противником (фулл-контакт), и 20 спортсменов. Средний возраст спортсменов составил 19-26 лет. Методы исследования: анализ научно-методических источников, психофизиологические, математической статистики, нечеткая логика.
Результаты. Проведенные исследования доказали наличие достоверных различий в значениях психофизиологических показателей и реакции на тренировочную нагрузку спортсменов с различным уровнем тренированности, которая позволила использовать эти показатели для построения модели прогноза динамики функционального состояния. Изменения функционального состояния, определенные по психофизиологическими показателями, подтвержденные соответствующими изменениями показателей вариабельности сердечного ритма. Разработанная модели прогноза позволяет по двум психофизиологическими показателями (время сложной зрительно-моторной реакции и индексом реакции на движущийся объект), полученными к нагрузке, прогнозировать изменение функционального состояния спортсменов, занимающихся рукопашным боем, с общей точностью 95,5%. Прогноз изменения функционального состояния предоставляет тренеру возможность своевременно корректировать объемы тренировочных нагрузок и режима тренировок.
Выводы. Выявлены достоверные различия между группами тренированных спортсменов и начинающих по показателям состояния нервных процессов (время сложной зрительно-моторной реакции и индексом реакции на движущийся объект) к нагрузке позволили разработать модель прогноза функциональной реакции на нагрузку у спортсменов с различным уровнем спортивного мастерства. Использование полученной модели позволяет прогнозировать изменения функционального состояния спортсменов, которые состоятся под влиянием тестовой нагрузки, по психофизиологическими показателями без использования нагрузки с общей точностью 95,5%.
Ключевые слова: рукопашный бой; психофизиологические показатели; нечеткая логика; модель прогноза.

Introduction

Today's high-achieving sport places significant demands on the functional state of athletes. In the process of improving sportsmanship training and competitive load on the physiological systems of the athlete is constantly increasing. This can cause not only an increase in the level of adaptation-compensatory reactions, but also negative shifts in the functional systems of the body of athletes, lead to overtraining, the emergence of donological and pathological conditions. Assessment of the functional state of athletes at rest and predicting its changes in the dynamics of training require the creation of methods and models that allow to obtain and process information, to calculate appropriate indicators that can serve as markers of adverse changes in the body, to classify states and to develop prevention and rehabilitation measures.

Assessment of changes in functional status in the process of training and competitive loads can be performed according to the indicators of the electrocardiogram [1, 2, 3, 4], heart rate variability [5, 6, 7, 8, 9], external respiration function [10], various biochemical indicators [11, 12, 13, 14, 15], and indicators of psychological status [16, 17].

Different indicators can be used to develop models for predicting changes in athletes' functional status in training dynamics. Among the most studied are the indicators of the cardiovascular system and indicators of heart rate variability [18, 19], statodynamic stability [20], indicators of the central nervous system [21], etc.

According to Shinkaruk [22], forecasting in sports is the first stage in managing the process of sports training. Predicting the possible consequences of using training technologies, taking into account the individual capabilities of athletes allow the coach to achieve significant results [23, 24]. But this prediction is purely subjective, based on the personal experience and intuition of the coach and is inherent in him. Kuan et. al. [25] consider that to make the forecasting process objective, appropriate criteria are needed and mathematical forecasting models developed using them.

One of the most important systems of the body of athletes is the central nervous system, the fundamental properties of which are the peculiarities of mental and physiological processes, temperament, character, set of prevailing feelings and motives of activity. Combining the properties of the central nervous system is purely individual and in each case can contribute to the professional success of athletes, or vice versa, can be an obstacle to high achievements.

Important characteristics of the central nervous system include sensorimotor reactions (simple visual-motor response and complex visual-motor response, which combine sensory and motor components of mental activity. Simple and complex visual-motor reaction characterize the features of the nervous processes in athletes, Martial Arts Quick and Accurate Response to Incentives When Determining Simple and Complex Visual Motor Response Time Indicates Responsive Athlete Responses Against Action during the hand-to-hand combat, which, according to Kuan et al. [25], is the key to success.

According to the results of numerical studies Makarenko et. al. [12] believed that the individual typological qualities of athletes can be determined by the strength, mobility and dynamism of the nervous system [26]. Characteristics of sensory functions of athletes of different specializations were studied by Rovniy [27]. The strength of the nervous processes characterizes the functional endurance of the central nervous system, as well as the ability to concentrate the excitation process. Smaller values of the index of the strength of the nervous process indicate the better for the combat ability of athletes [28].

Functional mobility of nervous processes characterizes the ability to switch from performing one motor action to another. The smaller the value of this indicator, the faster is the change of the CNS states, which provides better adaptation to the difficult conditions of hand-to-hand combat.

The dynamics of nerve processes according to Tropin [3], Iermakov et.al [29] characterize the ability to form reactions that are adequate to external conditions. The smaller the dynamics of nervous processes, the faster the corresponding reactions of the central nervous system to changes in external conditions are formed.

Useful information about the psychophysiological state of hand-to-hand athletes can be obtained by determining the response rates of a moving object [30]. These indicators include the ratio of the reaction time that occurred before the test stimulus (anticipation) and the delay time when the reaction occurred after the test stimulus, as well as the ratio of the number of anticipation reactions to the number of delay reactions, which characterizes the ratio of excitation and inhibition reactions in the central nervous system. The indicator can evaluate the equilibrium of processes in the cortex of the athlete's brain [31, 32]. The success of athletes in hand-to-hand combat depends more on arousal processes that provide a quick response to external stimuli.

The hypothesis of the study is the assumption that changes in psychophysiological indicators in the dynamics of training and competitive load can be

used to assess the functional status of athletes, as well as to develop forecast models.

The purpose of the work is to develop a model for predicting changes in the functional state of hand-to-hand athletes under the influence of training load using psychophysiological indicators.

Material and methods

Participants

Under our observation, there were 24 male athletes professionally engaged in hand-to-hand combat with full contact with the enemy (full contact - Group I), and 20 beginner athletes (beginners - Group II). The average age of athletes was 19-26 years. The first group consisted of 3 international-class masters of sports, 8 masters of sports, 10 candidates for sports masters, and 3 first-graders. The second group consisted of athletes engaged in hand-to-hand combat at the amateur level. All athletes agreed to participate in the study.

Procedure

Registration of the studied parameters was carried out before and immediately after the training load. Training in both groups took place over 1.5 hours. The structure of the training and the level of exercise were developed in accordance with the level of physical fitness of the athletes.

The study of psychophysiological indicators was performed using the device "PFI-1" chronoreflexometer (LLC "ASTER-ITI", Kharkov). A PFI rhythmograph-1 device (ASTER-ITI LLC, Kharkov) with EasyHRV software package was used for cardiac signal registration.

The following psychophysiological indicators were determined in all athletes: functional mobility of nervous processes, strength of nervous processes, dynamic of nervous processes, simple visual-motor reaction and complex visual-motor reaction, as well as time of advance, time of delay, number of reactions of anticipation, number of reactions of delay test for the speed of reaction to a moving object. The moving response rate for a moving object was calculated by the moving object response index, which was equal to the module in relation to the lead time to the delay time.

To verify changes in the functional state of athletes before and after loading in them were determined indicators of heart rate variability, which according to Adamovich RG. with co-authors reflect the current FS of athletes and its changes [33].

Functional status information was obtained using two measurement circuits. The main circuit consisted of a computerized chronoreflexometer, which allows a comprehensive study of the functional response of athletes to various stimuli by standard psychophysiological techniques [26, 28]. The obtained indicators of the state of nervous processes were stored in the study database and used for further analysis. An additional circuit formed by a computerized cardiothymograph allows synchronization with the main circuit to record a cardiogram. Indicators of heart rate variability, stored in the study database, allowed to conduct a cross-analysis of the functional status of the subjects.

Statistical analysis

Fuzzy Zadeh logic was used to develop a model for predicting changes in functional state under the influence of training load [34]. Statistical analysis of the results of the study was performed using descriptive statistics (with determination of mean values and mean square error). In the presence of a significant variation of indicators, medians (Me) and quartiles (25%; 75%) were determined. The significance of the differences between the indicators was assessed using the non-parametric Mann-Whitney criteria (independent samples) and Wilcoxon (dependent samples) [35]. The significance of the obtained results was determined at 95%.

Results

The test load used to develop a model for predicting changes in the functional state of trained athletes is given in Table. 1. The proposed first group test load in structure and content corresponds to the standard training of athletes engaged in melee combat. The load offered to beginners differed in content and time of exercise and corresponded to their level of fitness.

Table 1

Training structure of athletes engaged in hand-to-hand combat that was used as a test load

Components of training	Structural components	Content of load	Time distribution, %	Intensity load, % of max.
Introductory part	General training	General developmental exercises	5	30-40
	Special training		15	75-80

(20% of the time)				
Main part (70% of the time)	Technical training	Special exercises	10	75-80
	Tactical training	Improvement of the technique of complex elements	15	75-80
	Callisthenics	Correction of correlation of structural components of tactical schemes taking into account technical skill, anthropometric data and development of explosive force	10	75-80
		Basic: Increase of the level of explosive force in the conditions of anaerobic regime of energy-saving cookie.	10	75-80
	Integral preparation	Specialized: Increasing intramuscular and intramuscular coordination	25 10	75-80 -
		Implementation of technical skill in combination with the individual level of power development in the process of corrective sparring	10	-

In the table. 2 shows the average values of certain psychophysiological indicators of athletes of both groups before and after exercise.

Table 2

The average values of psychophysiological indicators of the subjects studied before and after loading

Terms of registration	Indexes	Groups	
		I (n=24)	II (n=20)
Before loading	Simple motor-visual reaction time (ms)	261,1±13,8	261,7±19,8
	Time of complex visual-motor reaction (ms)	361,5±21,4	396,9±55,6[2] U=83; Z=2,57; p=0,01
	Functional mobility of nerve processes (ms)	246,7±57,9	282,1±45,5
	Strength of nervous processes (ms)	406,1±74,7	442,9±80,2
	Number of anticipation reactions / Number of delay reactions (yo)	0,18 (0,11;0,96)	0,74 (0,18; 1,22)[2] U=43; Z=2,29; p=0,021
	Moving Object Reaction Index	2,4±0,7	0,86±0,4[2] U=92; Z=2,29; p=0,021
After loading	Simple motor-visual reaction time (ms)	242,7±21,1[1] Z=3,771; p=0,0002	254,3±38,9
	Time of complex visual-motor reaction (ms)	337,0±32,5[1] Z=3,343; p=0,001	381,9±49,7[2] U=65; Z=2,95; p=0,003
	Functional mobility of nerve processes (ms)	212,6±44,7[1] Z=2,57; p=0,001	203,3±60,2
	Strength of nervous processes (ms)	343,6±73,4[1] Z=3,03; p=0,002	357,1±54,4[1] Z =3,03; p=0,002
	Number of anticipation reactions / Number of delay reactions (yo)	0,67 (0,38; 1,22)	0,82 (0,43; 1,22)
	Moving Object Reaction Index	0,9±0,5[1] Z=2,37; p=0,018	0,87±0,03

Notes: 1 - differences in the mean values obtained before and after training are valid according to the Wilcoxon criterion; 2 - differences in mean values of group II and group II indicators are significant by the Mann-Whitney test ($p < 0.05$); for the indicator Number of anticipation reactions / Number of delay reactions (yo) medians and quartiles were calculated (25%; 75%); n is the number of athletes in the group

Further analysis and modeling of the change of functional state under the influence of the test load were performed according to the procedures shown in Fig. 1.

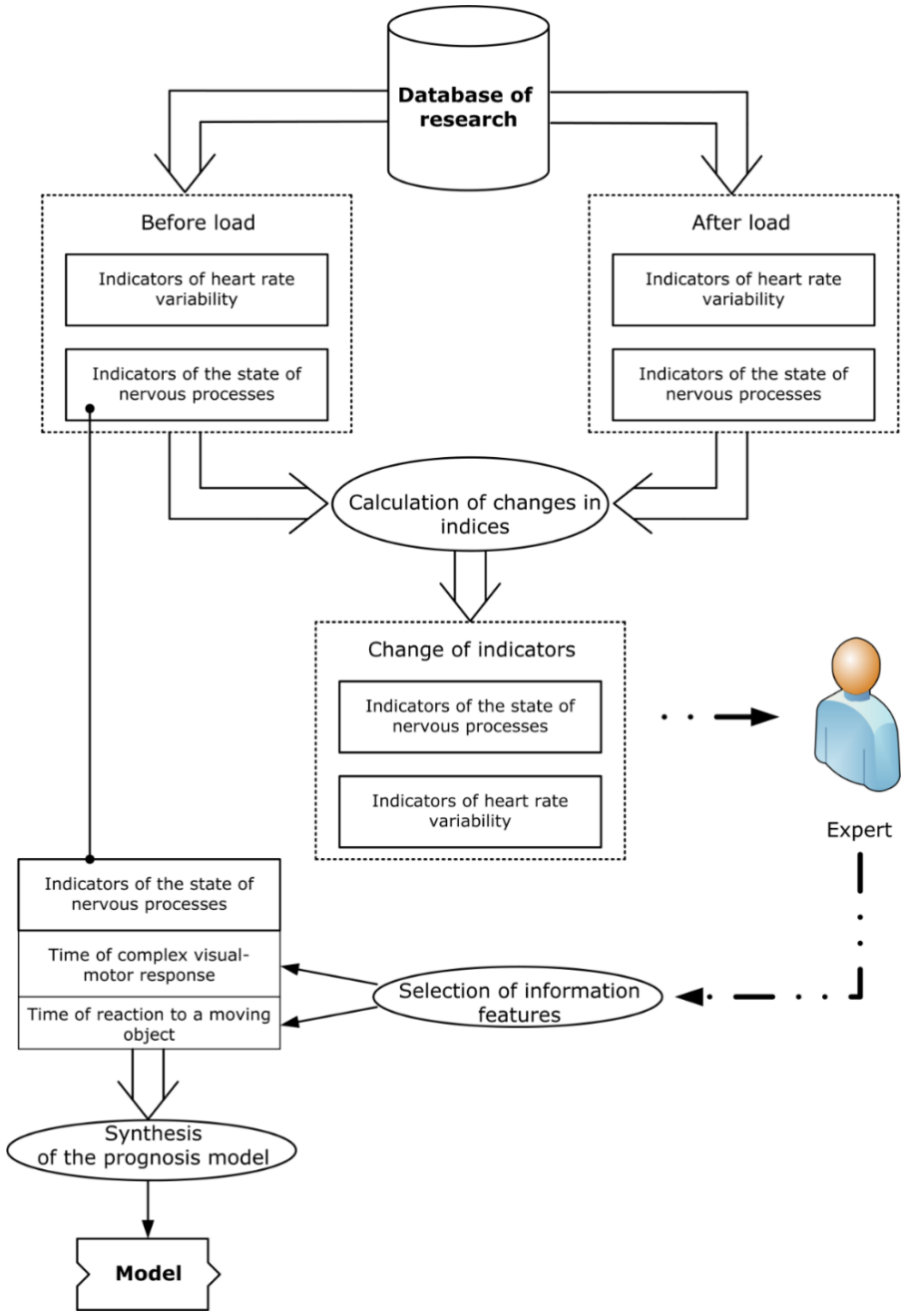

Fig. 1. Procedure for analysis of functional state indicators and simulation of reaction to test load

From the database of the results of the study were taken indicators of the variability of cardiac rhythm and state of nervous processes and calculated the change in their absolute values by subtracting the initial values from the final ones. These changes were then analyzed and hypotheses were made regarding the relationship between these changes in functional status and exercise load.

Analysis of changes in heart rate variability using fuzzy clustering according to the fuzzy c-mean algorithm revealed that all athletes who are new to the dynamics of change in heart rate variability under the influence of load belong to the cluster of its perception, indicated by the index t, and , which is indicated by index 1. That is, the response to the load of athletes of the studied groups was different. Significant differences in the load between groups of athletes were found only in the proportion of investigated indicators of heart rate variability [33], but after the load almost all indicators differ significantly. On the other hand, significant differences were found between the studied groups of athletes by the indicators of the state of nervous processes before loading, namely the time of complex visual-motor reaction (ms) and the index of reaction to a moving object (cu) (Table 2).

According to these two indicators, a model for predicting the functional response to loading in athletes with different levels of athletic skill was synthesized.

The procedure of synthesis of the model of forecasting the reaction to load in graphical form is shown in Fig. 2. To obtain fuzzy rules, a matrix was formed from previously selected indicators of the state of nervous processes, namely: the time of complex visual-motor reaction (ms) and the index of reaction to a moving object (cu). These data were supplemented by a column indicating which load sensing group (1 or 2) the athlete was assigned to. Complex visual motor response time (ms) and response index for a moving object (cu) were subjected to subtractive clustering (a mountain clustering algorithm) developed by Yager et. al. [36].The parameters of the clustering algorithm were set in accordance with the recommendations of the Scilab package. Each received cluster was matched by one fuzzy rule, and the coordinates of the cluster centers were the coordinates of the maximum of the membership functions, which used the Gaussian function [37]. According to the received logical rules and membership functions, a set of linear functions is formed, which links the logical rules and data of the corresponding load perception group (1 or 2). Formal recording of a system of fuzzy equations, a set of coordinates of centers and parameters of compression-stretching and linear equations of forms is a model of forecast. In the process of model synthesis, the procedure of adjusting it was performed, which consisted of cyclic modification of the parameters of compression - stretching of the membership function and coefficients of linear functions to minimize the error of the forecast using the model.

The scheme of using the model of prediction of change of functional state under the influence of the test load is shown in Fig. 3. Using the obtained model will allow to predict changes in the functional state of athletes that will arise under the influence of test load according to certain psychophysiological indicators. It is enough to define only two indicators: time of complex visual-motor reaction (ms) and index of reaction to the moving object (cu). Validation of the prediction model using indicators of 20 non-training athletes showed an overall accuracy of 95.5%.

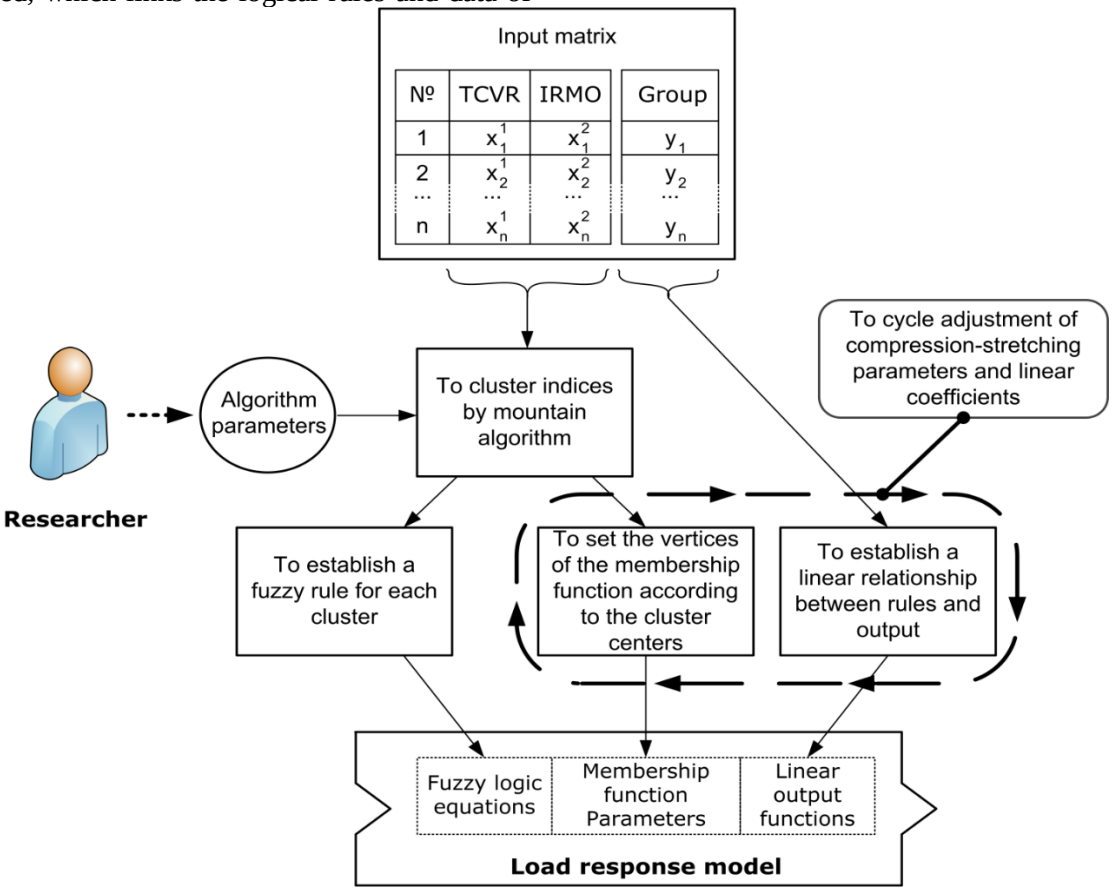

Fig. 2. Procedure of synthesis of model of predicting change in the functional state of an athlete under the influence of load

Discussion

According to the Table. 2, it can be noted that the Simple Motor-Response Time (ms) and the Complex Visual-Motor Response Time (ms) are significantly reduced after loading in the first group and practically do not change in the second. In addition, there are significant differences in the time of complex visual motor response (ms) between the first and second groups before and after loading. Initial values Functional mobility of nerve processes (ms) and Strength of nerve processes (ms) in athletes of the studied groups did not differ significantly, after loading these indicators decreased significantly in the first groups. When examining the results of a test for the response rate of a nra, a moving object to the load found that significantly more balanced processes in the nervous system are observed in trained athletes, as evidenced by the number of anticipation reactions / the number of delay reactions (cu). After loading, this indicator is close in value in both groups. Also, prior to loading, the groups differed significantly in the Moving Object Reaction Index (cu).

Our previous studies of the dynamics of heart rate variability indicators [2] showed that before the test load, there were significant differences between the studied groups only in the vegetative rhythm index, the adequacy of the regulation processes, as well as the spectral characteristics. After loading, virtually all indicators of heart rate variability in the athletes of the studied groups differed significantly. This confirmed the presence of reliable response of the body of athletes to the test load and sensitivity to changes in the functional state of certain psychophysiological indicators.

Thus, the data obtained confirm the different response of the athletes of the studied groups to the training load. On the other hand, the presence of significant differences in psychophysiological indicators between the studied groups made it possible to use these indicators to build a model for predicting the dynamics of the functional state.

Physical activity causes each athlete appropriate changes in functional status, which can be classified as a norm of reaction or indicate a pre-existing or pathological condition. The proposed scheme (Fig. 3) identifies two ways of changing the functional state.

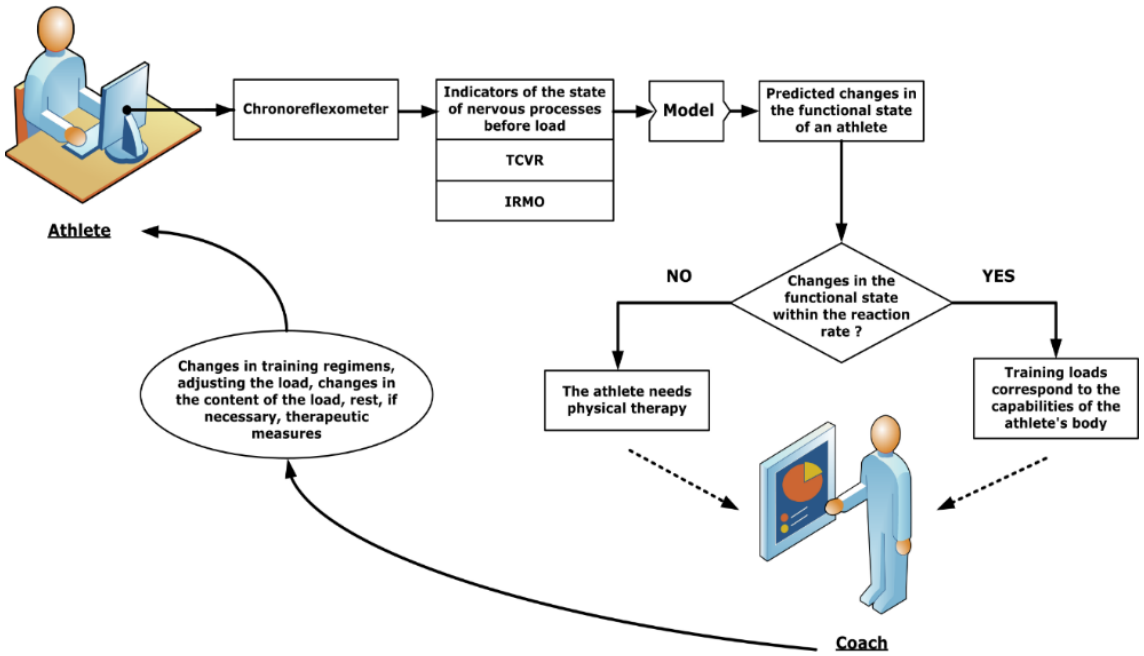

Fig. 3. Scheme of using models of predicting changes in the functional state of athletes under the influence of test load

If the predicted functional state changes relate to the normal reaction, ie the athlete enters cluster 1 in response to the load, training can be carried out according to the scheme corresponding to the current stage of training. If, as a result of using the prediction model, the athlete falls into cluster 2, then normalization of his functional state is required, which includes not only correction of the training process, but also more in-depth medical examination and appropriate rehabilitation measures in order to prevent overtraining, occurrence of pathological or pathological changes.

Predictive approaches in sports can be divided into two groups. The first group includes the prediction of success in training or competitive activities, the second - changes in the functional state

of athletes under the influence of training (competitive) loads.

Predicting the success of athletes' competitive activity is described in a large number of papers in which the authors study different changes in functional status indicators, morphofunctional indicators, model characteristics of athletes of a particular sport, previous success, and indicate that they can predict changes in functional status, efficiency . But there is no prediction mechanism or real model of forecast itself. For example, comparisons with model characteristics and the statement that for athletic success in adult sports athletes must be runners-up in youth are suggested by Latishev [26]. The approach proposed by the author to predict sports performance is not supported by the results of the use of any statistical criteria or methods and is verbal [38].

Volodchenko [39] proposes to use a table in which to score the scores of 31 varied athletes, whose determination requires the use of a large number of instrumental techniques to obtain a prediction of competitive performance in kickboxing. Prediction of the proposed approach requires the preliminary determination of all indicators and the calculation of the forecast threshold according to the proposed table, that is, there is a time-consuming process of estimating a large number of indicators in manual mode, which reduces the effectiveness of the proposed methodology.

Currently, there are a number of works in which predictions in sports are constructed using modern methods of data mining - neural networks, fuzzy logic, discriminant, correlation-regression and factor analysis [40, 41, 42].

For example, Yavorska [16] proposed a program for predicting the performance of athletes based on their specific sports parameters using a complex mathematical approach, which includes vector and matrix analysis, variance and factor, as well as the theory of multidimensional linear regression in Euclidean space. Glotov et. al. [43] proposed, by a large number of indicators characterizing the functional status of athletes and their genotypes, to create regression models that allow one to determine the most informative ones and predict success in certain sports. Baranaev [44], using correlation structures of indicators of young athletes, revealed the criteria for the selection and prediction of athletes' success at the stage of sports specialization.

Thus, the use of modern methods of data analysis allows to obtain reliable new results, to build models of forecasting changes in the functional state of athletes under the influence of load, the success of athletes in certain sports, to determine the criteria for sports selection.

The developed model allows to predict, by two psychophysiological indicators (Time of complex visual-motor reaction (ms) and Index of reaction to the moving object (uo)), the functional state of hand-to-hand athletes, with probability 95 , 5%. The prognosis of the change of the functional state gives the trainer the opportunity to adjust the amounts of training loads and training regimes in a timely manner.

Conclusions

1. Significant differences between groups of trained athletes and beginners by the indicators of the state of nervous processes of time of complex visual-motor reaction and the index of speed of reaction to a moving object to the load were revealed, which allowed to develop a model of forecasting of functional reaction to loading in athletes with different level of sportsmanship.

2. It is shown that physical activity causes in each athlete corresponding changes in the functional state, which can be classified as a norm of reaction or indicate a donological (pathological) state. If the predicted functional state changes relate to a normal reaction, the training may be performed according to a pattern consistent with the current preparation stage. Otherwise, the normalization of the functional state, which includes not only the correction of the training process, but also more in-depth medical examination and appropriate rehabilitation measures to prevent adverse conditions, is required.

3. Using the obtained model will allow predicting changes in the functional state of athletes under the influence of test load on psychophysiological indicators without using a load with an overall accuracy of 95.5%, which allows the trainer to timely adjust the amount of training loads and training regimes.

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Conflict of interest

Authors state no conflict of interest.

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Execution efficiency research of different ways of serves in the beach volleyball men's teams competitive activity

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Abstract
Purpose: to develop the technique for assessment of quantitative indicators of execution efficiency of serves in competitions of beach volleyball league in Kharkiv among men's amateur teams.
Material and methods: the analysis of statistical data, which are obtained as a result the pedagogical observations of power jump serves and aimed serves in 25 games of these competitions, is carried out (with total number of serves 2055). The following methods were used: analysis of scientific-methodical literature; pedagogical observation, methods of mathematical statistics.
Results: calculated: distributions of power jump serves and aimed serves according to a certain four-point rating scale; quantitative indicators of execution efficiency of serves which are generalized by results of the analysis of the relevant statistical data. The results of the corresponding calculations showed that players tried not to execute serves in the 4th, 5th and 6th conditional zones because the rival's players are there who after serve receiving in most cases precisely addressed a ball to the partner for the organization of attack in reply. Power jump serves weren't also given to 1, 2 and 3 zones, and their greatest number was sent to the 8 and 9 zones. The direction of aimed serve generally concentrated in the 8th and also the 2nd zones of the playground. The assessment of indicators of serve efficiency, which were directed to different conditional zones of the court, is carried-out.
Conclusions: the technique for carrying out the analysis of statistical data concerning execution of different ways of serves in beach volleyball competitions and assessment of the corresponding quantitative indicators of their execution efficiency is generalized. The results can be used in solving the problem of increase in execution efficiency of serves in the course of training and competitive activities of beach volleyball teams.
Keywords: zone, distribution, indicator, effectiveness, assessment.

Анотація
Мельник А.Ю., Стрельнікова Є.Я. Дослідження ефективності виконання різних способів подач у змагальній діяльності чоловічих команд з пляжного волейболу
Мета: узагальнити методику для оцінки кількісних показників ефективності виконання подачі в змаганнях пляжної волейбольної ліги м. Харкова серед чоловічих аматорських команд.
Матеріал та методи: проведено аналіз статистичних даних, які одержані в результаті педагогічних спостережень за виконанням силових подач у стрибку та націлених подач в 25 іграх (з загальною кількістю подач 2055) даних змагань. Використовувались наступні методи: аналіз наукової-методичної літератури; педагогічне спостереження, методи математичної статистики.
Результати: розраховані: розподіли силових подач у стрибку та націлених подач відповідно визначеної чотирибальної шкали оцінок; кількісні показники ефективності виконання цих подач, які узагальнені по результатам аналізу відповідних статистичних даних. Результати відповідних розрахунків показали, що гравці намагалися не подавати, в 4, 5 та 6 умовні зони, оскільки там знаходяться гравці суперника, які після прийому подачі у більшості випадків точно адресували м'яч партнеру для організації атаки у відповідь. Силову подачу у стрибку також не подавали у 1, 2 та 3 зони, а найбільшу їх кількість направляли в 8 та 9 зони. Напрямок націлених подач в основному зосереджувався в 8, а також 2 зону ігрового майданчика. Проведена також оцінка показників ефективності подач, які були спрямовані в різні зони ігрового майданчика.
Висновки: узагальнена методика для проведення аналізу статистичних даних стосовно виконання різних способів подачі в змаганнях з пляжного волейболу та оцінки відповідних кількісних показників ефективності їх виконання. Результати можуть бути використані у вирішенні проблеми підвищення ефективності виконання подачі в процесі тренувальної та змагальної діяльності волейбольних команд з пляжного волейболу.
Ключові слова: зона, розподіл, показник, результативність, оцінка.

Аннотация
Мельник А.Ю., Стрельникова Е.Я. Исследование эффективности выполнения различных способов подач в соревновательной деятельности мужских команд по пляжному волейболу.
Цель: обобщить методику для оценки количественных показателей эффективности выполнения подачи в соревнованиях пляжной волейбольной лиги г. Харькова среди мужских любительских команд.
Материал и методы: проведен анализ статистических данных, полученных в результате педагогических наблюдений за выполнением силовых подач в прыжке и нацеленных подач в 25 играх (с общим количеством подач 2055) данных соревнований. Использовались следующие методы: анализ научной методической литературы; педагогическое наблюдение, методы математической статистики.
Результаты: рассчитаны: распределения силовых подач в прыжке и нацеленных подач в соответствии с определенной четырехбалльной шкалой оценок; количественные показатели эффективности выполнения этих подач, которые обобщены по результатам анализа соответствующих статистических данных. Результаты соответствующих расчетов показали, что игроки старались не подавать, в 4, 5 и 6 условные зоны, поскольку там находятся игроки соперника, которые в большинстве случаев после приема подачи точно адресовали мяч партнеру для организации атаки в ответ. Силовую подачу в прыжке также не подавали в 1, 2 и 3 зоны, а наибольшее их количество направляли в 8 и 9 зоны. Направление нацеленных подач в основном сосредоточен в 8, а также 2 зону игровой площадки. Также проведена оценка показателей эффективности подач, которые были направлены в различные зоны игровой площадки.
Выводы: обобщена методика для проведения анализа статистических данных по выполнению различных способов подачи в соревнованиях по пляжному волейболу и оценки соответствующих количественных показателей эффективности их выполнения. Результаты могут быть использованы в решении проблемы повышения эффективности выполнения подачи в процессе тренировочной и соревновательной деятельности волейбольных команд по пляжному волейболу.
Ключевые слова: зона, распределение, показатель, результативность, оценка.

Introduction

The development of beach volleyball in Ukraine, as well as in the international arena, the successful debut at the Atlanta Olympic Games and participation in further Olympic forums, the expansion of the network of international and national competitions attracts the attention of organizers, coaches, athletes and spectators [1, 2].

Success in the competitive activities of beach volleyball teams is determined by various factors that require close attention. The decisive factor for winning games in both men's and women's teams is submission. [3] This is one of the main techniques by which the ball is introduced into the game without affecting its teammates and opponents in order to win a point immediately after its execution or to complicate its reception in order to disrupt the organization of the appropriate attack [2 , 4-6].

In this case, volleyball players, as a rule, have to overcome difficulties that prevent them from completing the pitch qualitatively. They are related to external weather conditions, especially strong wind, rain, bright sun, high air temperature, hot sand [2, 3, 7].

Important in beach volleyball, as in classical volleyball, is the ability of players to perform 2-3 types of innings powerfully and accurately and effectively apply them depending on the playing situation. Considering that the size of the playground (16x8 m) in beach volleyball is almost the same as in the classic (18x9 m), and there are only two players, it is obvious that each player in the first case is much more responsible for the success of the submission . On the complexity of the submission depends largely on the quality of receiving the ball by the opponent, which, in turn, affects the efficiency of his transfer to the attacker and, ultimately, creates the prerequisites for winning a point. Given that in classical volleyball, up to 5 players can take part in receiving the ball, it is much more difficult for a team of two players (one blocking and one defender) to organize a high quality reception in the beach volleyball. This also applies to game actions after successful receiving of the ball from the pitch, which are related to the subsequent transfer of his partner for the execution of the striker in response, the result of which depends largely on the role of the player receiving the transfer [3, 8, 9] .

Beach volleyball is most commonly used in the form of serves such as: jumping (it can be power or top straight), planning and candlelight. Currently, two-thirds of innings are done in the jump. The serves in the jump alternate with the goals (mostly in the last meter of the playground). Increasingly, scheduling serves are used in the jump [2, 3].

It should be noted that in the current scientific and methodological literature, the studies that are related to the problem of increasing the efficiency of performing different ways of giving in beach volleyball, is not enough. When analyzing statistics on the performance of the submission in the competitive activity of teams widely used method of scoring the level of its performance, based on a four-point scale, which includes from 2 to 5 points [2, 10-12]. This system, in our opinion, allows only very superficial description of the quality of the filing. It is clear that in the framework of this methodology it is not possible to obtain detailed information on the quantitative characteristics of the efficiency of filing by individual players and teams, depending on various factors. Therefore, from a practical point of view, further study and improvement of different methods of evaluating the quantitative indicators of the effectiveness of different ways of submission in competitive activities is important for the coaches of the team and the professionals of beach volleyball.

The purpose of the work: to summarize the methodology for evaluating quantitative performance indicators of submission in Kharkiv beach volleyball competitions among men's amateur teams.

Material and methods

The paper analyzes the statistics obtained during pedagogical observations on the performance of submissions in 25 games of Kharkiv beach volleyball league among men's amateur teams [3]. The following methods were used: analysis of scientific and methodological literature; pedagogical observations, methods of mathematical statistics.

Results

Techno-tactical improvement of performance by volleyball players of different types of innings, improvement of their efficiency and quality is one of the main reserves for improving the effectiveness of competitive activity in volleyball. At the present stage of its development, there is an urgent need for a more detailed analysis of the efficiency of filing, which will allow coaches to use the results obtained and promptly make adjustments both in the training process and in the competitive activities of teams [4].

The analysis of literary sources devoted to various aspects of classical volleyball showed that many authors [13-18] repeatedly made attempts to create methods for evaluating the technical and tactical actions of volleyball players in competitive

activities. As for beach volleyball, like in the case of classical volleyball, the ball scoring technique is often used to assess the level of performance. This technique allows to evaluate to a considerable extent only the qualitative component of the performance of the filing: excellent is rated at 5 points, good - 4, satisfactory - 3, unsatisfactory - 2 [2, 12]. Such a simplified system of assessments allows for a significant risk of subjectivity in determining the appropriate assessment, does not contain quantitative characteristics of performance indicators such as the proportion of successfully completed or lost innings, the probability of winning a point depending on various factors, etc. Therefore, it is clear that, from a practical point of view, team coaches are very interested in receiving objective information about quantitative performance metrics that fully take into account the ultimate consequences of performing it.

The study of the problem of determining the efficiency of performing different ways of submission in competitive activities is carried out in this work on the basis of the method [4, 18-20], which was successfully used to solve a similar problem in classical volleyball. It is based on the mathematical processing of relevant statistics related to the submission. We suggest, by analogy with classical volleyball, to keep a record of the code record of their performance in pedagogical observations during competitions. The technique [4] was modified by us, taking into account the specifics of beach volleyball action. In particular, a four-point rating scale (1 to 4) is used to analyze relevant statistics and evaluate feed performance. According to the results obtained in [3, 4], a quantitative Ki indicator is introduced for each estimate. These metrics determine, in essence, the probability of winning a point after the subsequent game activities that accompany the submission. We have selected the following numerical values for Ki using the results of [3, 4]: $K_1 = 0$, $K_2 = 0.25$, $K_2 = 0.6$, $K_4 = 1.0$. For a detailed definition of these indicators, see work [3, 4].

In this study, in accordance with the results of [2] the quantitative indicator of the efficiency of performing a particular method of serves *(S)*, we will determine the following formula:

$$S = \sum_i n_i K_i / N \quad ,$$

where:

n_i - the number of serves that match the index score and the selected scale,

K_i - the above values of indexes (index and takes integer values from 0 to 4),

$N = \sum_i n_i$ – the total number of completed submissions of this type.

That is, the average efficiency S determines the combined probability of winning points after completing the innings, which are accompanied by a certain end result of scoring [4].

Because modern beach volleyball usually uses jumping power (more often men), planning and top straight (running from the spot or from the jump), so in our studies, we conditionally split them into two groups: jump and targeted serves, which included the scheduling and top feed [3, 4].

We conducted code records of the results of passing the innings during pedagogical observations, which were conducted in the 25 games of competitive activity of the teams mentioned above. The total number of innings in these games was 2055, of which 39.9% were power innings in the jump and 60.1% were targeted innings [3]. That is, all the innings that were made by all the players of the teams during the meetings between themselves, which were stipulated in the standings, were taken into account. In the future, when evaluating performance indicators, we will study only the relevant indicators, which are summarized by the results of the analysis of relevant statistics.

A detailed analysis of the statistics regarding the performance of jumping power and targeted serves has been performed. In Fig. In Fig. 1 shows the results of calculations of distributions of fixed filings, which are determined by the ratio of the values of the number of completed filings of this type ni to their total number N, in accordance with the scale of estimates that we used in the performance of this work [3].

Regarding the estimation of the quantitative measure of the efficiency of the submission S, the corresponding calculations using calculated distributions of the number of completed submissions of a certain type with respect to the scale of estimates show that they reach quite high values and are equal to 38.2% and 40.1% for power serves in the jump and targeted serves, respectively.

In our view, from the practical point of view of great interest for coaches and team players is the calculated distribution of innings on the conditional areas of the playground and the associated values of the efficiency of the filing in these areas [3].

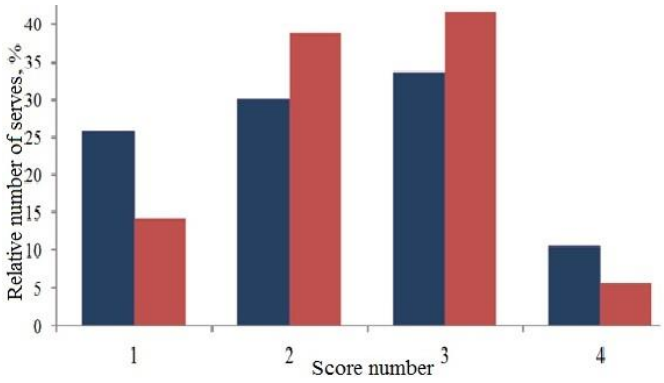

Fig. 1. The distribution of power serves in the jump and targeted serves according to a defined four-point rating scale:

- serves in the jump;
- targeted serves;

1 - filing out, grid, intersection of the front line;
2 - after receiving the ball, the ball is accurately addressed to the partner (organization of the corresponding attack of the opponent);
3 - after receiving the opponent's submission failed to organize the attack;
4 - loss of a point to a competitor directly after a poor reception of a pass or hit of a ball in his court ("Ace")

In Fig. 2 shows the results of calculating the performance of a jump in power and targeted innings, depending on the number of the playground area, in the direction in which, the corresponding innings, these figures reached the highest values.

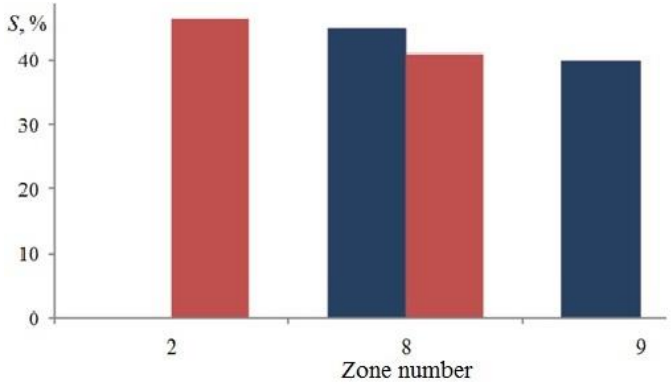

Fig. 2. Performance Indicator of Jumping Power and Targeting Depending on the Playground Area Number:

- serves in the jump;
- targeted serves;

S - quantitative indicator of the efficiency of performing a particular method of serves

Discussion

The results of the study, which are related to the calculations of the power distribution in the jump and the targeted innings according to the determined four-point scale of assessment, show (see Fig. 1) that 25.8% of the force innings in the jump and 14.1% of the targeted innings were lost (out or out) relative to the total total innings. The high number of innings lost indicates that many players in the games demonstrated an inability to choose the right way of submission and did not take due account of external environmental conditions [3]. It should be noted that only 10.5% of power passes in the jump and 5.5% of targets were won immediately after their execution due to the unsuccessful reception of the opponent's submission or hit of the ball in his court ("aces").

A detailed analysis of the statistics obtained regarding the distribution of completed innings, depending on the number of the playground area to which the players mainly directed them. As the result of this analysis, players tried not to file in the fourth, fifth and sixth zones, because there are opponents, who in most cases accurately addressed the partner's ball to organize the attack. The power supply in the jump was not submitted in zones 1, 2 and 3, and the

largest number was sent to zones 8 and 9 [3]. Moreover, the calculated values of the efficiency of filing in these zones are 45% and 39.8%, respectively (Fig. 2).

Regarding targeted innings, their focus was mainly concentrated in zone 8 - 23.5% of innings, as well as in zone 2 of the playground - 21.3% [3]. As can be seen from Fig. 2, the performance index S reached 41% and 46.3% for these zones, respectively.

It should be noted that from the tactical point of view 8 the zone is between two players near the front line, which makes it possible to ensure a high probability of winning a point due to the inconsistency of the actions of the opponent's players.

From a practical point of view, it is important for team coaches to have an objective assessment of the quantitative performance indicators of the various modes of submission. In order to further determine the capabilities of the proposed methodology and to verify the validity of the analysis results, it is necessary to carry out the processing of relevant statistical material of a larger volume in order to calculate the performance indicators in the performance of different filing methods as individual players and teams as a whole, depending on the party number and conditional playground areas. Further work is required to perform the appropriate calculations.

Conclusions

1. A generalized methodology for analyzing statistics on the performance of various methods of submission in beach volleyball competitions and the assessment of appropriate quantitative indicators of their performance. It is based on the results of pedagogical observations of the game, which are combined by a single system of code-recording of the submission of the application using the appropriate four-point rating scale and mathematical processing of the information obtained. When calculating these characteristics, the jump statistics and targeted innings were used to obtain the relevant statistics we obtained from the analysis of 25 Kharkiv beach league games among men's amateur teams.

2. The results of the calculations of the performance of the filing performance show, in particular, that: they reach quite high values and are 38.2% and 40.1% for power jump and targeted serves, respectively; the highest values of these indicators were observed in the direction of power serves in the jump zone 8 - 45% and targeted serves in zone 2 - 45,3%.

Conflict of interest

Authors state no conflict of interest.

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Red blood cells state and calcium content of in the blood plasma during physical activity in marathon runners of various qualifications

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Abstract
The aim of the work is to investigate the morpho-functional state of peripheral blood erythrocytes and the content of Ca^{2+} in the blood plasma during physical exercise in marathoners of different qualifications.
Material and methods. The studies were conducted in three groups of marathoners aged 20–25 years old with conditionally high, medium and low performance. Exercise was performed for 90 minutes on a bicycle ergometer with a given power. The study of peripheral blood erythrocytes was performed before and after exercise. The osmotic resistance of erythrocytes, the content of Ca^{2+} and free fatty acids in the blood were determined. Morphological study of erythrocytes was performed using a scanning electron microscope and stained by standard techniques. The red blood cell form index was determined by a special formula. Changing the content of Ca^{2+} enhances lipid melting, increases membrane fluidity and increases surface tension, with the result that the discocytes are stretched and thinned, the central pits deepen and the surface roughness increases, the volume and number of conical pores, and peripheral blood erythrocytes density.
Results. Marathon runners of different groups after physical exercise differed in terms of the frequency of cardiac sweeps, the content of free fatty acids and the osmotic resistance of red blood cells. This is closely correlated with changes in the electrolyte and metric composition of erythrocytes and the presence of their reversible and irreversible forms in the general circulation after exercise.
Conclutions. Physical activity causes structural and functional reorganization of erythrocytes, which is based on a change in their microelement composition, a decrease in osmotic resistance, mainly in poorly trained marathoners, and the appearance of various forms of erythrocytes against the background of the destruction of degenerative forms and an increase in the active release of young forms, which is a sign of high adaptive capacity in highly skilled athletes.
Key words: physical loading, red blood cells, osmotic resistance, calcium, marathon runners.

Анотація
Олиференко І.А., Попель С.Л. Стан еритроцитів і зміст кальцію в плазмі крові при фізичному навантаженні у марафонців різної кваліфікації
Мета роботи – дослідити морфо-функціональний стан еритроцитів периферичної крові і вміст Ca^{2+} в плазмі крові при фізичному навантаженні у марафонців різної кваліфікації. **Матеріал і методи.** Дослідження проводилися в трьох групах марафонців у віці 20-25 років з умовно високою, середньою і низькою працездатністю. Фізичне навантаження виконувалася протягом 90 хв на велоергометрі із заданою потужністю. Дослідження еритроцитів периферичної крові проводили до і після фізичного навантаження. Визначали осмотичну резистентність еритроцитів, вміст Ca^{2+} і вільних жирних кислот в крові.
Результати. Марафонці різних груп після фізичного навантаження розрізнялися за показниками частоти серцевих скорочень, вмістом вільних жирних кислот та осмотичної резистентності еритроцитів. Це тісно корелює зі зміною електролітного і метричного складу еритроцитів та наявності їх оборотних і необоротних форм в загальному кровотоці після фізичного навантаження. Зміна вмісту Ca^{2+} підсилює плавлення ліпідів, збільшує плинність мембран і підвищує поверхневий натяг, в результаті чого дискоцити витягуються і витоншуються, центральні ямки поглиблюються і збільшується шорсткість поверхні, обсяг і кількість конусоподібних пор, а також щільність еритроцитів периферичної крові.
Висновки. Фізичне навантаження викликає структурно-функціональну перебудову еритроцитів, в основі якої лежить зміна їх мікроелементного складу, зниження осмотичної резистентності, в основному у мало тренованих марафонців і появі різноманітних форм еритроцитів на тлі деструкції дегенеративних форм і посиленням активного викиду молодих форм, що є ознакою високих адаптаційних можливостей у висококваліфікованих спортсменів.
Ключові слова: фізичне навантаження, еритроцити, осмотична резистентність, кальцій, марафонці**.**

Анотация
Олиференко И.А., Попель С.Л. Состояние эритроцитов и содержание кальция в плазме крови при физической нагрузке у марафонцев разной квалификации
Цель работы – исследование морфо-функциональное состояние эритроцитов периферической крови и содержание Ca^{2+} в плазме крови при физической нагрузке у марафонцев разной квалификации.
Материал и м**етоды**. Исследования проводились в трех группах марафонцев в возрасте 20-25 лет с условно высокой, средней и низкой работоспособностью. Физическая нагрузка выполнялась в течение 90 мин на велоэргометре с заданной мощностью. Исследование эритроцитов периферической крови проводили до и после физической нагрузки. Определяли осмотическую резистентность эритроцитов, содержание Ca^{2+} и свободных жирных кислот в крови.
Результаты. Марафонцы различных групп после физической загрузки различались по показателям частоты сердечних покращений, содержанию свободных жирних кислот и осмотической резистентности эритроцитов. Это тесно корелирует с изменением электролитного и метрического состава эритроцитов при наличии их обратимых и необратимых форм в общем кровотоке после физической нагрузки. Изменение содержания Ca^{2+} усиливает плавление липидов, увеличивает текучесть мембран и повышает поверхностное натяжение, в результате чего дискоциты вытягиваются и истончаются, центральные ямки углубляются и увеличивается шероховатость поверхности, объём и количество конусовидных пор, а также плотность эритроцитов периферической крови.
Выводы. Физическая нагрузка вызывает структурно-функциональную перестройку эритроцитов, в основе которой лежит изменение их микроэлементного состава, понижение осмотической резистентности, в основном у мало тренированных марафонцев, и появлении разнообразных форм эритроцитов на фоне деструкции дегенеративных форм и усилением активного выброса молодых форм, что является признаком высоких адаптационных возможностей у высококвалифицированных спортсменов.
Ключевые слова: физичекая загрузка, эритроциты, осмотическая резистентность, кальций, марафонцы.

Introduction

Currently, one of the main tasks in the practice of sports is the timely correction of the educational process in order to optimize it [1]. In this regard, the question arises of choosing the most informative indicators that reflect different levels of adaptation of the athlete's body to physical activity, especially for the development of general endurance in sports that present special requirements for this physical ability [2].

According to modern scientific data, such studies must be carried out at different levels of the organization of the human body. In the vast majority of cases, the leading role in endurance studies belongs to the identification of factors contributing to the activation of energy metabolism, especially oxygen in the transport system [3]. At the same time, studies of cellular reactions in the process of training associated with an increase in the overall endurance of the athlete's body are ignored. The peripheral blood red blood cells in this case are a convenient model for this kind of research, since they take part in the processes associated with maintaining homeostasis at the level of the whole organism [4, 5, 6]. In addition to their inherent specific gas transport function, these cells take part in the regulation of the acid-base state, water-electrolyte balance, micro-rheological status of the blood, in immune responses, the binding and transfer of amino acids and lipids, which is of direct interest in the development of the general endurance of the body [7].

One of such indicators can be the presence of circulating and non-circulating forms of peripheral blood red blood cells, the erythrocyte deformability index, their macro-microelement composition, osmotic resistance of red blood cells, which, according to modern concepts, are integrative indicators of the state of cell membranes in the whole body and are very sensitive to action physical activity [6, 8, 9]. An important role in the stabilization of the membrane can be played by calcium ions [10], which also have a wide spectrum of action on various physiological processes: regulation of cell sensitivity to various stimuli, control of the functional activity of the cell and the cellular metabolism system.

The purpose of the work is to study the morphological and functional state of peripheral blood red blood cells and the concentration of Ca^{2+} in blood plasma during physical activity in marathon runners of various qualifications.

Material and methods

Studies were conducted in three groups of marathon runners aged 20-25 years. The first group, with a conditionally high working capacity, is highly qualified athletes involved in marathon running (masters of sports of international class, masters of sports). The second group, with average working capacity, is represented by marathon runners with a qualification level at the level of the CCM and grade I. The third group with conditionally low working capacity is students of the Faculty of Physical Education and Sports of the Carpathian National University named after V. Stefanik who are involved in a marathon and do not have a sports category.

Physical exercise was performed for 90 minutes on a bicycle ergometer with a given power of 17 kgm / min per 1 kg of weight, which corresponds to 50-60% of the MPC. At rest, during exercise and at the 2nd minute of recovery, ECG was used to determine the heart rate (HR). The studies were conducted on heparinized blood taken from the pulp of the fourth finger of the left hand before and after exercise. The osmotic resistance of red blood cells was determined by the method of ND Vasilevskaya [7]. The Ca^{2+} content in the blood was measured by a direct potentiometric method using membrane ion-selective electrodes in combination with an EV-74 ionomer and a B7-22 digital millivoltmeter [10].

The content of free fatty acids in the blood was studied by the enzymatic method on a Humalyser 2000 biochemical analyzer (Germany) using a set of reagents from Human [14, 19].

A morphological study of peripheral blood erythrocytes was performed using a JEOL-25M-T220A scanning electron microscope (Japan) according to generally accepted methods [6, 13, 18]. Electron microscopic images were analyzed in the ImagerJ editor.

The shape index was determined as the ratio of the maximum and minimum diameters of peripheral blood red blood cells according to the formula:

$IF = D_{max}/D_{min}$, [16]

where:

IF - form index;

Dmax - maximum diameter

Dmin - the minimum diameter.

Samples of the values obtained for all types of measurements had a normal distribution. This allowed the use of Student's t-test when comparing intergroup differences. The differences were considered significant at $p < 0.05$.

Results

The differences between the three groups in the duration of the work and the reaction of the cardiovascular system in response to the FN give reason to say that the studied groups differ in

performance. The change in heart rate under the influence of physical activity in athletes of group I was 92.0% (67.1±2.93 beats·min^{-1} at rest, 142.0 ± 3.35 beats·min^{-1} after physical load), in athletes of group II - 102, 0% (respectively 72.5 ± 3.67 beats·min^{-1} and 154.0 ± 7.28 beats·min^{-1}), in group III the highest heart rate rise was 137.0% (respectively 76.3 ± 4.45 beats·min^{-1} and 171.1 ± 5.33 beats·min^{-1}). Not all the subjects coped with physical activity, designed for 90 min: in group I of 8 people all managed (average work time 90 min), in group II of 8 persons 3 (average work time 84 min), in group III out of 8 persons, only 4 coped (average work time - 74 min).

Before exercise, the content of free fatty acids was 0.28 mmol·l^{-1} in group I, in group II - 0.44 mmol·l^{-1}, and in group III - 0.89 mmol·l^{-1}. The study of the content of free fatty acids in the blood of athletes of groups I and II in response to physical activity increased on average by 112.8 ± 1.42% and 76.3 ± 1.11%, respectively ($p<0.05$), whereas In group III, it amounted to only 3.1 ± 0.33% ($p> 0.05$) (Tab. 1).

Calculation of the average values of osmotic hemolysis showed that peripheral blood erythrocytes in group II are most stable. The breakdown of peripheral blood erythrocytes in two other groups was significantly higher, while its value was almost the same in both the I and III groups (Table 1, Fig. 1).

Table 1

Indicators of osmotic hemolysis of peripheral blood erythrocytes in marathon runners of various qualifications before and after physical activity (%)

Saline concentration, %	I group, n=6		II group, n=6		III group, n=6	
	Before physical load	After physical load	Before physical load	After physical load	Before physical load	After physical load
0,4	76,9 ±2,92	78,9 ±2,53	80,1 ±2,25	69,1 ±2,49	78,5 ±3,01	82,8 ±3,52
0,42	52,6 ±2,34	54,9 ±3,11	31,6 ±1,02	35,7 ±1,81	53,2 ±2,44	56,2 ±2,64
0,44	36,1 ±2,45	38,1 ±2,27	22,4 ±1,66	15,2 ±1,14	38,5 ±2,37	31,2 ±2,68
Hypotension 50% red blood cell destructuring	0,421± 0,001	0,423 ±0,003	0,412 ±0,003	0,409 ±0,004	0,423 ±0,005	0,422 ±0,005

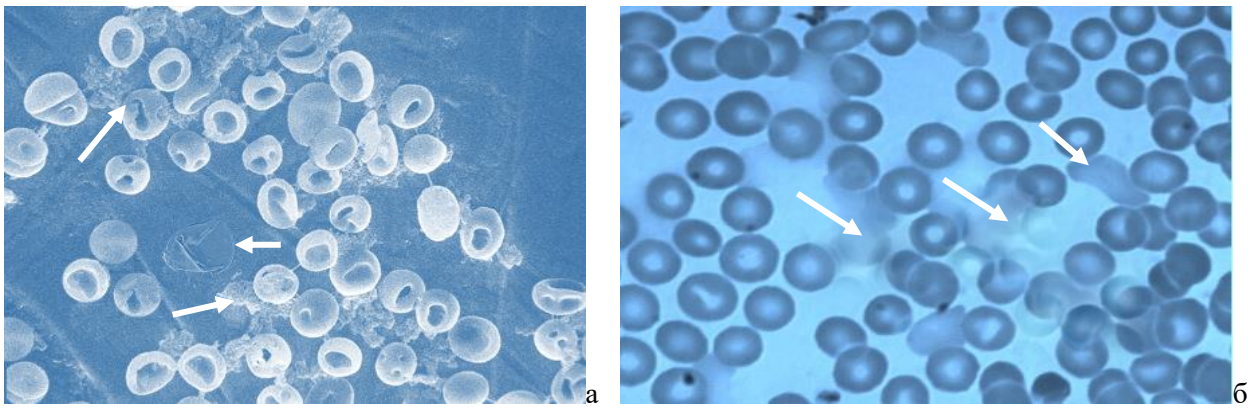

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Fig. 1. Specific lytic forms of red blood cells (shown by arrows) in a blood smear of athletes of group I (a) and III (b). Method: a - scanning electron microscopy, b - Romanovsky staining. Uv .: a - x 1500, b - x 1350

The results of the study showed that in different groups there are significant differences in the content of Ca2 + in the blood, and its level was highest among athletes of group I, while among athletes of group II it was lower and in group III it was the smallest (Fig. 2). Changes in the concentration of Ca2 + in the blood under the influence of physical activity are multidirectional,

nevertheless, according to average data, one can speak of a tendency to its decrease in the first group of athletes and an increase in the third group, while in the second group the level of Ca2 + practically did not change.

At the same time, a significant (p <0.05) increase in the ability of peripheral blood erythrocytes to deformity was revealed in comparison with the initial values to FN in athletes of groups I and II.

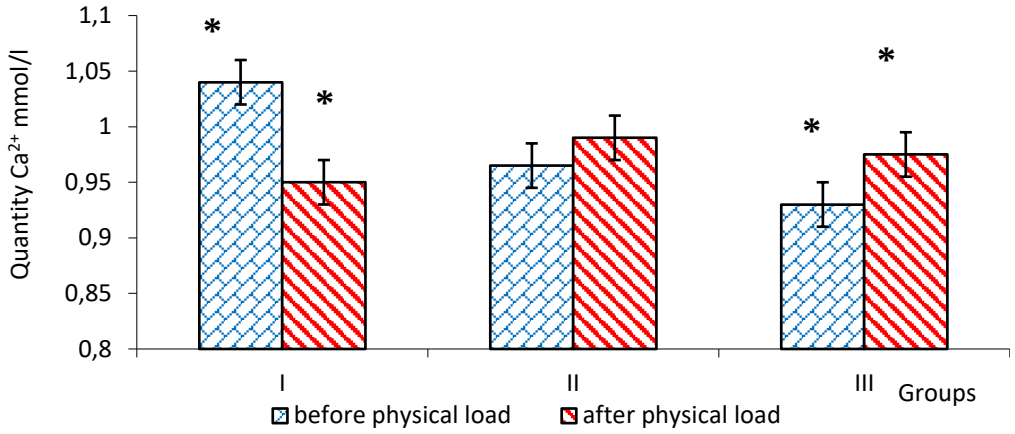

Fig. 2. The content of Ca^{2+} in blood plasma before and after prolonged physical activity:
* - p <0.05 between groups I and III

The linear dimensions of peripheral blood red blood cells during physical exertion are characterized by small, but systemic shifts. In particular, the maximum sizes of red blood cells of peripheral blood differ only in the form of tendencies to increase diameters. Ho, shorter axes show more significant and statistically significant differences (Tab. 2).

Table 2

Morphometric indicators of red blood cells of peripheral blood of marathon runners after exercise, $\bar{x} \pm S$

Parameter	Group		
	I	II	III
Diameter of disks, mcm	7,0±0,02	7,0±0,03	6,6±0,02
Disc height, mcm	0,79±0,004	0,61±0,003	0,37±0,001*
Form index, rel. units	1,01±0,001	1,06±0,002	1,12±0,008*
Pore Diameter, nm	100,9±3,03	120,7±3,51	181,5±11,23*

Note: * – p<0,05

These tables indicate rather small deviations of each of the parameters (within 5-7%), but they accumulate and take on a systemic character. This makes these shifts functionally significant in post-exercise.

In contrast to group I, where the erythrocytogram has the appearance of a normal distribution (Fig. 3), in group III, the histogram of the distribution of peripheral blood red blood cells by size is asymmetric and multipolar due to an increase in the number of varying classes of the small-sized (left) wing of cellular elements (Fig. 4) . A comparative analysis shows that for marathon runners of groups I and II, the size class size in the left wing is only 7.0%, while in group III it is about 70.0%. An increase in the amount of EPA of the left wing of the histogram is accompanied by a significant (p <0.05) decrease in the median and mode values.

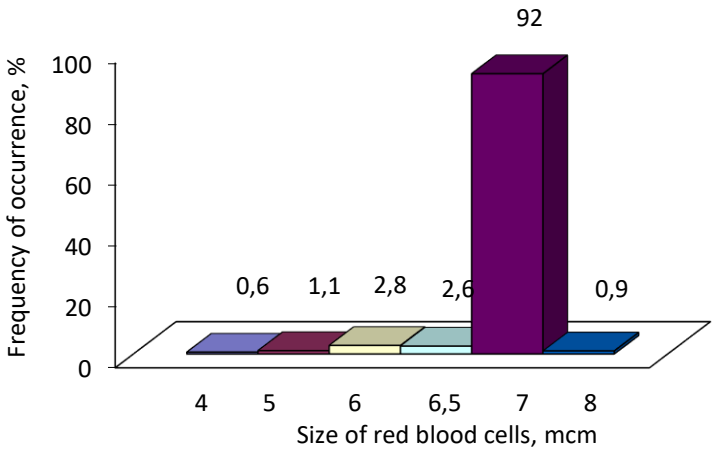

Fig. 3. Distribution of erythrocytes of peripheral blood of marathon runners I and II groups by size classes. Parameters: median 7.0 ± 0.3 mcm, mode 6.8 ± 0.3 mcm, dispersion 0.5, kurtosis 2.2, interval 1.0 mcm

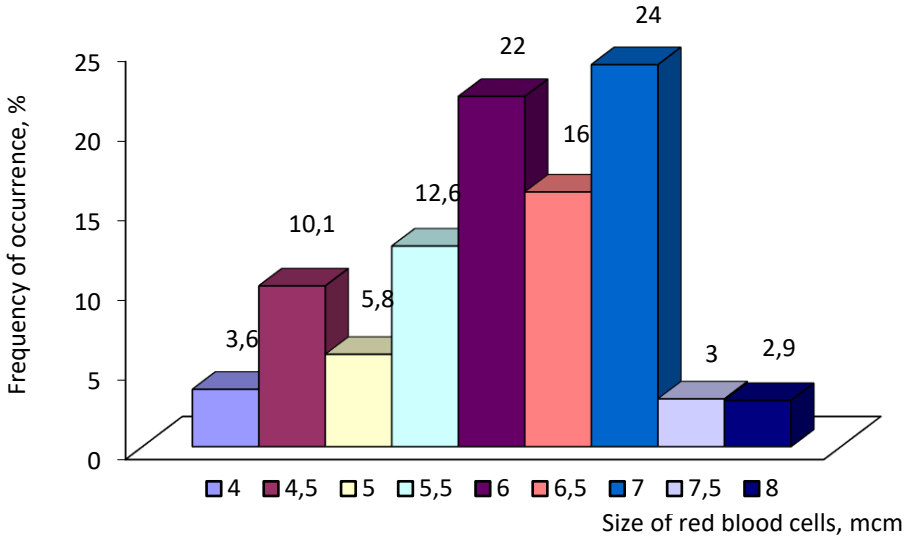

Fig. 4. Distribution of red blood cells of peripheral blood of marathon runners of group III according to size classes. Parameters: median 6.2± 0.2 mcm, mode 5.8 ± 0.2 mcm, dispersion 0.5, excess k 2.2, interval 0.5 mcm

Discussion

Our studies have shown that the body of athletes of different qualifications reacts differently to physical activity. It is known that an untrained organism responds to physical activity with a pronounced stress reaction, accompanied by a large release of catecholamines into the blood [19].

In the process of formation of long-term adaptation to physical activity, the apparatus of hormonal regulation is being restructured [17, 18].

An increase in the level of catecholamines in the blood in response to physical activity is much less. One of the mechanisms that allow the body to function sparingly in conditions of prolonged physical activity may be a change in the sensitivity of tissues to hormones [12]. It has been established that Ca^{2+} can regulate the sensitivity of adrenergic receptors to catecholamines [19]. With the participation of Ca^{2+} in this process, differences in the content of these ions in people with different levels of physical performance may be associated. In addition, an increase in the concentration of Ca^{2+} promotes the activation of α-adrenergic receptors of cell membranes and deactivates β-adrenergic receptors. Conversely, a decrease in the extracellular concentration of Ca^{2+} activates β-adrenergic receptors and decreases the sensitivity of α-adrenergic receptors [8]. The change in the sensitivity of various structures to hormones is probably due to the concept of Labori [5], with the predominance of one of the metabolic pathways in

metabolic processes with the predominant use of fats or glucose as an energy substrate.

An increase in the concentration of Ca^{2+} that occurs in untrained people under the influence of physical activity can cause deactivation of β-receptors of fat cells, which can lead to inhibition of lipolysis, insufficient mobilization of fats, which are the main source of energy during prolonged work [14]. The decrease in Ca^{2+} concentration observed in most cases in highly qualified athletes can contribute to the intensive course of lipolysis, effective mobilization of energy resources [15]. This is confirmed by our analysis of the lipid composition of the blood: the content of free fatty acids in the blood of athletes in response to physical activity increased mainly in athletes of groups I and II, while in group III it was statistically unreliable. As part of lipoproteins, which are thus the transport form of fatty acids, they are delivered to target organs, in which fatty acids serve either as energy sources (cardiac and striated muscles), or as precursors for the synthesis of tissue triglycerides, followed by deposition in organ cells (in the form of a lipid depot) [19]. At rest, free fatty acids are oxidized mainly in the liver and heart muscle. Under load, oxidation increases in skeletal muscle. It is believed that free fatty acids are not only high-energy "fuel", but they are signaling molecules. A change in their concentration is a factor affecting the intensity of glucose utilization in muscles, especially during prolonged physical activity [9].

Physical activity can cause both an increase in the osmotic resistance of red blood cells, and its decrease [8]. Calculation of average values revealed a tendency to increase this indicator in group II, while in the other two groups the changes were insignificant.

Similar results were obtained by Kremmyda et al., [7] in the study of osmotic resistance of red blood cells in groups with different levels of physical performance. It has been established that the content of total cholesterol in blood plasma in individuals with high and low physical performance is approximately the same and that in people with moderate physical performance it is higher [5, 9].

Other authors [11], when studying hemorheological criteria, such as viscosity and blood adhesion in laboratory animals, showed that their change in response to extreme physical activity was characterized in animals in the phase of "achieving full adaptation" in the absence of significant differences from control (untrained animals) and differed sharply in animals at the training stage [8]. In another laboratory, the same relationship was found between the rate of erythropoiesis and physical performance. The rate of erythropoiesis was almost equal in the control group and among highly qualified athletes, while in individuals with average working capacity it was significantly higher. However, the indicated regularity of the dependence of the values of the studied indicators on the degree of fitness has not found a satisfactory explanation for today within the framework of existing theories of the adaptation process.

People with varying degrees of fitness are at different levels of adaptation. The long-term adaptation that develops during training is characterized by shifts in functional indicators towards more economical work and is a consequence of the restructuring that occurs at the cellular and subcellular levels of the body. This process, designated as the formation of a structural trace [21, 22], includes activation of the synthesis of nucleic acids and proteins and subsequent selective growth of cell structures, due to which the capacity of the system responsible for adaptation to physical activity is increased. The response to physical work in this case will be expressed in the mobilization of physiological functions to the maximum attainable level occurring under stress. In the process of training, the body enters the stage of restructuring the structural basis of the functional system. It is at this stage that the mechanisms that affect the deep level of functioning of the body are connected, associated with changes in permeability, modification of membranes and cellular metabolism [2, 4]. Therefore, we note an increased erythrocyte resistance compared to the first group in individuals with an average degree of fitness who are at the stage of transition to long-term adaptation. But the structural trace is still imperfect to a certain extent; it is generalized, redundant. Many processes are involved in perestroika, one way or another connected with ensuring functional activity in extreme conditions [3]. Such a mechanism cannot underlie the economical and efficient functioning of the body, which is characteristic of highly trained athletes. An alternative model is to selectively strengthen or inhibit the work of strictly defined elements of a functional system. Nonspecific stress response is minimized. Selective strengthening of the dominant links in the system allows many indicators to return to normal. Due to this, the osmotic resistance of red blood cells in highly qualified athletes and untrained people are similar. Apparently, the osmotic resistance of erythrocytes is an indicator by which we can judge the dynamics of the formation of a structural trace - the basis of long-term adaptation [8].

The indicated features of the histogram of the distribution of peripheral blood erythrocytes by size classes mean that small erythrocytes primarily respond to physical activity in response to exposure, which is typical for short-term, rapidly developing

reactions that obviously occur as a result of the release of the "first echelon of stress response" cells from the reserve pool of total blood flow [1].

At the same time, the central fossa of the discs deepen, but at the same time, the thickness of the discs decreases by 50–75 nm, which is due to a decrease in the thickness of the protein-globular layer of the membrane of peripheral blood erythrocytes [2]. This is adaptive, as it expands the plastic capabilities of red blood cells when passing through the capillary segment of the hemomicrocirculatory bed.

The distribution of red blood cells among athletes of the second and especially third groups becomes more extreme: the number of intervals increases, the volumes of individual classes vary due to jumps, and the achievement of the values of the central parameters occurs in waves (in the control according to a monotonously upward trend). The wavy shape of the histogram, apparently, reflects the unstable-vibrational state of peripheral blood erythrocytes in the period of active training of the body [3, 5].

In conclusion, it must be emphasized that the determination of Ca^{2+} and morphological changes in peripheral blood erythrocytes can serve as an informative test to assess not only the functional state of the body, but also its fitness and development of the general endurance of athletes of different specializations and qualifications.

Conclusions

1. In the acute phase of physical activity, peripheral blood erythrocytes undergo structural and functional transformations, the pathogenetic basis of which is a flicker-resonant increase in the amplitude and frequency of oscillating vibrations of the fluid, membranes and cells as a whole.

2. A change in the content of Ca^{2+} enhances the melting of lipids, increases the fluidity of the membranes and increases the surface tension, as a result of which the discocytes stretch and thin, the central fossa deepen and the surface roughness, volume and number of cone-shaped pores, as well as the density of red blood cells increase.

3. Due to the multidirectional action of the deforming forces, a violation of the regular disk-shaped form of red blood cells is observed, and changes in the structure and physico-mechanical properties initiate apoptosis and enhance their aggregation interactions.

After the training camp is over, systemic transformations of the peripheral blood erythrocyte pool occur due to the degradation of degenerative forms and increased regenerative capabilities due to the active release of young forms of red blood cells with increased fluidity of membranes, which is a positive adaptive adaptation for the body as a whole.

Conflict of interest. Authors declare that there is no conflict of interest.

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Determining the style of conducting a fight of qualified boxers based on neurodynamic indicators using multivariate analysis methods

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Abstract
Purpose: to justify the use of psychophysiological indicators to determine the style of conducting a fight in boxing.
Material and methods. The study involved 27 qualified boxers of the middle weight category of 22-25 years. Athletes were tested on psychophysiological indicators. Initially, the determination of the psychophysiological capabilities of athletes was carried out. Then, using a cluster analysis of psychophysiological indicators, the athletes were divided into groups and the features of the styles of conducting a duel between the athletes of each group were analyzed using an expert assessment of their technical and tactical actions. Next, a distinction was made between the psychophysiological indicators of the athletes of the formed groups, i.e. different fighting styles.
Results. Cluster analysis of indicators of psychophysiological testing showed the presence of 3 groups of athletes. An expert evaluation of the boxing match styles included in each group showed that the first group included boxers of the counterattack style, "Sluggers", the second group included athletes of the attacking style, "Swarmers (in-fighter, crowder)", the third group included athletes of the counterattack and defensive styles, "The out-boxers (out-fighter, boxers)". Boxers - "Sluggers" have higher mobility of nervous processes in comparison with representatives of other styles. Boxers - "pace" are distinguished by significantly higher neurodynamic endurance. "Attackers" - "Swarmer (in-fighter, crowder) " are distinguished by a higher strength of the nervous system, determined by the number of errors in the test for the speed of a complex reaction in the feedback mode.
Conclusions. Psychophysiological and neurodynamic indicators are informative for determining the inclinations of boxers to a particular style of conducting a duel. This provision can be applied at all stages of training athletes to quickly and effectively determine propensities for a particular style of conducting a duel based on innate neurodynamic and psychophysiological characteristics.
Key words: boxing; a cluster; style; duel; neurodynamics; psychophysiological indicators.

Анотація
Сафронов Д.В., Козін В.Ю., Козіна Ж.Л., Басенко А.В., Рябенков І.О., Храпов С.Б. Визначення стилю ведення поєдинку кваліфікованих боксерів на основі нейродинамічних показників за допомогою методів багатовимірного аналізу.
Мета роботи - обґрунтування застосування психофізіологічних показників для визначення стилю ведення поєдинку в боксі.
Матеріал і методи. У дослідженні взяли участь 27 кваліфікованих боксерів середньої вагової категорії 22-25 років. Було проведено тестування спортсменів по психофізіологічних показників. Спочатку було проведено визначення психофізіологічних можливостей спортсменів. Далі за допомогою кластерного аналізу психофізіологічних показників було здійснено розподіл спортсменів по групам і проведено аналіз особливостей стилів ведення поєдинку спортсменів кожної групи за допомогою експертної оцінки їх техніко-тактичних дій. Далі було проведено визначення відмінностей між психофізіологічними показниками спортсменів утворилися груп, тобто різних стилів ведення поєдинку.
Результати. Кластерний аналіз показників психофізіологічного тестування показав наявність 3-х груп спортсменів. Експертна оцінка стилів ведення поєдинку боксерів, які увійшли в кожну групу, показала, що в першу групу увійшли боксери контратакуючого стилю, «ігровики», до другої групи увійшли спортсмени атакуючого стилю, «силовики», в третю групу увійшли спортсмени контратакуючого і захисного стилів, «темповики». У боксерів - «ігровиків» вище рухливість нервових процесів у порівнянні з представниками інших стилів. Боксери - «темповики» відрізняються достовірно вищою нейродинамічної витривалістю. «Атакуючі» - «силовики» відрізняються більш високою силою нервової системи, яка визначається за кількістю помилок в тесті на швидкість складної реакції в режимі зворотного зв'язку.
Висновки. Психофізіологічні і нейродинамічні показники є інформативними для визначення схильностей боксерів до певного стилю ведення поєдинку. Дане положення може застосовуватися на всіх етапах підготовки спортсменів для швидкого і ефективного визначення схильностей до певного стилю ведення поєдинку на основі вроджених нейродинамічних та психофізіологічних характеристик.
Ключові слова: бокс; кластер; стиль; поєдинок; нейродинамика; психофізіологічні показники.

Аннотация
Сафронов Д.В., Козин В.Ю., Козина Ж.Л., Басенко А.В., Рябенков И.О., Храпов С.Б. Определение стиля ведения поединка квалифицированных боксеров на основе нейродинамических показателей с помощью методов многомерного анализа.
Цель работы — обосновать применение психофизиологических показателей для определения стиля ведения поединка в боксе.
Материал и методы. В исследовании приняли участие 27 квалифицированных боксеров средней весовой категории 22-25 лет. Было проведено тестирование спортсменов по психофизиологическим показателям. Вначале было проведено определение психофизиологических возможностей спортсменов. Далее с помощью кластерного анализа психофизиологических показателей было осуществлено распределение спортсменов по группам и проведен анализ особенностей стилей ведения поединка спортсменов каждой группы с помощью экспертной оценки их технико-тактических действий. Далее было проведено определение различий между психофизиологическими показателями спортсменов образовавшихся групп, т.е. разных стилей ведения поединка.
Результаты. Кластерный анализ показателей психофизиологического тестирования показал наличие 3-х групп спортсменов. Экспертная оценка стилей ведения поединка боксеров, вошедших в каждую группу, показала, что в первую группу вошли боксеры контратакующего стиля, «игровики», во вторую группу вошли спортсмены атакующего стиля, «силовики», в третью группу вошли спортсмены контратакующего и защитного стилей, «темповики». У боксеров – «игровиков» выше подвижность нервных процессов по сравнению с представителями других стилей. Боксеры - «темповики» отличаются достоверно более высокой нейродинамической выносливостью.
«Атакующие» - «силовики» отличаются более высокой силой нервной системы, определяемой по количеству ошибок в тесте на скорость сложной реакции в режиме обратной связи.
Выводы. Психофизиологические и нейродинамические показатели являются информативными для определения склонностей боксеров к определенному стилю ведению поединка. Данное положение может применяться на всех этапах подготовки спортсменов для быстрого и эффективного определения склонностей к определенному стилю ведения поединка на основе врожденных нейродинамических и психофизиологических характеристик.
Ключевые слова: бокс; кластер; стиль; поединок; нейродинамика; психофизиологические показатели.

Introduction

At the present stage of boxing development, the style of conducting a duel is a characteristic feature of every professional boxer [1, 2, 3]. So, there are boxers who are distinguished by great power assertiveness in a duel. They are distinguished by a large impact force, the desire for forceful suppression of the enemy. Such boxers include Mike Tyson, Vitali Klitschko, George Foreman, David Tua and other attacking "swarmers" [4, 5, 6]. Some boxers fight, constantly varying their actions, using a lot of feints, strike at the most unexpected moments, for example, counterattacking "sluggers" Roy Jones, Mohammed Ali, Floyd Mayweather [2, 7, 8]. There are boxers who "exhaust" the opponent at a high pace for many rounds, and win when the opponent is no longer able to withstand the imposed pace. These are counterattack "out-boxers" Manny Pacquiao, Joe Fraser and others [9, 10, 11]. The most successful option is the ability to combine different styles, and in different battles to show different manners of conducting a duel. However, nevertheless, the most characteristic features of the movements of athletes remain unchanged, which gives reason to talk about the prevailing style.

Determining the inclination of a boxer to a certain style of conducting a duel is an urgent task, since the merging of activities, as a rule, manifests itself at the stage of maximizing the athlete's capabilities, however, to increase the efficiency of training boxers, determining the inclination of athletes to a certain style of conducting a duel is of great importance at all stages of preparation. For this, it is necessary to use informative indicators that are sufficiently accessible in definition, do not require a long time period for their development and are relatively unchanged in ontogenesis [12, 13, 14]. For this purpose, psychophysiological indicators can be used, but their application requires in-depth theoretical and experimental justification [15, 16, 17].

The doctrine of the styles of activity and, in particular, of the styles of struggle, has its roots in antiquity [1, 2, 18]. To date, the nature of the origin of various styles is not fully understood. There are hypotheses that indicate that the styles occurred as a result of separate training of individual groups of people [19, 20, 21]. There are also historical facts that testify to the origin of fighting styles as an imitation of the movements and survival strategies of various animals [22, 23]. In this case, copying was carried out both external movements and internal states. Martial arts descended from the "crane style", as well as various fighting styles within the same martial art, have survived to our time (Fig. 1).

A number of Wushu styles are known, united by the general name Xiang Xinquan - "styles of image and form" or "styles of imitation of form". They are based on imitation of the movements and habits of animals. In Xiangqiuan, the state of naturalness, spontaneous emancipation (zijan) is achieved through complete self-identification with the chosen object, not only external, but most importantly, internal. Man, mastering the "form and image" of the tiger, snake, dragon, achieved the natural emancipation and natural power of the animal in its "pristine state" [24]. Imitation of animal movements has been known in China for a long time. In early totem dances, the ancestors of the Chinese imitated the manner of fighting the animal.

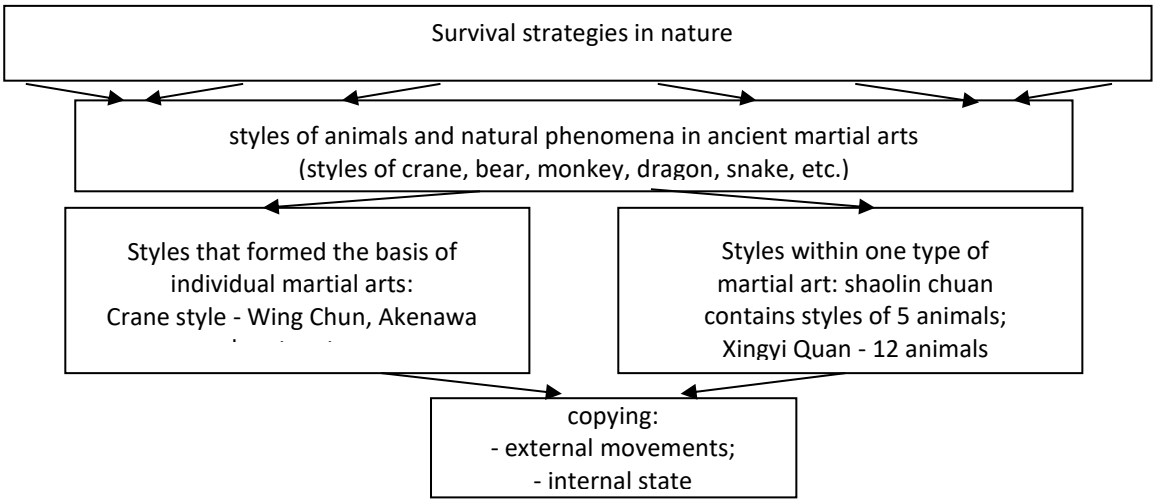

Fig. 1. Survival strategies in nature as a psychophysiological basis for the formation of a fighting style

For example, in the first centuries of our era, at the imperial court, monkey and crane dances were arranged. At the beginning of the 2nd century AD the Huainan Tzu treatise described the exercises "clambering bear", "bird stretched out in flight", "washing wild duck", "jumping monkey", "staring owl", "looking tiger", united under the name "game of six animals" (lucy) [24, 25]. A little later, the famous healer, Taoist Hua Tuo (141–208) created the "Game of Five Animals" (Wuxi) complex [26], based on the movements of a bear, tiger, deer, monkey and bird, arguing that this "can cure everyone." However, all these exercises related more to the systems of psychophysical regulation and did not represent martial art in the full sense of the word. But it was they who laid down the basic principles of xiangxiuan styles.

In the modern European tradition, there are several classifications of boxing combat styles, none of which, in our opinion, is universal due to the mixing of different categories of concepts. For example, the classic international classification of styles in boxing mixes categories such as the distance between rivals and the nature of the punches. This classification distinguishes between outsiders, punchers, infighters, sluggers [1, 2]. In the domestic classification, mixing of different categories, such as attack and defense, the predominance of various physical qualities, and the breadth of the technical arsenal also often occurs [1, 2]. In this regard, we have systematized the categories of different classifications of boxing combat styles, the scheme of which is presented on this slide. According to the predominance of attack or defense actions, styles are divided into attacking, counterattack, defensive. By the predominance of physical qualities, boxers are divided into "Swarmers (in-fighters, crowders)" and "The out-boxesr (out-fighters, boxers)", and "Sluggers" are distinguished, which, on the one hand, are distinguished by the development of coordination abilities or dexterity, and, on the other hand, possession of a wide technical arsenal. Very often there is a combination of the manifestation of any physical qualities and the predominance of attacking or counterattacking actions. For example, "Swarmers (in-fighters, crowders)" are most often attackers at the same time, and "Sluggers" are counterattacks, " The out-boxers (out-fighter, boxers)" are also most often counterattacks or defenders. It is logical to assume that the physiological basis for the formation of styles is relatively unchanged genetically determined functions, for example, neodynamic processes and psychophysiological capabilities, and the registration of these indicators in the training process will help determine at the stage of basic training the boxer's inclination towards the future style of the fight.

The purpose of the work was to justify the use of psychophysiological indicators to determine the style of conducting a duel in boxing.

Material and methods

Participants

The study involved 27 qualified boxers of the middle weight category of 22-25 years. Athletes were tested on psychophysiological indicators. Testing was conducted from 10-00 to 11-00. Athletes were tested in the same conditions for all.

Experimental protocol

The following parameters characteristic of the psychophysiological status, typological features of the nervous system, indicators of the nervous system efficiency, and attention indicators [27, 28] were set by using the Psychodiagnostics computer software:

– 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 1 element from 3 and selecting 2 elements 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 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 during the display of 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 lasts 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).

In determining the typological characteristics of the nervous system, we were guided by the provision that the higher the rate of exit to the minimum signal exposure, the shorter the time of the minimum signal exposure in the feedback mode, the higher the mobility of the nervous processes. The fewer errors when performing the test in the feedback mode, the higher the strength of the nervous system [13, 14, 15].

The indicators of mental working capacity were also determined in accordance with the Schulte test. In this test, the subject is provided with 5 × 5 tables of 25 digits (from 1 to 25) arranged in a random order. The task is 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 an individual time of work on the 4^{th} and 1^{st} tables, and the workability of the nervous system as an individual work time for the 2^{nd} and 1^{st} tables.

The ability to concentrate was studied with the proofreading (correction) method (Bourdon test) [13, 14, 15]. Switching attention was also determined by the Gorbov test "Red-black table" [18].

Statistical analysis

In connection with the tasks to justify the informativeness of psychophysiological indicators as the basis for the formation of the style of conducting a duel in boxing, we limited ourselves to conducting a hierarchical cluster analysis of indicators of psychophysiological testing.

At the first stage of this series of studies, the psychophysiological capabilities of athletes were determined [18, 27, 28]. Then, using a cluster analysis of psychophysiological indicators, the athletes were divided into groups and the features of the styles of conducting a duel between the athletes of each group were analyzed using an expert assessment of their technical and tactical actions. As a result, each group of boxers was given a name according to the styles of the match. After that, a determination was made of the differences between the psychophysiological indicators of the athletes of the formed groups, i.e. different styles of conducting a duel, and a characteristic of boxers of each style of conducting a duel according to the psychophysiological capabilities and special performance has been compiled.

Results

A hierarchical cluster analysis of indicators of psychophysiological testing was used to clarify the styles of conducting a boxing match [18, 27, 28]. In hierarchical cluster analysis, each particular case first forms its own separate cluster. At each step, two separate clusters that are closest in structure to each other are combined into one cluster. The stages of clustering are presented in table 1. From this table, as well as from the dendrogram (Fig. 2), it can be seen that at the first step, boxers No. 22 and 23 were combined into one cluster.

From this it follows that these boxers are close in their structure of psychophysiological capabilities, which must be taken into account when conducting training.

At the next stage of cluster analysis, they are joined by athletes No. 21, 26, 1, 20, etc.

In order to find out which number of clusters is optimal, subtract the number of the step at which the cluster coefficients begin to increase nonlinearly from the number of athletes analyzed. In our case, this is step No. 24 (Table 1). Therefore, the optimal number of clusters is 27-24 = 3.

So, we got 3 clusters, i.e. 3 groups of boxing athletes. In boxing, this meets the three main styles of conducting a duel. Figure 2 shows the affiliation of each player to a specific cluster.

Thus, a cluster analysis of indicators of psychophysiological testing showed the presence of 3 groups of athletes. An expert evaluation of the boxing match styles included in each group showed that the first group included boxers of the counterattack style, " Sluggers", the second group included athletes of the attacking style, " Swarmers (in-fighters, crowders)", the third group included athletes of the counterattack and defensive styles, "The out-boxers (out-fighter, boxers)" Since only psychophysiological indicators participated in the cluster analysis, and the athletes were divided into three groups, which turned out to be actually groups of boxers of different styles of conducting a duel, we can conclude that the hypothesis about the predominant influence of psychophysiological capabilities on the formation of a style of conducting a duel in boxing is confirmed.

Table 1

Agglomeration order in the cluster analysis of indicators of psychophysiological testing of boxers (n = 27)

Step, №	Cluster of boxers (according to conventional numbers)		Coefficients
	Cluster 1	Cluster 2	
1	22	23	0.65
2	21	26	0.68
3	1	20	0.82
4	5	6	0.85
5	18	25	0.90
6	19	21	0.97
7	18	22	1.07
8	7	16	1.21
9	4	11	1.30
10	9	18	1.46
11	4	17	1.52
12	8	9	1.55
13	8	19	1.76
14	1	7	1.86
15	1	27	2.02
16	14	15	2.86
17	1	8	2.92
18	24	28	3.15
19	4	5	3.61
20	10	13	4.16
21	1	24	4.88
22	4	12	5.20
23	1	2	5.29
24	10	14	**10.84**
25	1	4	11.06
26	1	10	65.31
27	1	3	92.67

For a more thorough verification of this hypothesis, a comparison was made of the formed groups of boxers by their psychophysiological capabilities. It was revealed that "counterattacking" - "Sluggers" significantly differ from other groups of boxers in a higher speed of simple and complex reaction, and the speed of a complex reaction for boxers - "Sluggers" is significantly higher both in the optimal mode of operation and in the feedback mode (Tabl. 2). They also have a higher output rate for minimum signal exposure, less time for minimum signal exposure (Tabl. 2). Thus, boxers - "Sluggers" have higher mobility of nervous processes in comparison with representatives of other styles. Boxers - "Sluggers" also differ from boxers of other styles with a significantly higher switchability of attention, concentration of attention. Boxers - " The out-boxers (out-fighter boxers)" are distinguished by a significantly higher neurodynamic endurance (mental stability), determined by the Schulte test, and by high workability (Tables 2, 3). It can be assumed that the higher mental performance of athletes does not allow them to realize an attacking power style, and they apply other qualities that are more developed for them, forming a counterattack or defensive style, and become "the out-boxers (fighter boxers)".

This is confirmed by the identification of significant differences between groups of boxers in terms of speed, strength and mobility of nervous processes. "Counterattacks" - "Sluggers" are distinguished by a higher reaction rate, speed of work, and attentiveness when completing tasks (Tables 2, 3).

"Attackers" - "Swarmers (in-fighters, crowders)" are distinguished by a higher strength of the nervous system, determined by the number of errors in the test for the speed of a complex reaction in the feedback mode (Tables 2, 3).

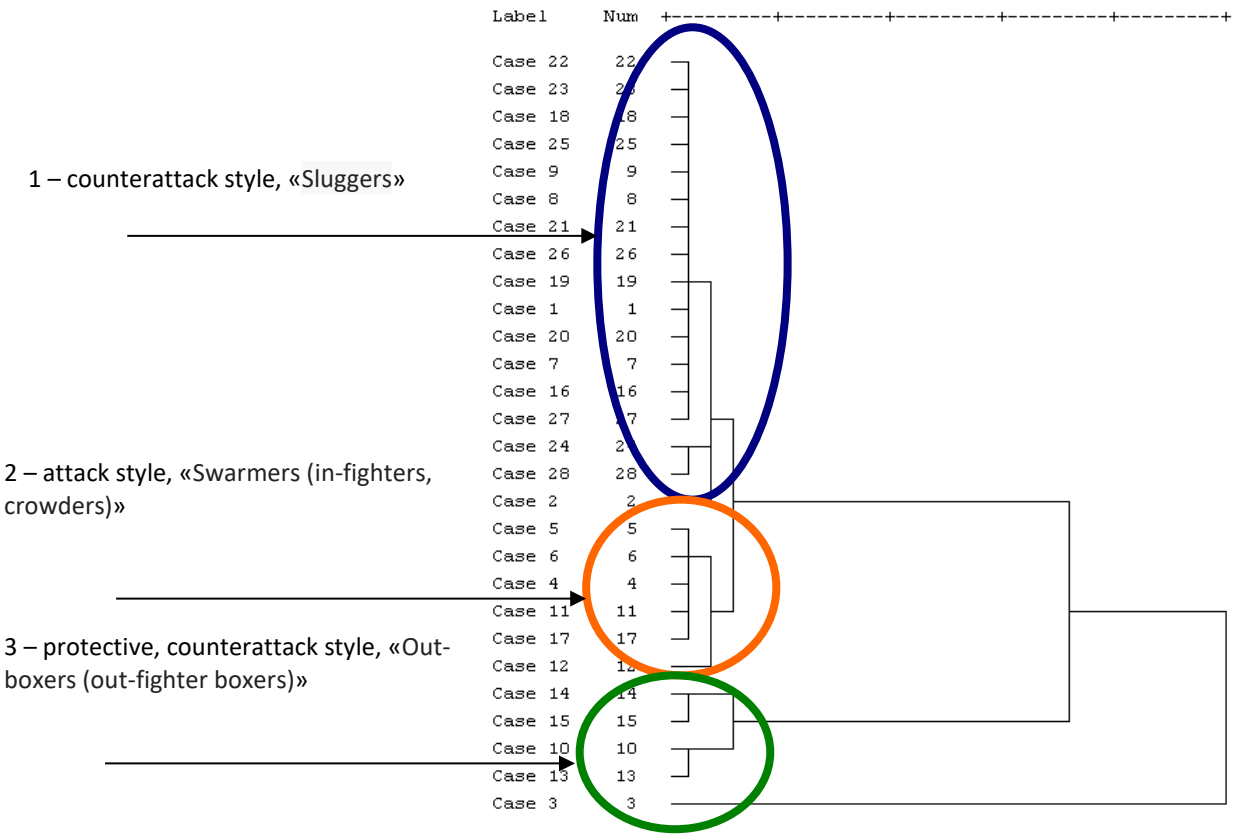

Fig. 2. The distribution of boxers into groups using cluster analysis of psychophysiological indicators (dendogram) (n=27)

Table 2

Neurodynamic indicators of boxers with different fighting styles (n=27)

Indicators	Groups	n	$\bar{x}$	S	m	t	p
Time of simple visual-motor reaction (ms)	1 sluggers	15	208,38	14,75	3,81	t_{1-2}	-7,61	<0,001
	2 out-boxers	6	254,19	11,43	4,67	t_{1-3}	-4,66	<0,01
	3 swarmers	6	266,23	28,92	11,81	t_{2-3}	-0,95	>0,05
Time of simple reaction on sound stimulus (ms)	1 sluggers	15	263,75	24,77	6,40	t_{1-2}	-2,98	<0,05
	2 out-boxers	6	301,32	26,6	10,86	t_{1-3}	-9,63	<0,001
	3 swarmers	6	394,41	29,33	11,97	t_{2-3}	-5,76	<0,001
Time of reaction of choice of 2 elements from 3 (ms)	1 sluggers	15	333,38	16,64	4,30	t_{1-2}	-16,85	<0,001
	2 out-boxers	6	459,05	14,93	6,10	t_{1-3}	-18,56	<0,001
	3 swarmers	6	478,56	16,01	6,54	t_{2-3}	-2,18	<0,05
Time of response selection in the feedback mode (ms)	1 sluggers	15	470,89	18,99	4,90	t_{1-2}	-2,22	<0,05
	2 out-boxers	6	487,68	14,08	5,75	t_{1-3}	-1,85	>0,05
	3 swarmers	6	492,00	25,19	10,28	t_{2-3}	-0,37	>0,05
Error in feedback test (quantity)	1 sluggers	15	22,94	2,38	0,61	t_{1-2}	2,88	<0,05
	2 out-boxers	6	19,59	2,42	0,99	t_{1-3}	3,49	<0,01
	3 swarmers	6	19,06	2,27	0,93	t_{2-3}	0,39	>0,05
Time to reach of Minimum Exposure in feedback test, s	1 sluggers	15	59,2	5,56	1,44	t_{1-2}	-1,72	>0,05
	2 out-boxers	6	62,3	2,66	1,09	t_{1-3}	-10,46	<0,001
	3 swarmers	6	77,8	2,57	1,05	t_{2-3}	-10,26	<0,01
Time of minimum signal exposure in the feedback mode (ms)	1 sluggers	15	320,4	29,74	7,68	t_{1-2}	-1,57	>0,05
	2 out-boxers	6	340,6	25,21	10,29	t_{1-3}	-4,30	<0,001
	3 swarmers	6	380,2	28,36	11,58	t_{2-3}	-2,56	<0,05

Table 3

Psychophysiological indicators of boxers with different fighting styles (n=27)

Indicators	Groups		n	$\bar{x}$	S	m	t		p
Work performance in the Schulte test (cu)	1	sluggers	15	66,29	5,46	2,23	t_{2-3}	3,35	<0,01
	2	out-boxers	6	32,87	2,91	0,75	t_{1-2}	-17,33	<0,001
	3	swarmers	6	77,40	6,02	2,46	t_{1-3}	-14,21	<0,001
The degree of involvement in the work on the Schulte test (cu)	1	sluggers	15	0,96	0,02	0,01	t_{1-2}	-2,29	<0,05
	2	out-boxers	6	1,11	0,16	0,07	t_{1-3}	2,07	>0,05
	3	swarmers	6	0,90	0,07	0,02	t_{2-3}	2,95	<0,05
Mental resistance according to the Schulte test (cu)	1	sluggers	15	0,88	0,08	0,03	t_{1-3}	16,71	<0,001
	2	out-boxers	6	1,33	0,1	0,03	t_{1-2}	10,81	<0,001
	3	swarmers	6	0,78	0,05	0,02	t_{2-3}	2,60	<0,05
The number of errors in the Bourdon test (cu)	1	sluggers	15	15,93	0,19	0,05	t_{1-2}	3,54	<0,05
	2	out-boxers	6	11,82	2,84	1,16	t_{1-3}	4,59	<0,01
	3	swarmers	6	12,36	1,90	0,78	t_{2-3}	-0,39	>0,05
Concentration of attention on the Bourdon test (cu)	1	sluggers	15	635,23	25,89	6,68	t_{1-2}	25,26	<0,001
	2	out-boxers	6	241,83	34,45	14,06	t_{1-3}	30,38	<0,001
	3	swarmers	6	291,64	22,35	9,12	t_{2-3}	-2,97	<0,05
Switching attention to the Bourdon test (cu)	1	sluggers	15	37,74	2,04	0,83	t_{1-3}	-6,23	<0,001
	2	out-boxers	6	23,73	3,42	1,40	t_{2-3}	8,62	<0,001
	3	swarmers	6	14,14	2,50	0,65	t_{1-2}	-22,40	<0,001
Attention switching indicator on the Gorbov test "Red-black table (cu)	1	sluggers	15	106,67	9,00	2,32	t_{1-2}	-5,61	<0,001
	2	out-boxers	6	140,00	13,40	5,47	t_{1-3}	-2,05	>0,05
	3	swarmers	6	119,45	14,21	5,80	t_{2-3}	2,58	<0,05

Discussion

In this study, the hypothesis of the informativeness of psychophysiological and neurodynamic indicators was confirmed to determine the propensity for a certain style of conducting a duel in boxing. The confirmation of this hypothesis is due to the coincidence of the groups of athletes formed using the cluster analysis tested on neurodynamic and psychophysiological indicators, with the opinion of experts regarding the similarity of boxers within each group in terms of the style of the fight. The informational content of neurodynamic and psychophysiological indicators is also confirmed by the presence of significant differences between boxers with different styles of conducting a duel according to neurodynamic and psychophysiological indicators. From this point of view, our results complement the results of studies presented in [1, 2, 18]. It should be noted that differences in the psychophysiological capabilities of boxers with different styles of combat are the physiological basis for the formation and manifestation of an individual style of activity. Thus, higher reaction rate indicators among boxers - "counterattacks, sluggers" determine the formation of a style of conducting a duel that requires a quick response to a changing environment, quick decision making. In addition, the style of boxers "sluggers" involves performing precise actions in a rapidly changing environment. The physiological prerequisites for the formation and manifestation of this style of action are such psychophysiological indicators as the speed of work, i.e. the number of correctly completed tasks per unit of time with an unpredictable nature and time of the appearance of the signal, and work efficiency (Tab. 2, 3).

It should be noted that boxers - "swarmers" compensate for the insufficient reaction speed, speed and accuracy of work with higher stability of work with fewer errors (Tab. 2, 3), i.e. they can do better than others with respect to identical actions. It follows that for such athletes, the best option for realizing their physiological inclinations is to achieve mastery in actions that do not require high variability of actions and consist in the manifestation of a high

level of strength in relatively similar actions, which is realized in the style of boxers - "attacking swarmers". Thus, physiological inclinations are realized in specific abilities, manifested in the formation of a certain style of activity, in our case, the style of conducting a duel in boxing. Similar provisions explain the higher mental performance of boxers - "out-boxers" (Tab. 2, 3). From this point of view, the results obtained are new.

It is known that each person has different "sets" of abilities. An individual-unique combination of abilities is formed throughout life and determines the uniqueness of a person. The success of the activity is also ensured by the presence of one or another combination of abilities that works for the result. In an activity, some abilities can be replaced by others - similar in manifestations, but differing in origin. The success of one and the same activity can be provided by different abilities, therefore the absence of one ability can be compensated by the presence of another or even a whole complex. Therefore, the individual uniqueness of the complex of individual abilities that ensure the successful implementation of activities is commonly called the "individual style of activity". In modern psychology, more often they began to talk about competencies, as integrative qualities (abilities), which are aimed at achieving a result. We can say that competencies are abilities through the eyes of employers. In fact, the employer does not care what the internal composition of the abilities that ensure the fulfillment of the task, the fact of its implementation is important for them. Therefore, competencies are even called by the task: "the ability to perform such and such a task". And due to what internal resources it will be implemented - this is the problem of the one who performs this work.

Psychophysiological differences of boxers with different styles of conducting a duel are the basis for differences in the indicators of the special performance of boxers (Tab. 1-3, Fig. 3).

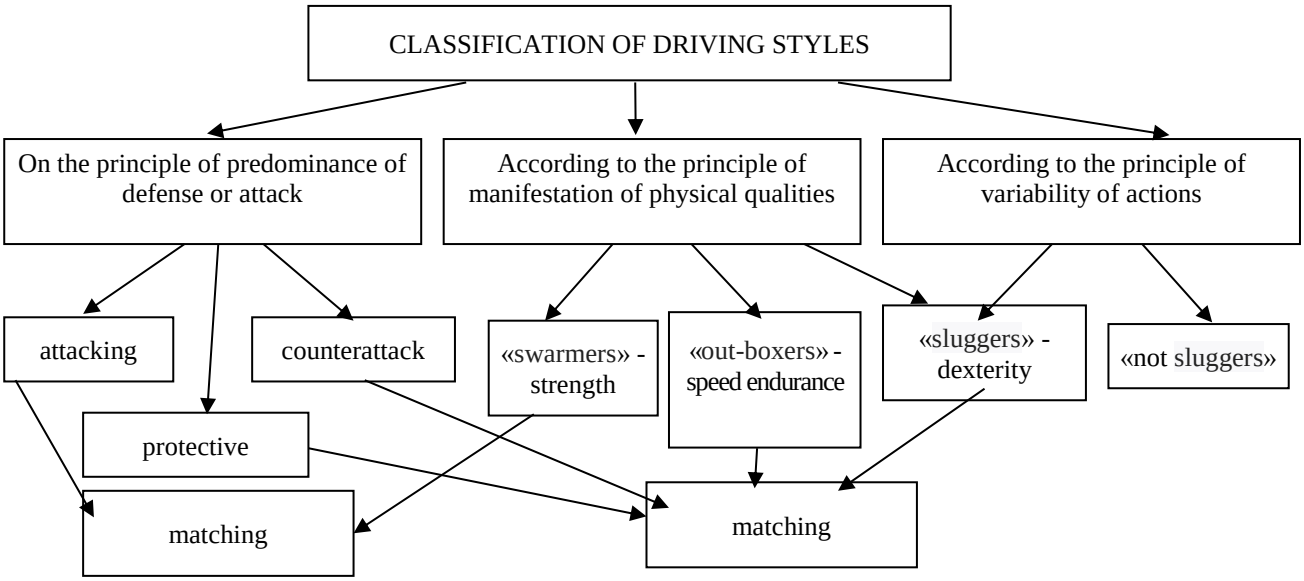

Fig. 3. Systematization of classifications of boxing combat styles according to various category criteria

Very often there is a combination of the manifestation of any physical qualities and the predominance of attacking or counterattacking actions. For example, "swarmers" are most often attackers at the same time, and "sluggers" are counterattacks, "out-boxers" are also most often counterattacks or defenders. It is logical to assume that the physiological basis for the formation of styles is relatively unchanged genetically determined functions, for example, neodynamic processes and psychophysiological capabilities, and the registration of these indicators in the training process will help determine at the stage of basic training the boxer's inclination towards the future style of the fight.

Conclusions

1. Cluster analysis of indicators of psychophysiological testing showed the presence of 3 groups of athletes. An expert evaluation of the boxing match styles included in each group showed that the first group included boxers of the counterattack style, "sluggers", the second group included athletes of the attacking style, "swarmers", the third group included athletes of the counterattack and defensive styles, "out-boxers".

2. Boxers - "sluggers" have higher mobility of nervous processes in comparison with representatives of other styles. Boxers - "sluggers" also differ from boxers of other styles with a

significantly higher switchability of attention, concentration of attention.

3. Boxers - "out-boxers" are distinguished by significantly higher neurodynamic endurance (mental stability), as determined by the Schulte test, and are highly developed. "Counterattacking" - "sluggers" are distinguished by a higher reaction rate, speed of work, and attentiveness when completing tasks.

4. "Attackers" - "swarmers" are distinguished by a higher strength of the nervous system, determined by the number of errors in the test for the speed of a complex reaction in the feedback mode.

5. Psychophysiological and neurodynamic indicators are informative for determining the inclinations of boxers to a certain style of conducting a duel. This provision can be applied at all stages of training athletes to quickly and effectively determine propensities for a particular style of conducting a duel based on innate neurodynamic and psychophysiological characteristics.

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Conflict of interest

Authors state no conflict of interest.

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Method for the development of physical qualities of tennis players 12-13 years old using react balls and stretching

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Abstract
The purpose – to develop and experimentally substantiate the method of developing the physical qualities of tennis players aged 12–13 years old, using React Balls and stretching.
Material and methods. The experiment was attended by 28 tennis players 12-13 years old sport school № 3, Severodonetsk, who were divided into control and experimental group of 14 people. The study was conducted within 8 months from August 2018 to March 2019. Before and after the experiment, tennis players' physical fitness was tested (shuttle run 6x8 m, push-ups 30 s, jumps with skipping-rope, running 6 m, running 30 m, long jump from the spot, throwing ball 1 kg, torso inclination forward from a sitting position, circular rotations in the shoulder joint with a gymnastic stick).
Results. Complexes of exercises with React Balls and stretch exercises for all muscle groups were developed and introduced into the training process of young tennis players. A significant ($p<0.05$) increase in the flexibility indicators of athletes from the experimental group, as a result of the use of stretch exercises, was determined. It was revealed that doing exercises with React Balls and tennis balls significantly ($p <0.05$) increased the level of speed and coordination capabilities in the control and experimental groups. According to the test results «running 30 m», «circular rotations in the shoulder joint with a gymnastic stick», «torso inclination forward from a sitting position» in the experimental group, these figures are significantly higher compared with the athletes of the control group.
Conclusions. It was shown that the use of stretching exercises contributes to the development of greater amplitude of movements, and also forms motor freedom, which affects the development of coordination and speed of movement of a tennis player. It is recommended to use the method of development of physical qualities using React Balls and stretching balls in the training process of young tennis players 12-13 years old.
Keywords: tennis; physical qualities; stretching; react balls; physical fitness; stretching exercises

Анотація
Собко И.М., Колесов О.В., Улаева Л.О. Методика розвитку фізичних якостей тенісистів 12-13 років з використанням реагуючих м'ячів та стретчингу
Мета роботи - розробити та експериментально обґрунтувати методику розвитку фізичних якостей тенісистів 12-13 років, з використанням реактивних м'ячів і стретчингу.
Матеріал і методи. В експерименті взяли участь 28 тенісистів 12-13 років КДЮСШ №3 м Сєвєродонецьк, які були розділені на контрольну та експериментальну групу по 14 чоловік. Дослідження проводилося протягом 8 місяців з серпня 2018 по березень 2019 року. До і після експерименту було проведено тестування фізичної підготовленості тенісистів (човниковий біг 6х8м, згинання розгинання рук в упорі лежачі за 30 с, стрибки зі скакалкою за 1 хв, біг 30 м, біг 6 м, стрибок у довжину з місця, метання набивного м'яча, нахил тулуба вперед з положення сидячи, викрутив з гімнастичною палицею).
Результати. Розроблено і впроваджено в тренувальний процес юних тенісистів комплекси вправ з реактивних м'ячів і стретчингу для всіх груп м'язів. Визначено достовірне ($p<0,05$) збільшення показників гнучкості спортсменів експериментальної групи, в результаті застосування стретч-вправ. Виконання вправ з реактивних м'ячів і з тенісними м'ячами достовірно ($p<0,05$) підвищило рівень швидкісних і координаційних можливостей в контрольній та експериментальній групах. За результатами тестів «біг 30 м», «викрутитися з гімнастичною палицею», «нахил тулуба вперед з положення сидячи» в експериментальній групі дані показники достовірно вище в порівнянні зі спортсменками контрольної групи.
Висновки. Показано, що застосування вправ на розтягування сприяє розвитку більшої амплітуди рухів, а також формує рухову свободу, що відбивається на вихованні координації і швидкості пересувань тенісиста. Рекомендовано використання методики розвитку фізичних якостей із застосуванням м'ячів реактивних м'ячів і стретчингу в тренувальному процесі юних тенісистів 12-13 років.
Ключові слова: теніс; фізичні якості; стретчинг; реактивні м'ячі; фізична підготовленість; стретч-вправи

Аннотация
Собко И.Н.1, Колесов О.В., Улаева Л.О. Методика развития физических качеств теннисистов 12-13 лет с использованием реактивных мячей и стретчинга
Цель работы – разработать и экспериментально обосновать методику развития физических качеств теннисистов 12-13 лет, с использованием реактивных мячей и стретчинга.
Материал и методы. В эксперименте приняли участие 28 теннисистов 12-13 лет КДЮСШ №3 г. Северодонецк, которые были разделены на контрольную и экспериментальную группу по 14 человек. Исследование проводилось в течении 8 месяцев с августа 2018 по март 2019 года. До и после эксперимента было проведено тестирование физической подготовленности теннисистов (челночный бег 6х8м, загибание разгибание рук в упоре лежа за 30 с, прыжки со скакалкой за 1 мин, бег 30 м, бег 6 м, прыжок в длину с места, метание набивного мяча, наклон туловища вперед из положения сидя, выкрут с гимнастической палкой).
Результаты. Разработаны и внедрены в тренировочный процесс юных теннисистов комплексы упражнений с реактивными мячами и стретч-упражнений для всех групп мышц. Выявлено достоверное ($p<0,05$) увеличение показателей гибкости спортсменов экспериментальной группы, в результате применения стретч-упражнений. Выявлено, что выполнение упражнений с реактивными мячами и с теннисными мячами достоверно ($p<0,05$) повысило уровень скоростных и координационных возможностей в контрольной и экспериментальной группах. По результатам тестов «бег 30 м», «выкрут з гимнастической палкой», «наклон туловища вперед из положения сидя» в экспериментальной группе данные показатели достоверно выше по сравнению со спортсменками контрольной группы.
Выводы. Показано, что применение упражнений на растягивание способствует развитию большей амплитуды движений, а также формирует двигательную свободу, что отражается на воспитании координации и скорости передвижений теннисиста. Рекомендовано использование методики развития физических качеств с применением реактивнsх мячей и стретчинга в тренировочном процессе юных теннисистов 12-13 лет.
Ключевые слова: теннис; физические качества; стретчинг; реактивные мячи; физическая подготовленность; стретчинг

Introduction

High performance in sports depends on the health status of an athlete, the characteristics of his physique, level of physical and motor fitness, coordination abilities associated with the development of physical qualities. Of particular importance for an athlete is the success of learning applied motor skills and skills, and the formation of technique. Tennis belongs to the type of sports games that combine versatile athletic abilities, psychological content and emotional struggle, aesthetics of movements and a high level of entertainment effect [1]. Tennis requires a sportsman to develop high coordination abilities (especially the differentiation of spatial-temporal parameters of movements and accuracy of movements), strength abilities (especially speed strength), speed abilities (to a greater degree of starting speed and speed in complex motor reactions), aerobic abilities (matches can occurs from 1 to 4 hours), flexibility in the joints (especially in the hip and shoulder joints), functionality (especially the function of the visual analyzer), intelligence abilities [2]. From this it follows that the process of training qualified athletes is an urgent task of the entire coaching corps.

The whole perennial process of sports training in tennis has a complex dynamic structure, which includes a wide range of different pedagogical influences, diagnostics of athletic abilities, and adequate use of the means, methods and forms of the teaching and educational process. The relevance of education, development and improvement of various aspects of athletes' preparedness cannot be overestimated. It is due to the need to have information on maintaining a high level of performance in extreme competitive conditions, the effectiveness of technical and tactical actions, predicting a player's noise immunity in a competitive fight, and developing methods for the effectiveness and sustainability of their activities [1].

Modern scientific researchers discuss various aspects of the sports activities of tennis players of various qualifications [3-5]. Many works are devoted to the issues of psychological preparation of tennis players [6-7]. The authors emphasize that psychological training should become an integral part of the whole training process when working with young athletes, provided that they have an adequate choice of means and methods, taking into account the age and individual characteristics of children. The scientist Makuts [7] develops individual psychological profiles for tennis players, which determine the content and choice of means of psychological preparation. The authors also analyze the problems of injuries and diseases of the musculoskeletal system of tennis players, suggest means and methods for preventing injuries in sports [3]. Scientists emphasize the importance of planning the preparation of high-class tennis players for the main competitions of the season [9]. Some authors define the features of the construction of the training process of young tennis players 5-6 years old, in particular, the specifics of the use of pedagogical control to assess the level of development of children's coordination abilities [10]. Researches of many specialists [12-14] prove the need to create optimal programs of the training process for the development and improvement of the athletic fitness of young athletes. When using such a system, it is necessary to remember that the creation of programs must be closely interconnected with all the components of a whole, that is, the development of physical fitness is determined by the interrelation of all qualities. Many scientists [1, 2, 5] identified the main approaches to the technical and tactical training of tennis players of different ages 5-6 years, 10-12 years, 14-15 years. However, the number of studies aimed at the development and improvement of the physical qualities of young tennis players is limited.

The purpose of our research was to develop and experimentally substantiate the method for developing the physical qualities of tennis players aged 12–13 years using React Balls and stretching.

Material and methods

Participants

The experiment was attended by 28 tennis players 12-13 years old sport school № 3 Severodonetsk, who were divided into control and experimental group of 14 people. Athletes of both groups did not significantly differ in most indicators of technical and physical readiness.

Organization of research

The research was conducted within 8 months from August 2018 to March 2019. In the control group, standard exercises were used to develop flexibility. Such as: springy bends forward and to the side (standing, sitting); standing at the gymnastic wall; swing legs forward, backward; exercise with a partner (sitting, leaning forward with a partner's hands on the shoulder blades); exercises with the burdening of your own body (from hanging on the rear bar - sagging); exercises using your own strength (sitting, leaning forward with pulling the body to the legs with the hands on the feet). For the development of coordination and speed qualities in the control group, a set of exercises developed for the

experimental group was used, tennis balls were used instead of React Balls.

For athletes of the experimental group, a method of developing physical qualities was developed and implemented using exercises with React Balls and stretching. Stretch exercises were used in the preparatory and main parts of each training session of tennis players. Exercises with React Balls were used in the main part of each training session.

Stretch exercises were performed from a position of standing and sitting in static and dynamic modes. Mobility exercises in the elbow joints, stretching of the radial flexor of the wrist, and triceps muscles were performed as 2 sets of 10 s each. Stretching exercises for the muscles of the legs and ankles, including the muscles of the lower leg, ankle joints, peroneal muscle, and plantar fascia, were performed in 2-3 sets of 10 s each. The complex of exercises for the back muscles included lower lumbar rotation, stretching the muscles of the lower back, stretching with rotation, stretching with lateral tilts of 2-3 sets of 10-15 s each). Rest between approaches 10-30 s, the nature of the rest - complete relaxation. The number of exercises in one complex is from 4 to 10. The total duration of the entire load is from 10 to 15 minutes.

Also used were exercise React Balls, which consist of 100% rubber, diameter: 6.6 cm. It works on any solid surfaces, including wood shavings, rubber coatings, walls and soil. The six sides of this ball rebound in an unpredictable direction. Sample exercises:

1. Dribbling, as in basketball, changing the receiving hand.

2. Throws the ball into the wall at different angles and at different points. Catching the ball with one hand, then the other hand.

3. In pairs: standing facing each other, the partner throws the ball to the right or left. It is necessary to catch the ball after one rebound from the court (the distance must vary from 3 to 6 m).

4. In pairs: standing with your back to the partner, the partner throws the ball to the right or left. It is necessary to turn on the signal and catch the ball after one rebound from the court (the distance must vary from 3 to 6 m).

5. In pairs: standing facing the wall, back to the partner, the partner throws the ball into the wall. It is necessary to catch the ball after a rebound from the wall (the distance must be varied from 3 to 6 m).

6. In pairs: a partner throwing balls at different speeds to a player at the net or back line (the distance must be varied from 3 to 6 m).

Before and after the experiment, the physical fitness of tennis players from the control and experimental groups was tested.

Methods. To determine the level of development of speed, the following tests were used:

Running 6 m (s); running 30 m (s).

To determine the level of development of coordination, the following tests were used:

Shuttle run 6 x 8 m was performed with a stop and touching the line. The execution time was fixed (s).

Jumps with skipping-rope, (number of times). Recorded the number of jumps in 1 minute.

To determine the level of development of strength and speed-power qualities, the following tests were used:

Throwing ball 1 kg, (sm), throwing was carried out in a movement similar to the feed. The best result was recorded after three attempts.

Push-ups 30 s (number of times).

Long jump from the spot (sm).

To determine the level of development of flexibility, the following tests were used:

Torso inclination forward from a sitting position (sm). Testing was carried out sitting on the floor, the test result was a mark on the perpendicular marking in centimeters, in which athletes reached out with the tips of their fingers in the best of three attempts.

Circular rotations in the shoulder joint with a gymnastic stick (number of times), the athlete takes the ends of the gymnastic stick, performs straight arm twists back. The number of revolutions recorded.

Statistical analysis

Digital material was processed using traditional methods of mathematical statistics using Microsoft Excel, SPSS. For each indicator, the arithmetic mean value, the standard deviation σ (standard deviation), the assessment of the significance of differences between the parameters of the initial and final results by the Student's t-test with the corresponding significance level (p)

Results

As a result of the experiment in the control group, the indicators of 3 tests significantly improved: «running 6 m, s», «shuttle run 6x8 m, s», «throwing ball 1 kg, sm», ($p<0,05$; $p<0,01$) (table 1)

Table 1

Indicators of physical fitness testing of tennis players of the control group before and after the experiment (n = 14)

Name of metrics	Group	Statistical Indicators				
		$\bar{x}$	S	m	t	p
Running 6 m, s	K_1	1,58	0,14	0,04	2,03	<0,05
	K_2	1,48	0,12	0,03		
Running 30 m, s	K_1	4,98	0,09	0,03	1,58	>0,05
	K_2	4,93	0,07	0,02		
Push-ups 30 s, number of times	K_1	18,57	2,38	0,63	-0,66	>0,05
	K_2	19,14	2,14	0,57		
Jumps with skipping-rope, number of times	K_1	118,14	4,13	1,37	1,75	>0,05
	K_2	120,43	2,59	0,69		
Shuttle run 6x8 m, s	K_1	13,97	0,11	0,03	4,21	<0,01
	K_2	13,75	0,16	0,04		
Throwing ball 1 kg, sm	K_1	945,50	8,86	2,37	3,77	<0,01
	K_2	956,86	6,96	1,86		
Circular rotations in the shoulder joint with a gymnastic stick, number of times	K_1	3,51	0,89	0,24	1,53	>0,05
	K_2	4,86	1,23	0,33		
Torso inclination forward from a sitting position, sm	K_1	10,36	2,27	0,61	-1,84	>0,05
	K_2	11,59	1,03	0,28		
Long jump from the spot, sm	K_1	194,93	2,40	0,64	-1,32	>0,05
	K_2	196,64	3,32	0,89		

Note: * K_1 – control group before the experiment; K_2 – control group after the experiment

In the experimental group, the indices of 6 tests significantly improved: «running 6 m, s», «running 30 m, s», «jumps with skipping-rope, number of times», «shuttle run 6x8 m, s», «throwing ball 1 kg, sm», «circular rotations in the shoulder joint with a gymnastic stick, number of times», «torso inclination forward from a sitting position, sm» ($p < 0,05$; $p < 0,01$) (table 2).

Table 2

Indicators of physical fitness testing of tennis players of the experimental group before and after the experiment (n = 14)

Name of metrics	Group	Statistical Indicators				
		$\bar{x}$	S	m	t	p
Running 6 m, s	E_1	1,56	0,13	0,03	3,99	<0,05
	E_2	1,42	0,05	0,01		
Running 30 m, s	E_1	4,96	0,11	0,03	2,45	<0,05
	E_2	4,85	0,12	0,03		
Push-ups 30 s, number of times	E_1	19,35	1,90	0,50	-0,33	>0,05
	E_2	19,57	1,45	0,38		
Jumps with skipping-rope, number of times	E_1	117,43	2,47	0,66	-2,20	<0,05
	E_2	120,57	2,41	0,64		
Shuttle run 6x8 m, s	E_1	13,88	0,24	0,07	3,47	<0,01
	E_2	13,51	0,31	0,08		
Throwing ball 1 kg, sm	E_1	945,71	6,80	1,82	0,54	>0,05
	E_2	947,07	6,38	1,70		
Circular rotations in the shoulder joint with a gymnastic stick, number of times	E_1	3,36	0,63	0,17	3,34	<0,01
	E_2	6,21	0,70	0,19		
Torso inclination forward from a sitting position, sm	E_1	10,64	1,69	0,45	-3,20	<0,05
	E_2	12,86	1,96	0,52		
Long jump from the spot, sm	E_1	193,71	2,73	0,73	1,36	>0,05
	E_2	194,93	1,94	0,52		

Note: * E_1 – experimental group before experiment; E_2 – experimental group after the experiment

After the experiment, significant differences between the control and experimental groups were identified. According to the test results «running 30 m, s», «circular rotations in the shoulder joint with a gymnastic stick, number of times», «torso inclination forward from a sitting position, sm» in the experimental group, these figures are significantly higher compared with athletes in the control group; based on test results «throwing ball 1 kg, sm» control group is significantly higher than experimental ($p<0,05$, $p<0,01$) (table 3).

Table 3

Indicators of physical fitness testing of tennis control (n = 14) and experimental (n = 14) group after the experiment

Name of metrics	Group	Statistical Indicators				
		$\overline{X}$	S	m	t	p
Running 6 m, s	К*	1,48	0,12	0,03	1,90	>0,05
	Е	1,42	0,05	0,01		
Running 30 m, s	К	4,93	0,07	0,02	2,15	<0,05
	Е	4,85	0,12	0,03		
Push-ups 30 s, number of times	К	19,14	2,14	0,57	0,61	>0,05
	Е	19,57	1,45	0,39		
Jumps with skipping-rope, number of times	К	120,43	2,59	0,63	-0,14	>0,05
	Е	120,57	2,41	0,64		
Shuttle run 6x8 m, s	К	13,75	0,16	0,04	-1,04	>0,05
	Е	13,51	0,31	0,08		
Throwing ball 1 kg, sm	К	956,86	6,96	1,86	3,87	<0,05
	Е	947,07	6,38	1,70		
Circular rotations in the shoulder joint with a gymnastic stick, number of times	К	4,86	1,23	0,33	2,18	<0,05
	Е	6,21	0,70	0,19		
Torso inclination forward from a sitting position, sm	К	11,29	2,20	0,59	2,03	<0,05
	Е	12,86	1,96	0,52		
Long jump from the spot, sm	К	196,64	3,32	0,89	1,66	>0,05
	Е	194,93	1,94	0,52		

Note: K – control group; E – experimental group

Discussion

In the research, it was hypothesized that the use of stretching and exercising with React Balls in the training process of tennis players 12-13 years old, will increase their level of physical qualities. This hypothesis was fully confirmed. The results of the study are consistent with the opinion of many authors that the level of physical fitness of tennis players is one of the leading factors that ensures the steady progress of sportsmanship [12, 14, 15]. In the age period from 7 to 17 years, a solid foundation is laid for important motor skills and habits, the development of motor skills and the maturation of the main functions of the athlete's body are under development [1]. Therefore, at each stage of growing up, the trainer is obliged to pay special attention to the development of each physical quality. At the same time, it is necessary to develop individual qualities in mutual connection with other qualities, but in no case isolated from each other. Modern coaches are constantly looking for new ways associated with the preparation of young athletes. In the course of the training process, the role of the coach is in the proper selection and use of all means and methods for developing the physical qualities of an athlete [12-14].

In this research, for young tennis players, stretch exercises and exercises with React Balls for the development of the reaction were selected. The combination of exercises for the development of flexibility, coordination and speed of reaction contributes to the formation of an optimal technique for performing motor actions of tennis players. The flexibility of a tennis player is manifested in the performance of basic techniques, especially such as serving, a blow above head. A tennis player with greater mobility in the joints has a better chance of hitting the ball, which is at a considerable distance from it (all other things being equal) [16]. Coordination qualities in tennis are especially pronounced when mastering the technique of strikes with different strength, direction, ball rotation, in other words - in the process of mastering the whole variety of technical actions of tennis players in a difficult game situation. It is very important to be able to quickly rebuild the motor activity also because it is often necessary to play on courts with

different surfaces. Different coatings are big differences in the speed of the ball and in the degree of its rotation. How quickly an athlete adapts to the rebound will largely depend on his success in the match. In addition, tennis players play tournaments either indoors or in the open air. Meteorological conditions, especially wind, place great demands on the coordination abilities of tennis players. Windy weather affects the game of both rivals, but the one who can, having understood his actions, can rebuild even a stronger opponent, can rebuild them according to the changed situation. The speed of a tennis player manifests itself during the movements he makes at maximum speed, if necessary, to get, for example, a shortened ball or a ball sent to the side. And how quickly the player starts moving in the direction of the ball, how quickly he picks up the desired speed, the success of the point draw depends in many respects.

Currently, among sports professionals it is extremely popular to use stretching as a form of preparing the muscular-ligamentous apparatus for training and competitive loads as a form of active rest for recovery [17-18]. The results of this study supplemented the data on the use of stretching in the training process of tennis players. So, scientists Aftimichuk et. al. [19] use stretching to prevent injuries, to prepare the body for stress and to correct the state of fatigue of tennis players. The authors emphasize that the physiological essence of stretching is that by stretching the muscles and holding a certain posture in them, the processes of blood circulation and metabolism are activated. They use the stretch exercises in the preparatory and final parts of the training session to warm up the muscles and hitch after physical exertion. In this study, stretch exercises were used in the main part of the training as the main means for developing flexibility. Stretching contributes to the development of the flexibility of the cervical, dorsal, lumbar, gastrocnemius and other muscle groups, joints, ligaments and tendons - almost without leaving any of them involved. In turn, in tennis, each movement has its own amplitude, and the larger this amplitude is, the more free movement, the stronger and more accurate the impact. Therefore, the use of stretching allows the tennis player's movements to be as wide and free as possible, contributes to the economy of movements, is an important condition for the development of other physical qualities [20-21].

Also, coaches in various sports often use exercise complexes with tennis balls. Such exercises develop coordination, speed and speed of reaction, help to respond quickly to an irritant at short distances. In this study, React Balls were used, which require extreme concentration of vision and speed of reaction. The six-sided design of the ball allows you to suddenly change its direction of flight and rebound, the hexagon design causes the ball to jump and randomly bounce. When performing an exercise, the athlete is forced to move at different speeds in an unpredictable direction.

As the analysis of the results showed, at the end of the experiment, the indicators of flexibility, speed, and coordination improved significantly in the experimental group. This can be explained by the fact that stretching exercises contribute to the development of greater amplitude of movements, as well as form motor freedom, which affects the development of coordination. Only with sufficient flexibility can one achieve the necessary level of development of the physical qualities required by a tennis player. Improving speed, associated with repeated exercises with React Balls. The tennis player must see the ball, evaluate the direction of flight and the strength of the ball bounce, and then perform high-speed movements. In the control group, exercise complexes with tennis balls were used, which increased the level of speed and coordination abilities of athletes.

Thus, the positive results obtained in the course of work allow us to recommend the developed methodology for the development of physical qualities in the process of training tennis players in accordance with the tasks set.

Conclusions

A method of developing the physical qualities of young tennis players, using React Balls and stretching, was developed and introduced into the training process. The use of this technique can significantly improve the performance of flexibility, speed, coordination of tennis players 12-13 years.

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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 comprehensive preparedness of shooters 14-15 years old, specializing in shooting from classic bow

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Abstract
The purpose of the work: to determine the factor structure of the complex preparedness of shooters of 14-15 years who specialize in the Classic bow, for rational construction of the training process of athletes of this age category.
Material and methods. The experiment was attended by 16 bow-shooters (girls) aged 14-15 years old, specializing in Classic bow, sport school "Avangard" in Kyiv. The experiment was conducted in the preparatory period, September 2018. The archers were tested for physical fitness (shuttle running 4x9m, push-ups 30 s, jumping with skipping-rope, running 30 m, Romberg test, hanging on bent hands at an angle of 90˚, jump in length from place, raising the torso to a sitting position, dynamometry of the right and left hands), technical preparedness (holding the bow in the "stretch", archery 18 m, archery 60 m, stretching the bow on the right and left hand for 30 s). The obtained data were processed mathematically using factor analysis methods.
Results. The factor structure of physical and technical preparedness of shooters, which are at the stage of specialized basic training, is established. Five factors were identified: static power endurance, dynamic power endurance, coordination capabilities, speed capabilities, strength capabilities.
Conclusions. It is revealed that the most important indicators of the complex training of archers 14-15 years old are the indicators of shooting in the open air and indicators of the static strength of the archer, as well as indicators of shooting in the room and indicators of the dynamic endurance of the archer, indicating the dependence of physical and technical training. The use of rational means and methods of physical and technical training in the training process of athletes is recommended.
Key words: archery; shooters; factor analysis; technical preparedness; physical preparedness.

Анотація
Собко И.М., Ковтун А.Л., Улаєва Л.О. Факторна структура комплексної підготовленості стрільців 14-15 років, що спеціалізуються в стрільбі з класичного луку
Мета роботи: визначення факторної структури комплексної підготовленості стрільців 14-15 років, що спеціалізуються в стрільбі з олімпійського лука, для раціональної побудови тренувального процесу спортсменів цієї вікової категорії.
Матеріал і методи. В експерименті взяли участь 16 стрільців (дівчат) у віці 14-15 років, що спеціалізуються в стрільбі з олімпійського лука, які займаються в ДЮСШ «Авангард» в м. Києві. Експеримент проводився в підготовчому періоді, вересень 2018 року. Лучники пройшли тестування фізичної підготовленості (човниковий біг 4х9 м, згинання, розгинання рук в упорі лежачи за 30 с, стрибки зі скакалкою, біг 30 м, проба Ромберга, вис на зігнутих руках під кутом 90˚, стрибок в довжину з місця, підняття тулуба в сід, динамометрія правої і лівої рук), технічна підготовленість (утримання лука в «розтягу», стрільба з лука 18 м, стрільба з лука 60 м, розтягнення лука правою і лівою рукою протягом 30 с). Отримані дані були оброблені математично з використанням методів факторного аналізу.
Результати. Встановлена факторна структура фізичної та технічної підготовленості лучників, які перебувають на етапі спеціалізованої базової підготовки. Були визначені п'ять факторів: статична витривалість, динамічна витривалість, координаційні здібності, швидкісні здібності, силові здібності.
Висновки. Виявлено, що найбільш важливими показниками комплексної підготовки лучників 14-15 років, є показники стрільби на відкритому повітрі і показники прояву статичної сили лучника, а також показники стрільби в приміщенні і показники прояву динамічної витривалості лучника, що вказують на залежність фізичної та технічної підготовки. Рекомендовано використання раціональних засобів і методів фізичної і технічної підготовки в тренувальному процесі спортсменів.
Ключові слова: стрільба з лука; лучники; факторний аналіз; технічна підготовка; фізична підготовка.

Аннотация
Собко И.Н., Ковтун А.Л., Улаева Л.А. Факторная структура комплексной подготовленности стрелков 14-15 лет, специализирующихся в стрельбе из классического лука
Цель работы: определение факторной структуры комплексной подготовленности стрелков 14-15 лет, специализирующихся в стрельбе из олимпийского лука, для рационального построения тренировочного процесса спортсменов этой возрастной категории.
Материал и методы. В эксперименте приняли участие 16 стрелков (девочек) в возрасте 14-15 лет, специализирующихся в стрельбе из олимпийского лука, которые занимаются в ДЮСШ «Авангард» в м. Киеве. Эксперимент проводился в подготовительном периоде, сентябрь 2018 года. Лучники прошли тестирование физической подготовленности (челночный бег 4х9 м, згибание, разгибание рук в упоре лежа за 30 с, прыжки со скакалкой, бег 30 м, проба Ромберга, вис на согнутых руках под углом 90˚, прыжок в длину с места, поднятие туловища в сед, динамометрия правой и левой рук), техническая подготовленность (удержание лука в «растяжке», стрельба из лука 18 м, стрельба из лука 60 м, растяжение лука правой и левой рукой в течение 30 с). Полученные данные были обработаны математически с использованием методов факторного анализа.
Результаты. Определена факторная структура физической и технической подготовленности лучников, находящихся на этапе специализированной базовой подготовки. Были определены пять факторов: статическая выносливость, динамическая выносливость, координационные способности, скоростные способности, силовые способности.
Выводы. Выявлено, что наиболее важными показателями комплексной подготовки лучников 14-15 лет, являются показатели стрельбы на открытом воздухе и показатели проявления статической силы лучника, а также показатели стрельбы в помещении и показатели проявления динамической выносливости лучника, указывающие на зависимость физической и технической подготовки. Рекомендовано использование рациональных средств и методов физической и технической подготовки в тренировочном процессе спортсменов.
Ключевые слова: стрельба из лука; лучники; факторный анализ; техническая подготовка; физическая подготовка

Introduction

The problem of training athletes in Olympic sports is highly relevant [1, 2]. Qualitative improvement of sports and technical skills is the main task in the preparation of archers. Modern archery is a complex technical sport that places great demands on the physical, technical, tactical and psychological training of athletes of various qualifications. However, for beginners, archers is an interesting and accessible sport due to its emotional appeal and low energy costs. The practice of sports work and the results of scientific research show that systematic training for 8-10 years is necessary to achieve international class results in shooting sports [3]. In this regard, at each stage of multi-year preparation, it is necessary to search for the most effective ratios of loads of various directions and new forms of organization of the training process.

A theoretical analysis of scientific and methodical studies in archery indicates existing scientific data on improving the effectiveness of training with the help of control exercises with complicated performance conditions (shooting sitting on a chair, standing on the platform, eyes closed) [3], using a balance board with additional optical gun and special target exercises [4], as well as by improving the technical means of teaching motor actions [2].

Modern scientific research is devoted to the content of sports training of archers are focused mainly on the training of qualified athletes [5, 6]. Scientists have found that the sporting success of highly skilled shooters is most determined by the coordination abilities of the athlete. The stability of the shooter-weapon system largely depends on the ability to control this system when exposed to external and internal factors: the speed at which the shot is executed, the content front sight during aiming, and the processing of the shot [2, 7]. Some scientists note the importance of the problem of psycho-emotional stability of the shooter, which is essentially expressed in the duration of the retention of the sight at the center of the target until it stops completely [8]. Tarasova et.al. [7] determined the factor structure of the functional state and special physical performance of skilled archery shooters, which allowed to identify the most significant factors. Studies to determine the biomechanical and physiological parameters of archery are conducted by many researchers [9-11]. Some experts compared the muscular activity of the shoulder girdle and upper extremity of athletes with different levels of experience in archery and determined that training lower trapezius muscles actively influences the improvement of archery skills [12].

In methodical and partially in scientific studies it has been shown that effective work with young athletes is possible only on the basis of taking into account physiological changes that occur in the body of adolescents [13, 14]. Moreover, since the age of 10-15 is most favorable for the development of special physical qualities and the formation of specific coordination abilities. At the initial basic specialization stage, special attention is recommended to be paid to the development and improvement of the special quality of the archer - differentiation of the speed at which the boom reaches down. At the stage of special basic training, the training process is aimed at the development and improvement of special physical and technical training of athletes in accordance with the requirements of the specifics of archery. During this period, athletes begin to actively participate in competitions in the categories of Olympic and block bow. Therefore, when selecting training bows, coaches need to take into account the differences between Olympic and block bows. The main difference lies in the presence of a block system located on his shoulders, therefore the speed of the arrow and the strength of the shot of such a bow exceeds any Olympic variant by half or even three times. In contrast to the classic, a shot in a block bow occurs not only due to the strength of the shoulders, but also through the use of a system of block mechanisms.

In connection with the characteristics of the competitive activity of archers, and their specialization, the importance of physical and technical readiness in the formation and improvement of sportsmanship of athletes increases.

Thus, the purpose of our study was to determine the factor structure of the complex preparedness of shooters 14-15 years old, specializing in Classic bow, for the rational construction of the training process of athletes of this age category.

Material and methods

Participants

The experiment was attended by 16 bow-shooters (girls) aged 14-15 years old, specializing in Classic bow, Athletes have three years of experience in archery and are part of a group of basic training, sport school "Avangard" in Kyiv. The experiment was conducted in the preparatory period, September 2018.

Methods

. To determine the level of development of physical fitness, the following tests were used:

• Shuttle run 4 x 9 m was performed with a stop and touching the line. The execution time was fixed (s).

• Push-ups 30 s (number of times).

• Jumps with skipping-rope, (number of times).

• Running 30 m (s).

• Romberg's test (s).

• Hang on bent arms at an angle of 90˚ (s).

• Long jump from the spot (cm).

• Raising the torso to a sitting position (number of times).

• Dynamometer of the right and left hand (kg).

To determine the level of technical development of basketball players, the following tests were used:

• Bow content in "stretching". Testing was performed standing, the execution time (s) was recorded.

• Stretching a bow with right and left hand for 30 s. Testing was performed standing, recorded a number of times.

• Archery 18 m (number of points). Shooting is performed indoors at a distance of 18 meters at the target (120 s per series). There are a total of 20 series of 3 arrows each. Fixed number of points.

• Archery 60 m (number of points). Shooting is done in the air at a distance of 60 meters at the target (240 seconds per series). There are a total of 12 series of 6 arrows each. Fixed number of points.

Statistical analysis

Digital material was processed using traditional methods of mathematical statistics using Microsoft Excel, SPSS. The factor analysis was used by the method of main components to determine the hidden relationships between the indicators of special physical and technical readiness of athletes. The analysis served as a means of reducing variables and identifying the main components that determine the structure of the complex preparedness of athletes.

Results

Conducting a factor analysis, with the help of which a large number of variables (in our case, 15), was reduced to a smaller number of independent values, allowed us to identify five factors (Table 1).

Table 1

Matrix of components in factor analysis of indicators of complex testing of bow arrows (n = 16)

The name of the factor	Indication	Factors				
		1	2	3	4	5
Static power endurance	Archery 60 m, number of points	0,697				
	Push-ups 30 s, number of times	0,674				
	Bow content in "stretching", s	0,621				
	Romberg's test, s	0,592				
	Hang on bent arms at an angle of 90˚, s	0,565				
	Long jump from the spot, cm	0,563				
Dynamic power endurance	Archery 18 m, number of points		-0,810			
	Stretching a bow with left hand for 30 s, number of times		0,682			
	Stretching a bow with right hand for 30 s, number of times		0,564			
	Raising the torso to a sitting position, number of times		-0,587			
Coordination capabilities	Jumps with skipping-rope, number of times			0,569		
	Shuttle run 4 x 9 m, s			0,715		
	Dynamometer of the left hand, kg			0,647		
Speed capabilities	Running 30 m, s				0,706	
Power capabilities	Dynamometer of the right hand, kg					0,486

The first factor was called "Static power endurance". It includes test indicators: hanging on bent arms at an angle of 90˚ (r = 0.56), Romberg's test (r = 0.59), bow content in "stretching" (r = 0.62). These indicators characterize the endurance to long-term work of moderate power, the steady content of the stretched bow in the process of aiming and processing the release of the boom, including the functioning of the majority of the muscular system. This factor also includes indicators of testing flexion, push-ups 30 s, (r = 0.67) and a long jump from the spot (r = 0.56). These indicators characterize the

power capabilities of archers related to keeping the bow in a static position, the ability to maintain optimal power stresses for a long time. All indicators form the highest correlation coefficients with the first indicator of archery testing 60 m (r = 0.69). After all, the manifestation of the static power endurance of an archer is the ability to maintain an optimal level of performance during the entire shooting exercise for a few hours both during the competition and during training.

The second factor included the indicators that form the highest correlation coefficients with the first indicator of this factor archery 18 m (r = 0.81). These are indicators of stretching the bow with right and left hands for 30 s (r = 0.68–0.54) and raising the torso to a sitting position (r = –0.516). These indicators characterize the archers' ability to work for a long time and efficiently, aimed at multiple bow tension, therefore the second factor was named "Dynamic power endurance".

The third most important factor was named "Coordination capabilities". It included such indicators as jumping skipping-rope for 1 min (r = 0.56), shuttle running 4x9 m (r = 0.71), dynamometer of the left hand (r = 0,64). This factor is not less significant, because a high level of coordination abilities allows you to quickly acquire new motor skills; rationally carry out the existing stock of skills, abilities and motor skills; show the necessary variation of movements in accordance with the specific situations of training and competitive activities. In archery, coordination abilities are largely due to the speediness of the athlete, which is necessary for processing information received from visual, kinesthetic, tactile, auditory analyzers. This suggests that the improvement of technical skill is carried out through the improvement of the properties of analyzers, provide rich information about the nature and degree of accuracy of the actions performed in specific conditions and improve consistency in their work.

The fourth factor and the fifth factor included the test running 30 m (r = 0.821) and dynamometry of the right hand (r = 0.48), they were called "Speed capabilities" and "Power capabilities", respectively. These indicators stood out in separate factors, as the speed capabilities of the shooters provide a quick rise of the bow and its stretching when firing in adverse meteorological conditions and with a shortage of time left to execute the shot. And power capabilities are manifested in opposition to the growing fatigue caused by the power component of the load, that is, the onion content in a relatively stable position (a certain time) and its tension.

Thus, in the general structure of preparedness of archers, five factors were singled out, the percentage of which from the total variance is presented in Fig. 1.

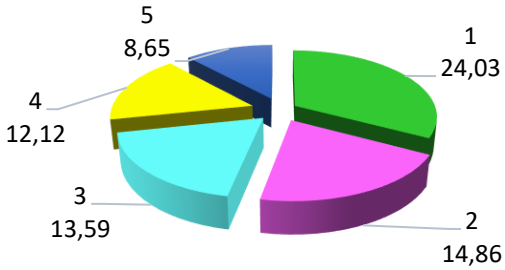

Fig. 1. The percentage of the total variance of the main factors of testing Archers

Analyzing the percentage contribution of various factors to the total variance, we note that the first factor "Static power endurance" prevails in the structure of preparedness of shooters from the bow. Then follow the second and third factors, their percentage contribution is almost the same, which indicates the equal importance of these factors. This can be explained by the fact that the activity of the shooter, who specializes in the Classic bow, is the alternation of long-term static and dynamic relatively uniform work performed in a few hours. But the amount of static work is much higher, since with static voltage fatigue occurs faster than with dynamic. This is due to the large load on the nervous system, which should regulate the high accuracy and uniformity of muscular effort with a large number of executed shots. Coordination capabilities depend on the archer's motor fitness, as well as on the effectiveness of mental processes that determine the reliability of motion control and ensure that the athlete performs technical actions at the same time. Coordination abilities are needed to execute the shot, ensure the sustainability of the "gunner-weapon" system and adequately respond to changes in the conditions of sports activity (lighting, wind, rain, etc.).

Discussion

Modern scientists [15–17] actively apply multivariate analysis methods to study the structure of the integrated fitness of young and skilled athletes

in various sports. Leading Ukrainian specialists [18] consider factor analysis to be the most appropriate mathematical tool. It allows you to reduce a wide range of indicators of preparedness and to identify the main components that determine the exact characteristics of the individual characteristics of athletes. The use of modern methods of analysis helps to create optimal training methods that best meet the requirements of the training process in a specific period of time. In sports games, using factor analysis, scientists [19] develop individual factor models of physical fitness of athletes of various game roles. In this regard, the studies conducted in this work confirm and supplement the data of the listed authors about the need to use a wide range of physical and technical readiness indicators to determine the factor structure of preparedness of archery shooters aged 14-15 years.

Sport experts emphasize that sporting achievements in archery are determined by the level of technical readiness of an athlete, because the strength of the shooter is characterized by the degree of quality of the motor actions on the basis of which the archery technique is performed [20-21]. One of the main indicators of technical excellence are efficiency and cost-effectiveness of actions. No less important are the indicators of accuracy and reliability that ensure the sustainability of the sporting result. In turn, the improvement of sports equipment will be fruitful and effective only if it provides for the formation of a biomechanically rational structure of movements, in accordance with the actual level of physical fitness of an athlete. After all, archery in competitive conditions requires the athlete to repeatedly use muscular efforts in static, overcoming and progressive modes and provide stretching of the bow (15-25 kg), holding the pose at the time of aiming (up to 10 s). In this study, the indicators of physical and technical readiness of young archers in the process of learning motor actions are analyzed. The data obtained emphasize the importance of the level of development of static and dynamic strength endurance, coordination of movements in the process of improving the sports and technical skills of athletes at the stage of special basic training. At this stage, to a greater extent than at previous ones, technical improvement is based on various rifle exercises. For example, shooting with different time intervals reached the arrows and the shot as a whole, without visual control, etc. As a result of the work on this and subsequent stages of many years of training, the archer must master the technique of many special preparatory exercises quite well. This approach forms his ability to quickly master the technique of shooting an Classic bow, which corresponds to his morphofunctional capabilities, and further provides the shooter with the ability to vary the basic parameters of technical skill depending on the conditions of specific competitions [2-22]. Thus, during this period, the focus should be on the development of static strength endurance, which provides for a long and repeated repetition of the posture on the alert and maintain it for a certain time, these actions are aimed at adapting the archer's body to specific loads. The optimal distribution of the efforts of all muscle groups involved in the implementation of an aimed shot is largely dependent on the level of development of dynamic strength endurance. Therefore, the development of this quality should be aimed at ensuring coordinated actions of numerous muscle groups of the back, arm, which directly performs the tension of the bow and arm, which provides the content of the bow and counteracts its pressure. The development of coordination abilities lays the foundation for the further development of accurate perception and reproduction of muscular efforts, as well as the ability to differentiate temporal, velocity, and power characteristics in combination of movements provide a shot. Therefore, it is necessary to develop the ability to effectively manage muscle tension and relaxation [22]. The manifestation of power abilities is closely related to the efficiency of the energy supply of the respective work, the level of development of speed abilities and flexibility, they are necessary for keeping the bow and resistance to its pressure, as well as for stretching the bow, so special strength is developed regarding the archer's technical actions.

The results of the study determine the main directions of physical training of archers from the bow of 14-15 years old, specializing in the Classic bow. To optimize the training process of athletes of this age category, optimal tools, forms and methods of training athletes were selected. For the development and improvement of static power endurance, the use of the method of strictly regulated exercises with the use of special schemes, providing for a long bow holding and tight rest intervals, has been proposed. For the development of dynamic strength endurance, it is recommended to perform multiple imitations of bow tension with a resistance of 25–50% of the maximum force at an average pace until complete fatigue (work on a simulator with the exception of a hand holding a bow, or with a rubber band) 60–70 % of maximum effort at an average pace. Special dexterity should be developed with the help of exercises characteristic of the activity of the archery bow. When training coordination abilities, it should be taken into account that the archer simultaneously performs several technical actions that require coherence in the work of various muscle

groups (bow holding, resistance to bow pressure, bow tension and orientation in the shooting plane, maintaining the necessary posture, correct brush position, which ensures release of a bowstring), and corrects various characteristics of his movements, agreeing with changes in the situation. In this regard, modeling the complicated conditions of activity in the process of shooting (reducing the time allotted for shooting, changing light, shooting in adverse meteorological conditions, etc.), which cause the archer to change the pace and rhythm of shooting, take into account the influence of artificially introduced obstacles and look for new ways to overcome the difficulties. For the development and improvement of speed capabilities, it is recommended to perform multiple repetitions of speed actions with maximum or maximum intensity on stimulus signals with a gradual reduction in response time without disrupting the execution technique. Exercises related to the imitation of individual elements of a shot with an arrow can be used, or directly shooting at various distances with specific tasks. For the development of strength, exercises with weights, exercises using various training devices and exercises that are performed at a slow pace with significant muscle tension are proposed.

Thus, regular monitoring and accounting of the dynamics of physical and technical readiness, proper selection of means and methods of sports training will optimize the training process of the archers at different stages of many years of training and adjust it when changing any training conditions (changes in the competition calendar, injuries, diseases and etc.).

Conclusions

It is shown that the indicators of complex testing of archers from 14 to 15 years old, specializing in Classic bow, are divided into five factors: static power endurance, dynamic power endurance, coordination capabilities, speed capabilities, strength capabilities. It was revealed that the first, the most important factor, included shooting indicators in the open air and indicators of the static power endurance of the archer, the second included shooting indicators in the room and indicators of the dynamic power endurance of the archer, which indicates the dependence of physical and technical training in archery. The use of rational means and methods of physical and technical training of archers on the stage of special basic training for the optimal construction of the training process of athletes is recommended.

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Conflict of interest

The authors declare that there is no conflict of interest.

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