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The journal presents articles on topical issues of physical education and sport, as well as on the problems of the formation, restoration, strengthening and preservation of health of representatives of different groups of people, physical rehabilitation and physical therapy, rehabilitation, sports medicine.
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Здоров'я, спорт, реабілітація
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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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CONTENT

ORIGINAL ARTICLES. SPORT

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ORIGINAL ARTICLES. SPORT

Ratio of maximum hamstring torque to maximum quadriceps torque in professional basketball and soccer players

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

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Abstract

Purpose: The aim of the study was to determine the differences between football players and basketball players in the mean absolute values of maximum torque flexors and extensors, ratio of maximum hamstring torque to maximum quadriceps torque dominant (DOM) non-dominant (ND) leg and differences in bilateral imbalance of flexor muscles and knee extensors.
Material and methods: The research included a sample of 39 professional athletes. The first subsample included 19 professional basketball players while the second subsample included 20 professional soccer players.
Results: Based on the results of the torques of the extensors in the knee joint of the DOM and ND legs, it was established that there is no statistically significant difference between basketball players and football players. However, a statistically significant difference was found in the torque flexors of the knee joint DOM ($p \leq 0.01$) and ND ($p \leq 0.00$) of the leg between basketball players and football players. On the other hand, the results of the research indicate that the difference between basketball players and football players in the ratio of Hamstrings peak torque to Quadriceps peak torque was recorded only in the ND leg ($p \leq 0.02$), while the difference in the DOM leg is not statistically significant. The results of our study indicate that basketball players have a higher percentage of imbalances compared to football players, especially in m. hamstrings.
Conclusion: This study provides normative data on populations specific to soccer and basketball, but does not provide evidence of the ability of the isokinetic assessment of lower extremity muscle strength to predict injuries to football players and basketball players.
Key words: knee joint, isokinetic testing, torque, extensor muscles and flexors

Анотація

Олександр Кукрич, Марко Йоксимович, Борко Петрович, Франческа Латіно, Ратко Павлович, Ружица Кувалья. Співвідношення максимального крутного моменту на підколінних сухожиллях та максимального крутного моменту на чотириголовому м'язі у професійних гравців у баскетбол та футбол

Мета: Метою дослідження було визначити відмінності між футболістами та баскетболістами у середніх абсолютних значеннях максимальних згиначів та розгиначів крутного моменту, домінуючої (DOM) недомінантної (ND) ноги та співвідношення максимального крутного моменту на підколінних сухожиллях до максимального крутного моменту на чотириголовому м'язі та відмінностей у двосторонньому дисбалансі м'язів -згиначів та розгиначів коліна.

Матеріал і методи: Дослідження включало вибірку з 39 професійних спортсменів. Перша підвибірка включала 19 професійних баскетболістів, тоді як друга підвибірка включала 20 професійних футболістів.

Результати: На підставі результатів обертальних моментів розгиначів у колінному суглобі ніг DOM та ND було встановлено, що немає статистично значущої різниці між баскетболістами та футболістами. Однак була виявлена статистично значуща різниця у згиначах крутного моменту колінного суглоба DOM (p≤0,01) та ND (p≤0,00) ноги між баскетболістами та футболістами. З іншого боку, результати дослідження вказують на те, що різниця між баскетболістами та футболістами у співвідношенні H / Q була зафіксована лише на етапі ND (p≤0,02), тоді як різниця в нозі DOM не є статистичною значний. Результати нашого дослідження показують, що баскетболісти мають більший відсоток дисбалансу порівняно з футболістами, особливо в м. підколінні сухожилля.

Висновок: Це дослідження містить нормативні дані про популяції, характерні для футболу та баскетболу, але не надає доказів здатності ізокінетичної оцінки сили м'язів нижніх кінцівок передбачити травми футболістів та баскетболістів.

Ключові слова: колінний суглоб, ізокінетичне тестування, крутний момент, м'язи -розгиначі та згиначі

Аннотация

Александар Кукрич, Марко Йоксимович, Борко Петрович, Франческа Латино, Ратко Павлович, Ружица Куваля. Соотношение максимального крутящего момента на подколенных сухожилиях к максимального крутящего момента на четырехглавой мышце у профессиональных баскетболистов и футболистов

Цель: Целью исследования было определение различий между футболистами и баскетболистами в средних абсолютных значениях максимального крутящего момента сгибателей и разгибателей, отношение максимального крутящего момента на подколенных сухожилиях и максимального крутящего момента на четырехглавой мышце доминирующей (DOM) и недоминантной (ND) ноги и различий в двустороннем дисбалансе. мышц сгибателей и разгибателей колена.

Материал и методы. В исследовании участвовали 39 профессиональных спортсменов. В первую подвыборку вошли 19 профессиональных баскетболистов, а во вторую - 20 профессиональных футболистов.

Результаты. На основании результатов крутящих моментов разгибателей в коленном суставе ног DOM и ND установлено, что статистически значимой разницы между баскетболистами и футболистами нет. Однако статистически значимая разница была обнаружена в сгибателях крутящего момента коленного сустава DOM (p≤0,01) и ND (p≤0,000) ноги между баскетболистами и футболистами. С другой стороны, результаты исследования показывают, что разница между баскетболистами и футболистами в соотношении H / Q была зафиксирована только в ноге ND (p≤.02), в то время как разница в ветви DOM не является статистически достоверной. существенный. Результаты нашего исследования показывают, что у баскетболистов более высокий процент дисбалансов по сравнению с футболистами, особенно в m. подколенные сухожилия.

Выводы. Это исследование предоставляет нормативные данные о популяциях, специфичных для футбола и баскетбола, но не предоставляет доказательств способности изокинетической оценки силы мышц нижних конечностей прогнозировать травмы футболистов и баскетболистов.

Ключевые слова: коленный сустав, изокинетическое тестирование, крутящий момент, мышцы-разгибатели и сгибатели.

Ключевые слова: коленный сустав, изокинетическое тестирование, крутящий момент, мышцы-разгибатели и сгибатели.

Introduction

Muscular strength and power are important in terms of basic physiological capacities in most sports games (soccer, basketball, handball, et.al.). Soccer (a planetary phenomenon) is the most played sport in the world, and according to some estimates, as of 2006, there are as many as 265 million active football players [1]. The football game is characterized by intermittent periods ranging from high-intensity activities to low-intensity activities. In terms of physiological requirements, the football imperative implies that players be competitive in several aspects of fitness, which requires a high level of aerobic and anaerobic power, muscle strength, flexibility, and agility [2]. Precisely defined aspects of fitness differ depending on the position in the team as well as the style of play [3]. Unlike soccer, basketball is also increasingly popular in many countries, the game is played by more than 450 million people. Numerous tests and training programs are used at the professional level to monitor the cardiovascular and athletic performance of players and the results of these tests are used to adapt training techniques in an attempt to prevent traumatic and excessive injuries [4]. It is an intermittent sport that involves rapid, explosive, and repeated changes of direction [5] which during a field game (smaller dimensions) changes the direction of movement on average every 2 seconds. Energy mobilization during a basketball game comes mainly from aerobic sources, although this activity requires specific performance associated with short accelerations and jumps, which are more dependent on anaerobic sources [6].

During soccer and basketball matches, players perform various and numerous jumps, punches, turns of various technical exercises, which characterize the dynamics of the game by constantly changing the place, ie the position on the field. Functionally analyzed, such movements are primarily based on maximum strength muscle capacity. Therefore, the relationship between torque and speed (and consequently muscle strength) of the lower extremities of athletes is especially important for football and basketball matches [7]. In team sports, the quadriceps and hamstrings muscles are integrated into motor skills such as running and jumping [8] and muscle strength appears to be one of the most important components of these sports, both for high performance and for injury prevention [9]. Injuries to these muscle groups are one of the main problems faced by today's athletes. Inherent in these sports is a higher risk of anterior cruciate ligament (ACL) injury compared to other sports which causes a significant loss of time due to competition. It is assumed that one of the possible causes of injuries is an unbalanced relationship between muscle agonists and antagonists, which in practice is referred to as muscle imbalance [10]. Muscle imbalance is a condition in which one muscle is stronger or weaker than the other and can also occur as a result of reduced muscle length (shortened muscle).

A typical example of muscle imbalance is the unbalanced action of extensor and flexor muscles in the knee joint. In conditions when m. quadriceps femoris during dynamic activities generates significantly greater muscle force compared to m. hamstrings, excessive translational displacement of the upper leg may occur. In such conditions, the anterior cruciate ligament (ACL) suffers significantly higher pressure forces than usual. Therefore, if m. hamstrings too weak and cannot be opposed with sufficient force to the action of m. quadriceps femoris, ACL injury most commonly occurs in the knee joint [11]. These allegations are confirmed by Opar et al. [12], which indicate that if m. quadriceps femoris extremely strong and its activity in certain phases of movement too large, excessive elongation of m can occur. hamstrings, leading to its damage. The main reasons for such an injury are weakness of the flexor in the knee joint, bilateral imbalance m. hamstrings, an inadequate relationship between the flexor and extensor in the knee joint (H / Q ratio), which causes injuries to m. hamstrings up to 2.5 times more frequent than injury m. quadriceps femoris. Lower limb strength, strength imbalance between Hamstring and Quadriceps muscles and strength imbalance between dominant and non-dominant limbs are considered very important in increasing performance and also preventing injury [13].

According to Alentorn-Geli et al. [1] lower extremity plyometrics, dynamic balance and strength, stretching, body awareness and decision-making, and targeted core and trunk control appear to be successful training components to reduce non-contact ACL injury risk factors (decrease landing forces, decrease varus/valgus moments, and increase effective muscle activation) and prevent non-contact ACL injuries in players. Various laboratory tests are used to assess the strength parameters of elite soccer players and basketball players. Most studies have used isokinetic equipment at different speeds and joint angles for direct comparison [7, 6]. Isokinetic dynamometry tests have been widely used and are the most common tools to assess Quadriceps and Hamstring muscle strength both in professional athletic. Isokinetic testing also provides the essential information about the Hamstring to Quadriceps ratio (H/Q) and limb asymmetry index (LSI) which can be

used for evaluating lower limb muscle strength and imbalance between the muscles of the lower limb [14, 15, 16, 17].

Soccer and basketball are different sports games with different technical abilities, different training and playing positions. Therefore, muscle groups m. hamstrings and m. The quadriceps femoris include several important motor skills such as running and jumping. The aim of the research is to determine the differences between football players and basketball players in the mean absolute values of maximum torque of flexors and extensors, H / Q ratio dominant-non-dominant leg and differences in bilateral imbalance of flexor and extensor muscles of the knee joint.

Material and methods

Study participants

The research included a sample of 39 professional athletes. The first subsample included 19 professional basketball players with an average (Mean ± Std.Dev) body height 196.68 ± 8.00 cm, body weight 96.05 ± 8.64 kg, BMI 24.82 ± 1.69 kg / m2, age 25.95 ± 3.73. All basketball players are members of the Adriatic Basketball Association (ABA league), the highest competitive rank in the Balkans. The second subsample included 20 professional soccer players with body height 182.90 ± 6.80 cm, body weight 73.82 ± 5.64 kg, BMI 22.06 ± 1.00 kg / m2, age 21.05 ± 4.53. All football players are participants in the Premier League, the highest competitive rank in Bosnia and Herzegovina. The study is of a transversal nature and testing was done in the pre-competition period in the 2020/2021 season.

The criteria for inclusion were: that the players are participants of first team for at last least six months, that all the players went through the preparation period with the team, without injuries in the last six months, that they played one half-season before testing. Exclusion criteria were: athletes in the recovery phase from some form of acute or chronic injury, athletes who did not complete the entire preparation period. All respondents were first informed about the study, the purpose and goal of the research and possible consequences were explained to them. Also, the procedure and the course of the testing itself were explained to the respondents. Prior to the survey, each respondent signed a consent form to participate. For this research, the consent and

approval of the head coach and the president of the club were obtained, and after that, testing was started. The research was approved by the Ethics Commission of the Faculty of Sports and Physical Education, University of Banja Luka in accordance with the Declaration of Helsinki [18]. The players were instructed not to consume performance enhancing substances such as creatine, ribose etc. (coffee was limited to 1 cup) prior to tests, not to engage in high intensity physical activity 24 hours prior to the tests [19].

Study organization

Testing was performed by the same experienced examiner in the Laboratory for isokinetic testing at the Faculty of Physical Education and Sport in Banja Luka, Bosnia and Herzegovina. Laboratory was air-conditioned and room temperature was held between 22℃ - 24℃. Testing was performed between 09.00 am and 14.00 pm. Before testing on isokinetic apparatus, morphological characteristics of examinees had been tested. The day before the examination of the body composition, the examinees had to follow a protocol, which included the requirements not to consume food or drink after 22 pm. Additionally, in the morning, before the test, the respondents did not consume food and drink. The body weight and percentage of adipose tissue were measured by bioelectrical impedance, using a specialized scale Tanita BC418a (USA), with an accuracy of 0.1 kg, while body height was measured using an altimeter Seca 216 (Germany), whose accuracy is 0.5 cm. Testing on an isokinetic dynamometer (Cybex) was performed according to standard recommendations [20]. Prior to testing, a ten-minute warm-up was performed on a stationary bicycle (Monark), followed by stretching of the lower extremities [21].

Preparation for testing was continued on an isokinetic dynamometer, where 5 submaximal repetitions were performed in a concentric mode of flexor and extensor muscle work in the knee joint. After a break of 1 min, with maximum effort and commitment, the subjects performed 4 maximum concentric contractions of the flexor and extensor muscles in the knee joint. The test was performed in a sitting position on an isokinetic dynamometer chair (upper / lower body angle was approximately 85 °), where subjects were fixed with straps over the chest, hips, and distal end of the thigh. In the concentric mode of muscle work, flexors and extensors in the knee joint were tested at a speed of 60 $°\cdot s^{-1}$ The lateral femoral condyle was used as a reference point for the axis of rotation, and the length of the lever was determined individually for each individual [22]. The amplitude of the movement was determined at 90 ° (maximum extension was recorded and set as anatomical zero). Gravitational force correction was

performed in order not to help the flexors, that is, to make the activity of the extensor muscles more difficult when performing movements in the knee joint. Measure of the hamstrings to quadriceps ratio (H / Q ratio), calculated as the peak torque of the hamstrings divided by the peak torque of the quadriceps within the same limb (1) [16]:

$$\text{H/Q ratio} = \frac{Hamstrings\ peak\ torque}{Quadriceps\ peak\ torque} \quad (1)$$

Another ratio is calculated to compare peak torque between limbs and is referred to as the limb symmetry index (LSI). LSI is used to assess peak torque in the non-dominant relative to the dominant limb (2) [17]:

$$\text{LSI} = \frac{Dominant\ leg\ peak\ torque - nondominant\ leg\ peak\ torgue}{Dominant\ leg\ peak\ torque} \times 100\% \quad (2)$$

Statistical analysis

Data were processed using the Statistical Package for Social Sciences SPSS (v20.0, SPSS Inc., Chicago, IL, USA). In the first step, the basic descriptive parameters and distribution of variables were determined. Central and dispersive parameters were calculated for all tests: arithmetic mean (Mean), standard deviation (Std. Dev.). To determine the differences between the groups we used T-test. The statistically significant differences were determined at the level of $p < 0.05$.

Results

Table 1 contains the mean values and standard deviation of the maximum torques m. quadriceps femoris and m. hamstrings of the dominant (DOM) and non-dominant (ND) legs of basketball players and soccer players as well as the differences in mean values between the defined sample of athletes for each muscle group. In both groups of subjects, the right leg was dominant, and based on absolute values, it is evident that basketball players achieved slightly higher torque values in both tested muscle groups, for m.quadriceps femoris (DOM = 211.18 ± 43.28 $N \cdot m^{-1}$; ND = 200,37 ± 51,31 $N \cdot m^{-1}$), for m.hamstrings (DOM = 170,89 ± 35,86 $N \cdot m^{-1}$; ND = 169,32 ± 33,10 $N \cdot m^{-1}$) in relation to the sample of football players where torque value for m.quadriceps femoris (DOM = 196 ± 33.79 $N \cdot m^{-1}$; ND = 192.58 ± 42.84 $N \cdot m^{-1}$), and for m. hamstrings (DOM = 147.75 ± 18.92 $N \cdot m^{-1}$; ND = 141.69 ± 26.45 $N \cdot m^{-1}$). Applying the appropriate statistical procedures, it was found that there is a statistically significant difference in only the maximum torques of m.hamstrings between basketball players and football players in the dominant ($p \leq 0.01$) and non-dominant ($p \leq 0.001$) leg.

Table 1

Comparison between dominant and non-dominant muscle peak torque at $60° \cdot s^{-1}$

Muscle	Sports	Mean±Std.Dev.	Mean±Std.Dev.	p value	
		DOM	ND	DOM	ND
Quadriceps ($N \cdot m^{-1}$)	Basketball	211.18±43.28	200.37±51.31	0.22	0.60
	Soccer	196.00±33.79	192.58±42.84		
Hamstring ($N \cdot m^{-1}$)	Basketball	170.89±35.86	169.32±33.10	0.01*	0.00**
	Soccer	147.75±18.92	141.69±26.45		

Notes: DOM: Dominant leg (right); ND: non-dominant leg (left); *p≤0.05; **p≤0.01

Table 2 contains the average values of the limb asymmetry index (LSI) at maximum muscle torques m. quadriceps femoris-a and m. hamstrings DOM and ND legs (%) and H / Q ratio of DOM and ND legs in basketball players and football players. LSI is presented as a percentage difference in the strength of the extensor muscle (Quadriceps), that is, the flexor (Hamstring) in the knee joint DOM relative to the ND leg. The results confirmed that there is no statistically significant difference between basketball players and football players in terms of bilateral differences between extensor muscles (p=0.35) and flexors (p=0.30) in the knee joint. The H / Q ratio is presented as a coefficient corresponding to the quotient of the results of the maximum torques of the flexor and extensor muscles in the knee joint. The results obtained indicate that there is a statistically significant difference between basketball players and soccer players in the H / Q ratio of ND legs (p=0.02), while the difference was absent when it comes to DOM legs.

Table 2

Limb asymmetry index (LSI) and Hamstring to Quadriceps ratio (H/Q)

Velocity	Sports	H/Q ratio		LSI	
		Mean±Std.Dev.	Mean±Std.Dev.	Mean±Std.Dev.	
		DOM	ND	Quadriceps (%)	Hamstring (%)
60°·s^{-1}	Basketball	0.81±.11	0.86±.14	13.91±9.56	15.92±12.09
	Soccer	0.76±.12	0.75±.14	11.27±7.87	12.46±8.31
	p	0.22	0.02	0.35	0.30

Notes: DOM: Dominant leg (right); ND: non-dominant leg (left); *p≤0.05; H/Q ratio: Hamstring / Quadriceps ratio; LSI: Lims asymmetry index

Discussion

The aim of the study was to determine the differences between soccer players and basketball players in the mean absolute values of maximum torque of flexors and extensors, H / Q ratio dominant-non-dominant leg and differences in bilateral imbalance of flexor and extensor muscles of the knee joint. Appropriate power m. quadriceps femoris-a and m. hamstrings is essential for sports performance because these two muscles are functional antagonists; contraction m. quadriceps femoris results in knee extension, while contraction m. the hamstrings leads to flexion in the knee joint. These muscle groups together control the acceleration and deceleration of the lower leg relative to the thigh, and sufficient strength in both muscle groups is required for running, jumping, stopping, and other sports activities [23].

Based on the results of the mean values of the maximum torques of the extensors and flexors in the knee joint, obtained in this study, it can be concluded that the dominant leg in basketball players and football players is the right leg. Based on the results of the torques of the extensors in the knee joint of the DOM and ND legs, it was established that there is no statistically significant difference between basketball players and soccer players. On the other hand, a statistically significant difference was found in the torques of the knee joint flexor DOM (p≤.01) and ND (p≤.00) of the leg between basketball players and football players. Given the markedly different body weights of basketball players and soccer players, it was to be expected that basketball players would achieve significantly higher values of extensor torques in the knee joint compared to soccer players. Given that the tested groups differed significantly in body weight, and that body weight was associated with the manifestation of muscle strength, such results were expected. Larger body dimensions, significantly larger physiological cross-section of muscles, is one of the reasons why basketball players achieved slightly higher absolute values of torque [24].

In a study by Bradić et al. [25] in which elite basketball players participated, as a result of different body dimensions between players of different positions, different torque values were obtained. At an angular velocity of 60°·s^{-1}, the lowest values of the extensor torques in the knee joint were achieved by playmakers 268.7 ± 48.8 N·m^{-1}, and the highest values were achieved by the centers 321.7 ± 38.5 N·m^{-1}. When it comes to flexors in the knee joint, playmakers scored 157.1 ± 29.4 N·m^{-1}, while the centers scored 183.4 ± 24 N·m^{-1}. The mean value of the torque of the extensor in the knee joint of all subjects was 297.5 ± 43.5 N·m^{-1}, and the flexor 172 ± 27.3 N·m^{-1}. Compared to the results of our research, higher values of the torque of the extensor in the knee joint were achieved, while the values of the flexors are almost identical.

Comparing the results of our study with the results of other studies, subjects in both groups achieved low values of torque extensors in the hip joint, as well as approximately similar results of torque flexors in the hip joint [25]. The results of our study are not consistent with the results of the Erdemir [26] study, in which the authors, comparing top basketball players and soccer players, noted a statistically significant difference in torque extensors and flexors in the knee joint at the left and right leg. In isokinetic testing at 90º·s^{-1}, Magalhães et al. [27] noted a statistically significant difference in the maximum torques of extensors and flexors in the hip joint of the DOM and ND legs between volleyball players and soccer players. In both studies, the authors cited as one of the causes of statistically significant differences in the strength of the flexors and extensors of the knee joint markedly different body dimensions of the examined groups. Identical results with elite football players and basketball players were obtained [8, 28, 29].

The relationship between the strength m. hamstrings (flexor muscles) and m. the quadriceps femoris (extensor muscle), also known in the literature as the H / Q ratio, is widely used in the areas of sports training and rehabilitation to describe muscle strength properties affecting the knee joint and the detection of muscle imbalance. The

conventional H / Q ratio is defined as the ratio between the peak torque m. hamstrings and m. quadriceps femoris and is usually measured during concentric contraction, while the functional H / Q ratio is defined as the ratio between the peak torque m. hamstrings of the lower leg eccentric contraction and peak torque m. quadriceps femoris during concentric contraction (Hecc / Qcon) (representative of knee extension). Low values of H / Q ratio, strength (<0.6 for $60°\cdot s^{-1}$) may increase the risk of lower extremity injuries, especially anterior cruciate ligament (ACL) injuries and m deformities hamstrings [30], so this H / Q ratio is a measure of normal knee function and stability [31]. The results of our study in the H / Q ratio are in line with the results obtained [32, 33] , they are also above the set norms stated by Pelicer-Chenoll et al. [30]. On the other hand, the results of the research indicate that the difference between basketball players and soccer players in H / Q ratio was recorded only in ND leg ($p \leq .02$), while the difference in DOM leg is not statistically significant, therefore, lower values of H / Q ratio were recorded. in football players, which has been confirmed in studies [34, 35, 36] in which it is stated that m. hamstrings is not as strong as m. quadriceps femoris. It is this disproportionate H / Q ratio that may be inversely related to the occurrence of lower extremity injuries [37].

Our results of maximum strength of both legs can be explained by analysis of the physiological requirements of sports training. Garret et al. [38] point out that the muscles of m. hamstrings have a relatively high proportion of type II fibers compared to m. quadriceps femoris. Hunter et al. [39] and Hamada et al. [40] analyzed the structural and metabolic characteristics of muscles and concluded that the characteristic that most affects fatigue is the type of muscle fibers, where type II muscle fibers are more susceptible to fatigue than type I muscle fibers, so the difference in muscle composition may be a major factor in the divergence of strength loss between muscle groups. Biopsy studies have shown that a higher proportion of type II muscle fibers is higher in m. hamstings than in m. quadriceps femoris [41]. According to Croiser, [22] this imbalance and muscle weakness predispose to injuries m. hamstring. According to Benjuia et al. [43], this balance between muscle groups with antagonistic action is an essential element in understanding the epidemiology of many muscle injuries. Therefore, it is important to assess the H / Q ratio as a relevant factor in preventing muscle injury. Substantial lower limb neuromuscular asymmetry with regard to strength and power has been described as an important risk factor for sport injuries and linked to decrements in sports performance [44].

The relationship between strength and power asymmetry and injury risk or poor performance could be related to the inability of a weaker lower limb to produce and / or absorb the same amount of force that a stronger limb can. Previous research suggests that lower limb imbalances exist in cutting and pivoting sports such as basketball [31], soccer [45]. Analyzing the bilateral deficit of extensors and flexors in the knee joint, several studies have confirmed that an imbalance in muscle strength of 10% - 15% is considered as an indicator of a disturbed relationship of flexors and extensors of both legs [46, 47]. The results of our study indicate that basketball players have a higher percentage of imbalances compared to soccer players, especially in m. hamstrings. These differences in performance between the legs may be associated with anatomical asymmetry [48], previous injuries such as ACL rupture [49], specific sports requirements [44], training experience, and toys. positions [48]. The role of inter-limb strength asymmetry in lower limb injury prevention is not clear. In a recent meta-analysis [50] the hamstrings inter-limb asymmetry was shown to play a reduced role in predicting hamstrings injury risk. Nevertheless, it was reported previously that the inter-limb hamstrings eccentric strength asymmetry was predictive of the hamstrings strain-type injury risk [51].

Additionally, a reduced quadriceps inter-limb strength asymmetry is essential for a safe return to the sport after injury [52]. Interestingly, hamstrings and quadriceps inter-limb strength asymmetry were recently shown to be negatively correlated with changes of direction (COD) and sprinting ability [53]. Those authors reported that increasing the inter-limb asymmetry decreased the COD and sprint performance, with no impact on jumping ability. This could be due to the key role of both hamstrings and quadriceps in stabilizing, braking and accelerating the body during COD and a sprint [54], while the stronger limb seems to compensate for the work of the weaker limb in jumping ability [55].

Conclusion

This study provides normative data on populations specific to soccer and basketball, but does not provide evidence of the ability of the isokinetic assessment of lower extremity muscle strength to predict injuries to football players and basketball players. In addition, the isokinetic dynamometer allows the assessment of only the joint movement, limiting the conclusion about the complex multi-joint activities that are performed in both soccer and basketball.

Conflict of interest

The authors declare that there is no conflict of interest.

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Determination of fighting styles of qualified veteran boxers based on cluster analysis of biomechanical and psychophysiological indicators

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Abstract

Purpose: to reveal the styles of fighting veteran boxers on the basis of a multivariate analysis of psychophysiological and biomechanical indicators.
Material and methods. The study involved 42 qualified veteran boxers (age 45-50 years). As research methods, we used a biomechanical analysis of the indicators of the speed of movement of various points and the values of the angles in the joints when performing a direct blow by boxers. The psychophysiological method was used to determine the time of a simple and complex reaction under standard conditions and in various testing modes. We used the method of cluster analysis to distribute athletes into groups using the SPSS - 17.0 program. Within the groups, the athletes are as similar as possible to each other in terms of the analyzed indicators, and between the groups they differ as much as possible. The analysis of the groups of athletes obtained with the help of cluster analysis made it possible to identify athletes with the following styles of fighting: tempo, game, power.
Results. Cluster analysis of psychophysiological and biomehanical testing showed the presence of 3 groups of athletes. The clusters were named as follows: Cluster 1 - "Speed and coordination endurance", corresponds to the boxers of the pace of the fight; Cluster 2 - "Speed", corresponds to the boxers of the game style of fighting; Cluster 3 - "Strength and speed", corresponds to the boxers of the pace of the fight. Biomechanical features of boxers of different styles of fighting are reflected in the trajectories of the points of the fist, elbow, knee.
Conclusions. The results of this study should be used when planning the individual training of athletes in boxing and to determine the optimal style of competitive competition for qualified veteran boxers. The proposed methods of psychophysiological and biomechanical testing to determine the individual characteristics of boxers are an effective, fairly accessible and convenient tool for revealing the predisposition of boxers to a certain style of fighting.
Key words: technique, boxing, cluster, neurodynamics, speed, joint angle, physiology, psychology

Анотація

Козін В.Ю., Фальова О.Є., Крету М., Ягелло М. Визначення стилів ведення поєдинку кваліфікованих боксерів-ветеранів на основі кластерного аналізу біомеханічних і психофізіологічних показників

Мета: виявити стилі ведення поєдинку боксерів-ветеранів на основі багатовимірного аналізу психофізіологічних і біомеханічних показників.

Матеріал і методи. У дослідженні взяли участь 42 кваліфікованих боксера-ветерана (вік 45-50 років). В якості методів дослідження іспольльзовался біомеханічний аналіз показників швидкості руху різних точок і значеія кутів в суглобах при виконанню прямого удару боксерами. Використовувався психофізіологічний метод визначення часу простої і складної реакції в стандартних умовах і в різних режимах тестування. Ми використовували метод кластерного аналізу для розподілу атлетів на групи за допомогою програми SPSS - 17.0. Всередині груп атлети максимально схожі між собою по аналізованих показниками, а між групами - максимально розрізняються між собою. Аналіз отриманих за допомогою кластерного аналізу груп атлетів дозволив виявити атлетів з наступними стилями ведення поєдинку: темпової, ігровий, силовий.

Результаты. Кластерний аналіз показників психофізіологічного та біомеханічного тестування показав наявність 3-х груп атлетів. Кластери були названі наступним чином: кластер 1 – «Ш*видкісна та координаційна витривалість*», відповідає боксерам темпового стилю ведення поєдинку; кластер 2 – «Швидкість», відповідає боксерам ігрового стилю ведення поєдинку; кластер 3 – «Сила і швидкість», відповідає боксерам темпового стилю ведення поєдинку. Біомеханічні особливості боксерів різних стилів ведення двобію відображаються в траєкторіях руху точок кулака, ліктя, коліна.

Висновки. Результати даного дослідження доцільно використовувати при плануванні індивідуальної підготовки атлетів у боксі та для визначення оптимального стилю ведення змагального поєдинку для кваліфікованих боксерів-ветеранів. Запропоновані методи психофізіологічного і біомеханічного тестування для визначення індивідуальних особливостей боксерів є ефективним, досить доступним і зручним у застосуванні засобом виявлення схильності боксерів до певного стилю ведення поєдинку.

Ключові слова: техніка, бокс, кластер, нейродинамика, швидкість, кут в суглобі, фізіологія, психологія

Аннотация

Козин В.Ю., Фалева О.Є., Крету М., Ягелло М. Определение стилей ведения поединка квалифицированных боксеров-ветеранов на основе кластерного анализа биомеханических и психофизиологических показателей

Цель: выявить стили ведения поединка боксеров-ветеранов на основе многомерного анализа психофизиологических и биомеханических показателей.

Материал и методы. В исследовании приняли участие 42 квалифицированных боксера-ветерана (возраст 45-50 лет). В качестве методов исследования испольльзовался биомеханический анализ показателей скорости движения различных точек и значеия углов в суставах при выполении прямого удара боксерами. Использовался психофизиологический метод определения времени простой и сложной реакции в стандартных условиях и в различных режимах тестирования. Мы использовали метод кластерного анализа для распределения атлетов на группы с помощью программы SPSS – 17.0. Внутри групп атлеты максимально схожи между собой по анализируемым показателям, а между группами – максимально различаются между собой. Анализ полученных с помощью кластерного анализа групп атлетов позволил выявить атлетов со следующими стилями ведения поединка: темповой, игровой, силовой.

Результаты. Кластерный анализ показателей психофизиологического и биомеханического тестирования показал наличие 3-х групп атлетов. Кластеры были названы следующим образом: кластер 1 - «Скоростная и координационная выносливость», отвечает боксерам темпового стиля ведения поединка; кластер 2 - «Скорость», отвечает боксерам игрового стиля ведения поединка; кластер 3 - «Сила и скорость», отвечает боксерам темпового стиля ведения поединка. Биомеханические особенности боксеров разных стилей ведения поединка отражаются в траекториях движения точек кулака, локтя, колена.

Выводы. Результаты данного исследования целесообразно использовать при планировании индивидуальной подготовки атлетов в боксе и для определения оптимального стиля ведения соревновательного поединка для квалифицированных боксеров-ветеранов. Предложенные методы психофизиологического и биомеханического тестирования для определения индивидуальных особенностей боксеров являются эффективным, достаточно доступным и удобным в применении средством выявления предрасположенности боксеров к определенному стилю ведения поединка.

Ключевые слова: техника, бокс, кластер, нейродинамика, скорость, угол в суставе, физиология, психология

Introduction

At the present stage of boxing development, the style of fighting is a characteristic feature of every professional boxer [1, 2, 3]. Yes, there are boxers who are very forceful in the fight. They are distinguished by the great force of the blow, the desire for power victory of the enemy. Such boxers include Mike Tyson, Vitali Klitschko, George Foreman, David Tua and other attacking "security officers" [4, 5, 6]. Some boxers fight, constantly varying their actions, using a lot of feints, strikes in the most unexpected moments. These are boxers of game style - Roy Jones, Mohammed Ali, Floyd Mayweather [2, 3, 4]. 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 boxers of tempo style - Manny Pacquiao, Joe Fraser and others [7, 8]. The most successful option is the ability to combine different styles, and in different battles to show different ways of fighting. However, the most characteristic features of the movements of athletes remain unchanged, which gives reason to talk about the predominant individual style of fighting.

The doctrine of activity styles and, in particular, of fighting styles, has its roots in antiquity [1, 2, 9]. To date, the nature of the origin of different styles is not fully understood. There are hypotheses that suggest that the styles occurred as a result of separate training of certain groups of people [1, 9]. There are also historical facts that indicate the origin of the styles of dueling as an imitation of the manners of movement and survival strategies of different animals [9]. Thus copying was carried out both external movements, and internal states. Martial arts from the "crane style" have come down to our time, as well as different styles of fighting within one martial art.

There are a number of styles of wushu, united by the common name of xiang xinquan - "style of image and form" or "style of imitation of form." They are based on imitating the movements and habits of animals. In Xinxingquan, the state of naturalness, spontaneous looseness (jizhan) is achieved through complete self-identification with the selected object, not only external, but most importantly, internal. Man, mastering the "form and manner" of the tiger, snake, dragon, reached the natural looseness and natural power of the animal in its "original state" [10, 11].

Imitation of animal movements has been known in China for a long time [1]. In early totem dances, the ancestors of the Chinese imitated the manner of fighting the animal. The doctrine of activity styles and, in particular, of fighting styles, has its roots in antiquity. There are historical facts that indicate the origin of the styles of dueling as an imitation of the manners of movement and survival strategies of different animals. Thus copying was carried out both external movements, and internal states. It is logical to assume that the physiological basis of style formation is relatively constant genetically determined functions, such as neurodynamic processes and psychophysiological capabilities [12, 13], and registration of these indicators in the training process will help determine the propensity of a boxer to a certain style of fighting.

There are many different methods for measuring psychophysiological functions [14, 15]. At present, methods of studying psychophysiological functions are becoming more widespread, which make it possible to determine not only the reaction rate, the sense of time, but also the typological properties of the nervous system: strength, mobility, resistance to stimuli in time [15, 16 – 18].

Currently, the study of psychophysiological functions [19–22] in connection with the individual characteristics of the technique of movements, according to biomechanical indicators [23 –25], is of great importance. This makes it possible to quantitatively determine how and how the peculiarities of brain activity affect the formation of an individual style of human activity. For this purpose, qualified veteran boxers are one of the most suitable contingents for such studies for several reasons [26]: 1 – as a person's age increases, there is an improvement in technical skill while continuing to engage in a certain type of activity, including sports; 2 – as the age increases, the manifestation of individual psychological and psychophysiological traits occurs; 3 – the study of the peculiarities of technical skill of qualified middle-aged and elderly athletes in conjunction with the individual characteristics of psychophysiological functions is important as a tool for cognition of motor and psychophysiological manifestations of various styles of activity. However, there is much less scientific research on veteran athletes today than on younger active athletes.

In our previous studies [26], an attempt was made to determine the individual styles of fighting qualified veteran boxers on the basis of individual factor values of the analysis of psychophysiological and biomechanical indicators. With the help of factor analysis, carried out by the method of principal components, in the structure of complex readiness of qualified veteran boxers, 2 main factors were identified: "Speed" and "Speed and coordination endurance". Further, the individual factor structure of the athletes' readiness was found on the basis of

determining the percentage values of the severity of each factor in each boxer. All athletes have different severity of various factors, which indicates the presence of significant individual differences. This should be manifested in different styles of fighting and the need to use individual training programs for qualified veteran boxers [26].

Our previous studies have also shown that for an accurate distribution of veteran boxers according to fighting styles, it is necessary to use modern methods of mathematical statistics, in particular, cluster analysis [26]. Thus, this work is a continuation of our previous research to determine the fighting styles of qualified veteran boxers. In the presented work, it was assumed that a multivariate analysis of psychophysiological and ergonomic indicators would allow the athletes to be divided into groups that would correspond to different styles of fighting qualified veteran boxers.

Purpose: to reveal the styles of fighting veteran boxers on the basis of a multivariate analysis of psychophysiological and biomechanical indicators.

Material and methods

Participants

The study involved 42 qualified veteran boxers (age 45-50 years, body length – 178.67 ± 8.26 cm, body weight – 70.96 ± 9.38 kg). The total experience of boxing for the participants was 20 – 25 years. Athletes were selected as follows: a prerequisite for participation in the study was the presence of a sports qualification in the past not lower than a candidate for master of sports (the winners of competitions not lower than the level of the city and region) and the regularity of training for the last 10 years 3 – 4 times a week. The study was carried out on the basis of sports clubs "KhTZ", "Vostok", "Metalist" in Kharkov, Ukraine.

All participants were aware of the objectives of the study and agreed to participate. All participants gave written consent to participate in the study. The research was conducted in compliance with WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects, 2013.

Procedure

The study was conducted from April 18 to May 25, 2021. At the beginning, athletes were filmed while performing a direct blow in boxing. Each athlete performed a series of strikes alternately with the right and left hands in the training session against the background of a visible object for subsequent calibration with known dimensions. Video filming was carried out at training sessions from 18-00 after a short warm-up in the boxing gym of the KhTZ sports club. During one training session, 10 – 12 people were filmed. The next day after the video filming, the athletes underwent psychophysiological testing also from 18-00. When conducting psychophysiological testing, athletes were initially asked to pass the proposed tests in a training mode. Psychophysiological testing was carried out in the classroom for theoretical studies of the sports club "KhTZ".

Biomechanical Analysis of Direct Punch Technique in Boxing

We have chosen the direct punch as the main element for the analysis of the athletic technique of qualified veteran boxers. The choice of the direct hit was due to the fact that it is the main technical element in boxing [26, 27, 28]. This stroke is the most standardized of all boxing elements and provides the least variability in execution. This element is perfectly mastered by all qualified boxers, in particular – veteran boxers. Also, the individual style of movements is most traced precisely in those movements performed most automatically, that is, with minimal control from the side of consciousness. This blow is the most convenient for biomechanical analysis using video filming, since it is performed practically in the same plane.

Biomechanical analysis of the direct kick technique in qualified veteran boxers was carried out using the Kinovea software, version 0.8.15. (Fig. 1). The Kinovea program allows performing video analysis of movements [29, 30]. It is intended for athletes, coaches, healthcare professionals, and sports research. Also, the software can be useful for specialists in the field of ergonomics or animation. The main function of Kinovea is to view and analyze sports videos. The main tools used by users are "Line", "Chronometer", "Tracking", "Angles". The Line and Chronometer functions allow you to measure distance and time, while the Semi-automatic tracking tool can track both the path and time. When working with Kinovea, you can use video from external sources: video cameras, smartphones, and so on.

To analyze the biomechanical parameters of the direct strike technique of qualified veteran boxers, 6 frames were selected at a speed of 26 frames per second. Thus, the time of one frame was 0.03-0.04 s (Fig. 1 – 3). The duration of the direct impact was 0.13-0.16 s, depending on how many frames were analyzed (5 or 6, respectively). Distance

calibration was carried out along the length of a special device, against the background of which video filming was carried out (138 cm). The movement time was determined by the stopwatch indicators in the program. The speed of movement of the fist, shoulder joint, elbow joint, knee joint was determined (V, m • s^{-1}) (Fig. 2). Determination of the angles between the shoulder and the torso (the angle at the shoulder joint), between the shoulder and the forearm (the angle at the elbow joint), between the thigh and the lower leg (angle at the knee joint) (degrees) also worked (Fig. 1).

A total of 10 videos of direct kick were analyzed for each athlete. Averaged data for each athlete was analyzed from 10 videos. The total number of video recordings was 420. The point of the greatest extension of the striking arm in the shoulder joint was chosen as the end of the impact. In each video, 6 frames were selected for analysis (duration of a direct impact). If the impact ended on the fifth frame, then the sixth frame was excluded from the analysis. Earlier in the fifth frame, more than one athlete did not end the direct hit. Thus, the total duration of a direct blow in boxing among qualified veteran boxers was 0.13-0.16 s. The point of the minimum angle between the shoulder and the torso (shoulder joint), from which the movement of the striking arm begins [26, 29, 30], was chosen as the beginning of the impact.

To analyze the angles in the joints, the "Angles" tool was selected on the toolbar of the Kinovea 0.8.15 program. The point of the apex of the angle was selected, then the angle for analysis was determined. The angle chosen for analysis was determined in each frame (Fig. 1).

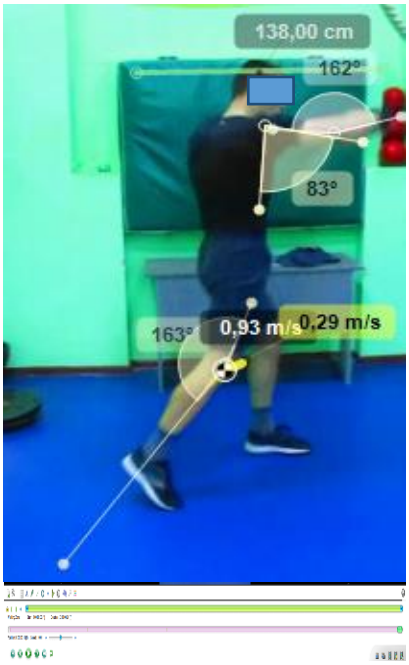

Fig. 1. Determination of the speed of movement of various points of the body and angles in the joints when performing a direct blow in boxing using the Kinovea 08.15 program

We carried out the following trajectory tracking for the subsequent analysis of the distance and speed of movement of each point (Fig. 1): 1 – we chose a point for analysis; 2 – select the "Track Path" option; choose the "End Path Edition" function; 3 – the analyzed point was corrected for each frame; 4 – Select the "Configuration" function and set the "Distance" function. The display showed the distance from the beginning of the movement to the selected segment of the path. To measure the speed of a point, we selected the "Configuration" function, and then we selected the "Speed" function. We chose meters per second as the unit of measurement. The measurement results were exported to the EXCEL program.

Psychophysiological methods

The following parameters characteristic of the psychophysiological state, typological features of the nervous system, indicators of the nervous system efficiency, and attention indicators [12, 14, 15] have been set using the computer program "Psychodiagnostics" (Kharkiv, Ukraine, KhNPU):

– A set of indices for the time of a simple visual-motor reaction (mean of 30 attempts (ms),

standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

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

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

Statistical analysis

We used the method of cluster analysis to distribute athletes into groups using the SPSS - 17.0 program. Within the groups, the athletes are maximally similar to each other in terms of the analyzed indicators, and between the groups they differ as much as possible [31–33]. The analysis of the groups of athletes obtained with the help of cluster analysis made it possible to identify athletes with the following styles of fighting: tempo, playing, strength styles.

When conducting cluster analysis, we used the following options of the SPSS program: Analyze – Classify – Hierarchical cluster analysis. We first printed the Agglomeration Schedule table without setting the estimated number of clusters. Based on the values of the coefficients in the table "Agglomeration Schedule" during the formation of clusters, we have determined the optimal number of clusters for our study. To do this, we subtracted the step number from the total number of cases (42), after which the increase in the coefficients occurs nonlinearly (39). As a result, we got the optimal number of clusters equal to 3. Next, we performed the cluster analysis again, setting the Cluster Membership – Single solution option. We set the number of clusters to 3. Thus, we got the cluster membership of each athlete. Further, we combined the results of determining individual factor values in absolute and relative terms with the results of the distribution of athletes into clusters (groups). Based on the prevalence of the severity of various factors in each group of athletes, we gave a name to each cluster.

Results

The test for normality of distribution of test indicators showed that all test indicators correspond to the normal distribution (Asymptomatic significance according to the Chi-square test> 0.05; Significance according to the Monte Carlo test> 0.05) [26]. The distribution of indicators of the analyzed sample does not significantly differ from the Gaussian normal distribution.

To determine the optimal options for combining qualified veteran boxers into groups based on the principle of different styles of fighting, a cluster analysis of testing indicators was carried out. The results of the cluster analysis were compared with the individual factor values, and the profiles of the athletes were drawn up. On the basis of the data obtained, the individual characteristics of qualified veteran boxers were determined by the prevalence of factors in the individual structure of preparedness and the corresponding styles of fighting.

In hierarchical cluster analysis, each individual case first forms its own separate cluster. At each step, two separate clusters that are closest to each other in their structure are combined into one cluster. First, the athletes who are closest in terms of the analyzed indicators are united, then athletes who are similar in the analyzed indicators join the formed pairs. Thus, groups of athletes appear, which can be considered as the groups most similar in their structure to the preparedness of the subjects.

Clusters were determined according to the degree of "similarity" of athletes according to the indicators of complex testing (Tables 1, 2, Fig. 2). In order to find out how many clusters are optimal, one should subtract the step number from the number of analyzed athletes, from which the cluster coefficients

begin to grow nonlinearly. In our case, this is step 39 (Table 1). Based on this, 42 – 39 = 3. That is, the optimal number of clusters is 3 clusters.

The first cluster included athletes No. 2; 5, 8; eleven; fourteen; 17; twenty; 23; 26; 29; 41 (n = 11) (Tables 1, 2, Fig. 2). The second cluster includes athletes No. 1; 4, 7, 10, 13; 16; 19; 22; 25; 28; 31; 32; 34; 37; 38; 40 (n = 16) (Tables 1, 2, Fig. 2). The third cluster included athletes No. 3, No. 6; nine; 12; 15; eighteen; 21; 24; 27; thirty; 33; 35; 36; 39; 42 (n = 15) (Tables 1, 2, Fig. 2). The stages of the combination of athletes into clusters are presented in Table 1. It can be seen from the table that at the first stage athletes No. 39 and No. 42 are united, in the next step athletes No. 38 and No. 41 are united. In the third step, athletes No 37 and No 40 are united. At the fourth step, athlete No 3 joins athletes 39 and 42. At the fifth step, athlete No 2 joins athletes No 38 and 41. At the sixth step, athlete No 1 joins athletes No 37 and 40. Further, each group of athletes is alternately replenished with the next veteran boxer. In total, 41 steps were taken to unite veteran boxers into clusters, 1 less than the number of athletes (42).

Table 1

Agglomeration Schedule in cluster analysis of biomechanical and psychophysiological indicators of qualified veteran boxers

Stage	Cluster Combined			Stage Cluster Last Appears		Next Stage
	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	
1	39	42	0.153	1	1	4
2	38	41	1.342	1	1	5
3	37	40	2.412	1	1	6
4	3	39	3.141	1	1	10
5	2	38	4.2705	1	2	11
6	1	37	5.2739	1	3	12
7	33	36	6.2773	1	1	10
8	32	35	7.2807	1	1	11
9	31	34	8.2841	1	1	12
10	3	33	9.2875	4	7	16
11	2	32	10.2909	5	8	17
12	1	31	11.2943	6	9	18
13	27	30	12.2977	1	1	16
14	26	29	13.3011	1	1	17
15	25	28	14.3045	1	1	18
16	3	27	15.3079	10	13	22
17	2	26	16.3113	11	14	23
18	1	25	17.3147	12	15	24
19	21	24	18.3181	1	1	22
20	20	23	19.3215	1	1	23
21	19	22	20.3249	1	1	24
22	3	21	21.3283	16	19	28
23	2	20	22.3317	17	20	29
24	1	19	23.3351	18	21	30
25	15	18	24.3385	1	1	28
26	14	17	25.3419	1	1	29
27	13	16	26.3453	1	1	30
28	3	15	27.3487	22	25	34
29	2	14	28.3521	23	26	35
30	1	13	29.3555	24	27	36
31	9	12	30.3589	1	1	34
32	8	11	31.3623	1	1	35
33	7	10	32.3657	1	1	36
34	3	9	33.3691	28	31	37
35	2	8	34.3725	29	32	38
36	1	7	35.3759	30	33	39
37	3	6	36.3793	34	1	41
38	2	5	37.3827	35	1	40

39	1	4	38.3861	36	1	40
40	1	2	267.014	39	38	41
41	1	3	612.816	40	37	0

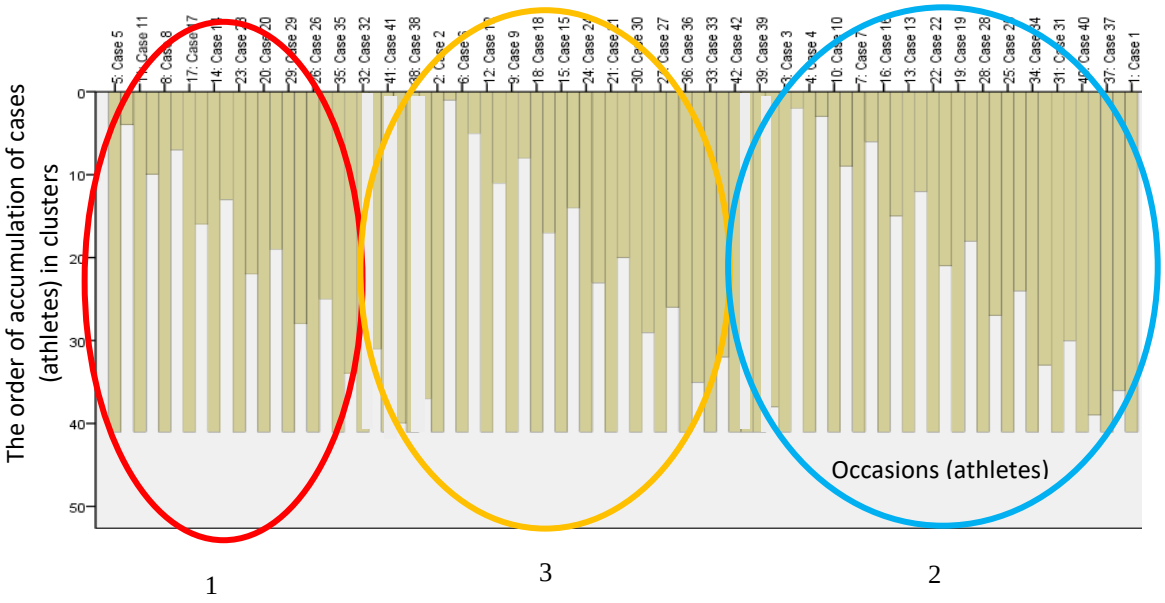

Fig. 2. Distribution of qualified veteran boxers into clusters:
1 – cluster 1; 2 – cluster 2; 3 – cluster 3

Thus, we received 3 clusters (groups) of veteran boxers, differing in their psychophysiological and biomechanical indicators. The athletes of these groups have different severity of factors in the individual structure of preparedness (Table 2). Individual severity of factors in the structure of preparedness of qualified veteran boxers was determined by us in our previous studies [26].

In the presented study, we found that in the athletes of the first cluster, the severity of the factor "Speed and coordination endurance" (more than 80%) and a small level of severity of the factor "Speed" (less than 30%) prevail. In athletes of the second cluster, the severity of the "Speed" factor (more than 80%) and the average severity of the "Speed and coordination endurance" factor (about 50%) prevail. Athletes of the third cluster have an average severity of the "Speed" factor (about 50%) and a small severity of the "Speed and coordination endurance" factor (less than 30%) (Table 2).

If we consider examples of factor models [26], built on the basis of individual values of the factor structure of veteran boxers (Table 2), it can be noted that the athletes of the first cluster have the most pronounced factor "Speed and coordination endurance". This means that these athletes are distinguished by their ability to maintain high speed and accuracy (coordination) of actions for a long time. That is why we named this cluster "Speed and coordination endurance". This cluster (group) of athletes in terms of their performance can be attributed to the style of fighting, requiring a high level of endurance with the support of a relatively high speed of movements. This is a style of fighting – tempo. In the athletes of the second cluster, the development of the first factor "Speed" and the average severity of the factor "Speed and coordination endurance" prevail. That is, these athletes are capable of high – speed actions at the beginning of movements and in average expressiveness of speed and coordination endurance. These qualities are most typical for boxers with a style of fighting – playing. Athletes of the third cluster have an average severity of the "Speed" factor and a small severity of the "Speed and coordination endurance" factor. We did not measure strength in this study because biomechanical analysis does not represent strength capability. We can draw conclusions indirectly about the manifestation of strength abilities. These athletes are characterized by the manifestation of speed with low endurance. Therefore, we named this cluster "Strength and Speed". This most characterizes the style of fighting – power.

Table 2

Cluster Membership and individual severity of the factors of qualified veteran boxers based on the analysis of biomechanical and psychophysiological indicators

Occasions	Clusters	Absolute individual values of factors		Individual values of factors, expressed as a percentage of the maximum values in a sample of athletes	
		Factor 1	Factor 2	Factor 1	Factor 2
1	2	35.50	21.50	84.52	51.19
2	1	7.50	35.50	17.86	84.52
3	3	21.50	7.50	51.19	17.86
4	2	34.68	20.72	83.19	50.26
5	1	7.68	35.79	19.65	85.64
6	3	19.86	6.48	52.28	18.75
7	2	35.50	21.50	84.52	51.19
8	1	7,.50	35.50	17.86	84.52
9	3	21.50	7.50	51.19	17.86
10	2	34.68	20.72	83.19	50.26
11	1	7.68	35.79	19.65	85.64
12	3	19.86	6.48	52.28	18.75
13	2	35.50	2.,50	84.52	51.19
14	1	7.21	38.64	15.59	85.58
15	3	21.50	7.50	51.19	17.86
16	2	34.68	20.72	83.19	50.26
17	1	7.21	38.64	15.59	85.58
18	3	19.86	6.48	52.28	18.75
19	2	34.68	20.72	83.19	50.26
20	1	7.50	35.50	17.86	84.52
21	3	21.50	7.50	51.19	17.86
22	2	35.50	21.50	84.52	51.19
23	1	7.21	38.64	15.59	85.58
24	3	21.67	8.50	56.19	18.86
25	2	34.68	20.72	83.19	50.26
26	1	7.50	35.50	17.86	84.52
27	3	21.50	7.50	51.19	17.86
28	2	34.68	20.72	83.19	50.26
29	1	7.68	35.79	19.65	85.64
30	3	19.86	6.48	52.28	18.75
31	2	35.50	21.50	84.52	51.19
32	2	21.67	8.50	56.19	18.86
33	3	21.67	8.50	56.19	18.86
34	2	35.50	21.50	84.52	51.19
35	3	7.21	38.64	15.59	85.58
36	3	21.50	7.50	51.19	17.86
37	2	35.50	21.50	84.52	51.19
38	2	35.50	21.50	84.52	51.19
39	3	21.50	7.50	51.19	17.86
40	2	34.68	20.72	83.19	50.26
41	1	7.21	38.64	15.59	85.58
42	3	21.67	8.50	56.19	18.86

The revealed regularities of speed in the movement of points of the fist, elbow, knee and angles in the joints are also reflected in the trajectory of movement of the points of the fist, elbow, knee (Fig. 2 – 4). The athletes of cluster 1 "Speed and coordination endurance" have the most pronounced trajectory of the knee point movement (Fig. 2). Also, the trajectory of movement of the knee point among athletes of cluster 1 "Speed and coordination endurance", which is typical for athletes of the tempo

style, is the lowest of all analyzed groups of athletes (Fig. 2).

The obtained facts can be explained by the fact that tempo-style boxers compensate for the lower level of speed of nervous processes by the speed of movement, which requires more flexion of the legs in the knee and hip joints. This causes a low stance during the fight and is displayed in the lower position of the knee point trajectory.

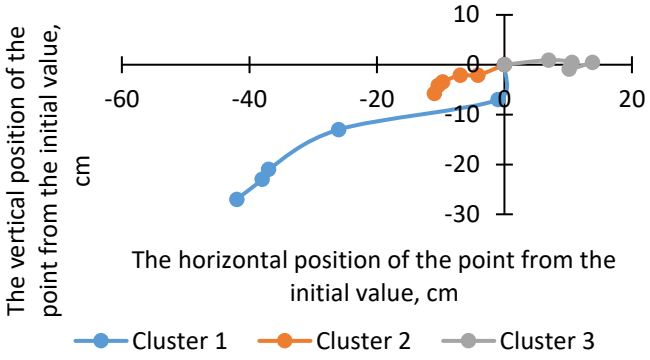

Fig. 3. Values of the trajectory of movement of the knee joint among qualified veteran boxers from different clusters:
Cluster 1 – «Speed and coordination endurance»;
Cluster 2 – «Speed»;
Cluster 3 – «Strength and speed»

The athletes of the "Speed" cluster, which corresponds to the boxers of the playing style, have the highest trajectory of the fist point movement (Fig. 3). This is due to the fact that the high speed of hand movement and the general variability of the boxers' actions in this cluster allows them to act in a high stance and execute strikes along a high trajectory. In addition, for the development of a high speed of movement of the fist point, the most favorable position is a high stance of a boxer, since a high stance requires the least strength and the least manifestations of speed endurance. The lowest trajectory of the fist point movement among boxers of the tempo style, the cluster "Speed and coordination endurance" (Fig. 3). This is due to the lowest stance of the boxers in the tempo style of fighting. The trajectory of the fist movement in power style boxers, the "Strength and Speed" cluster, occupies an intermediate position. In playing style athletes, the point of fist ends the movement earlier than the other two fighting styles. This is due to the higher speed of execution of the blow by the boxers of the playing style, cluster "Speed".

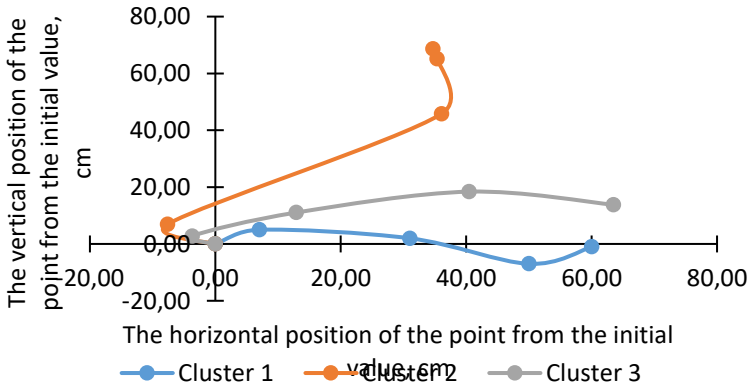

Fig. 4. Values of the trajectory of the fist movement among qualified veteran boxers from different clusters:
Cluster 1 – «Speed and coordination endurance»;
Cluster 2 – «Speed»;
Cluster 3 – «Strength and speed»

The trajectory of movement of the elbow joint is also the lowest in tempo style boxers, the cluster "Speed and coordination endurance" (Fig. 4). This is also due to the lowest stance in the bout of these athletes. Also, the trajectory of the elbow point in tempo style athletes is characterized by an initial

movement of the elbow back for a small swing, and then forward. At the end of the strike, the elbow point is practically at the same level for boxers of all analyzed styles. In playing style athletes, the elbow point finishes the movement earlier than boxers of the other two fighting styles (Fig. 4). This is due to the higher speed of execution of the blow by the boxers of the playing style, cluster "Speed".

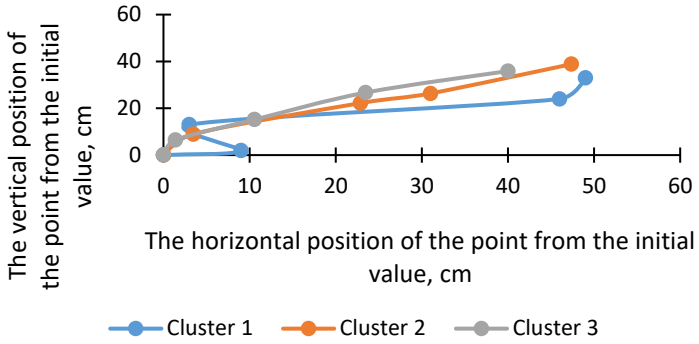

Fig. 5. Values of the trajectory of movement of the elbow joint among qualified veteran boxers from different clusters:
Cluster 1 – «Speed and coordination endurance»;
Cluster 2 – «Speed»;
Cluster 3 – «Strength and speed»

Discussion

As far as we know, this study is one of the first to determine the fighting styles of qualified veteran boxers. In our study, we used cluster analysis to distribute boxers into groups based on biomechanical and psychophysiological indicators. This method was applied for the first time to determine the styles of competitive activity of veteran boxers.

In our study, the hypothesis was confirmed regarding the effectiveness of using the methods of multivariate analysis (in our case, cluster analysis) of biomechanical and psychophysiological indicators to determine the styles of fighting qualified veteran boxers.

Issues related to the style of activity have occupied the attention of psychologists for several decades, both in work and, especially, in sports. The problem of the style of activity is the problem of the highest level of achievement in the activity of each person, the problem of mastery and its formation, the problem of optimal "docking", balancing the subject with objective requirements [1, 2]. Therefore, the most acceptable way of an individual approach is not to adjust the trainees' characteristics to a certain unified model, but to promote the formation of those techniques and methods of action that are most optimal for students and correspond to pronounced abilities. A person should look for individually unique ways of mastering the required qualities and skills, taking into account his natural inclinations; the insufficiency of some of them will have to be compensated for, while others will turn out to be favorable. Thus, the problem arises of the formation of an individual style of activity [3, 4]. Currently, the most effective in terms of ease of use and information content are psychophysiological indicators to determine the individual genetically determined factors in the formation of the style of activity [12–15].

Analysis of the research results in the aspect of comparing them with the available literature data showed that this work is one of the first in terms of determining the influence of the athlete's psychophysiological indicators in combination with the biomechanical data of individual technique on the formation of the style of fighting in boxing. The authors dealing with the issues of determining the styles of athletes' activity [3, 5], do not consider the process of training athletes from the point of view of the system, analysis of a wide range of indicators of readiness. The authors dealing with this problem [6] focused on visual observation of the boxer's activity, without offering specific indicators for determining the style of fighting. In our study, the effectiveness of the use of objective indicators has been shown, which makes it possible to determine the propensity of a boxer to a certain style of fighting, which is the data obtained for the first time. At the same time, the possibilities of using congenital psychophysiological characteristics are not considered.

Psychophysiological features are decisive in the formation of an individual style of activity, one of the manifestations of which is the style of fighting in boxing. Our research expands, confirms and supplements the data presented in the works [7–9,

12] regarding the informativeness of psychophysiological indicators for the current and operational control of the functional state of athletes and the determination of their individual characteristics. This is most important for predicting the results of competitive activity.

It should be noted that the problem considered in our work closely intersects with the problem of individualization of the training process considered in works [31–33] and is consistent with the concept of individualization presented in the works of Kozina [32–36]. The concept of individualization of the training process [31, 32] was developed using the deductive method. It lies in the fact that for the adequate construction of individual training programs it is necessary:

1 – to conduct comprehensive testing of athletes, which includes anthropometric, biomechanical, psychophysiological and other indicators;

2 – to carry out a factor analysis of the obtained indicators;

3 – to determine the individual factor structure of the complex fitness of athletes;

4 – to highlight the leading and lagging factors in the individual factor structure of athletes' fitness;

5 – to form groups of athletes according to the degree of similarity among themselves according to the individual factor structure of fitness or using cluster analysis of indicators of complex testing of athletes;

6 – develop and implement training programs for athletes of each group (cluster).

On the basis of the theoretical concept of individualization of the training process in sports, developed by Kozina [32], we determined the groups of boxers according to the indicators of complex testing. The concept assumes the use of an algorithm, which consists of the following stages [32, 33]: testing athletes, including a set of tests of at least 10; determination of the general structure of athletes' fitness by means of factor analysis. Determination of the main factors and drawing up their characteristics; conducting a hierarchical cluster analysis of testing indicators; determination of individual factor values; based on individual factor values and cluster analysis of compiling individual characteristics. Factor analysis with the determination of the individual severity of factors was carried out in our previous study [26]. In the study presented in the current work, the concept of individualization by Kozina was fully implemented [31–33]. The effectiveness of this concept was confirmed [32, 33] for determining the individual characteristics of athletes. In particular, we have applied this concept to define the fighting styles of qualified veteran boxers.

It should be noted that the methods of psychophysiological and biomechanical testing proposed in our work to determine the individual characteristics of boxers are an effective, informative and sufficiently accessible and convenient tool for identifying the predisposition of boxers to a certain style of fighting.

Prospects for further research

Further research suggests:

– identification of differences between boxers of different styles of fighting according to biomechanical and psychophysiological indicators;

– development and substantiation of recommendations regarding the construction of the training process of qualified veteran boxers of different styles of fighting.

Limitations

The study was conducted on qualified veteran boxers, therefore, the data obtained apply only to the studied contingent. Additional research is needed to disseminate the obtained data to boxers of other age and social groups, as well as to representatives of other sports.

Conclusions

1. Cluster analysis of psychophysiological testing showed the presence of 3 groups of athletes. 3 clusters (groups) of veteran boxers have been identified, which differ in their psychophysiological and biomechanical indicators. Athletes of the first cluster are dominated by the expression of qualities that determine the speed and coordination endurance (over 80%) and a small level of expression of speed qualities (less than 30%). This corresponds to the pace of the fight. The athletes of the second cluster are dominated by the expression of speed qualities (over 80%) and the average level of expression of qualities that determine the speed and coordination endurance (about 50%). This corresponds to the game style of the fight. Athletes of the third cluster have an average expression of speed qualities (about 50%) and a small expression of qualities that determine speed and coordination endurance (less than 30%). Approximation of the obtained results to the expression of different qualities made it possible to determine the greatest manifestation of the speed and strength qualities of the boxers of the third cluster. This corresponds to the power style of the

fight. The clusters were named as follows: Cluster 1 – "Speed and coordination endurance", corresponds to the boxers of the pace of the fight; Cluster 2 – "Speed", corresponds to the boxers of the game style of fighting; Cluster 3 – "Strength and speed", corresponds to the boxers of the pace of the fight.

2. Biomechanical features of boxers of different styles of fighting are reflected in the trajectories of the points of the fist, elbow, knee. The athletes of the "Speed and coordination endurance" cluster (tempo style boxers) have the most pronounced trajectory of knee point movement. The trajectory of movement of the knee point in tempo style athletes is the lowest of all analyzed groups of athletes. The athletes of the "Speed" cluster, which corresponds to the boxers of the playing style, have the highest trajectory of the fist point movement. The lowest trajectory of the fist point movement among boxers of the tempo style, the "Speed and coordination endurance" cluster. The trajectory of movement of the elbow joint is also the lowest in tempo style boxers, cluster "Speed and coordination endurance".

3. It is advisable to use the results of this research when planning the individual training of athletes in boxing and to determine the optimal style of conducting a competitive combat for qualified veteran boxers. The proposed methods of psychophysiological and biomechanical testing to determine the individual characteristics of boxers are an effective, informative and fairly accessible and easy-to-use tool for revealing the predisposition of boxers to a certain style of fighting.

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Conflict of interest

The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLES. SPORT

Predictive value of kinematic indicators for shot put result and selection of novice athletes

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Abstract

Purpose: to determine the most significant kinematic indicators in the sports selection of beginner shot putters.
Material and Methods: This study was carried out on a sample of 9 students at the fourth stage of the competition in Division 1, which took place in the 2017/2018 academic year at the Faculty of Physical Education of Maysan University. The following kinematic (biomechanical) parameters were analyzed: the angle of release of the nucleus, the velocity of release, the height of the point of ejection of the nucleus and the speed of swing. The correlation coefficients were determined between the kinematic indicators and the result in the shot put, as well as the regression equation for the dependence of the result in the shot put on the knematic indicators. The data obtained in the study were presented in the form of the arithmetic mean, standard deviation, median, skewness coefficient, Pearson's correlation coefficient, analysis of variance and linear regression, which included the contribution coefficients of each analyzed indicator, standard error, reliability of the regression equation as a whole, and reliability of the coefficients contribution to the shot put result of each kinematic exponent.
Results. It has been shown that the swing speed has the greatest influence on the result in the shot put among beginner athletes. The swing speed, shot angle, shot speed and shot height have significant relationships with the shot put result. The multiple regression equation for the dependence of the shot put result on the swing speed, shot angle, shot height and shot point turned out to be reliable in general. However, only the swing speed has a reliable coefficient of the regression equation. The shot angle tends to be the determining factor in the shot put result. The release rate and the height of the release point have significant correlations with the shot put result, although in the regression equation they have unreliable indicators of influence on the shot put result.
Conclusions. When teaching beginner shot putters, the greatest attention should be paid to the pushing swing technique, namely the swing speed. The second most important indicator is the angle of the shot put, it is recommended to use the basic prediction equation, which determines the expected results in the selection of young athletes in shot put, with high reliability of the results obtained. These characteristics are recommended to be used for evaluating young athletes, as well as in the process of training and preparing athletes for competitions.
Key words: kinematic indicators, young athletes, shot put

Анотація

Хікмат Альматкоорі, Ратко Павлович, Ірина Скрипченко, Боучареб Рафахія, Р. Рам Мохан Сінгх. Прогностична цінність кінематичних показників для результату в штовханні ядра і відбору атлетів-початківців

Мета: визначити найбільш значущі кінематичні показники в спортивному відборі штовхачів ядра, що починають.

Матеріал та методи: це дослідження було виконано на вибірці з 9 студентів на четвертому етапі змагань у Дивізіоні 1, які відбулися у 2017/2018 навчальному році на факультеті фізичного виховання Майсанського університету. Були проаналізовані такі кінематичні (біомеханічні) показники: кут випуску ядра, швидкість викиду, висота точки викиду ядра та швидкість замаху. Визначалися коефіцієнти кореляції між кінематичними показниками та результатом у штовханні ядра, а також рівняння регресії залежності результату у штовханні ядра від кнематичних показників. Дані, отримані в дослідженні, були представлені у вигляді середнього арифметичного, стандартного відхилення, медіани, коефіцієнта асиметрії, коефіцієнта кореляції Пірсона, дисперсійного аналізу та лінійної регресії, що включало коефіцієнти вкладу кожного аналізованого показника, стандартну помилку, достовірність рівняння регресії. вкладу у результат у штовханні ядра кожного кінематичного показника.

Результати. Показано, що на результат у штовханні ядра у атлетів-початківців найбільший вплив надає швидкість замаху. Швидкість замаху, кут випуску ядра, швидкість викиду та висота точки викиду ядра мають достовірні зв'язки з результатом у штовханні ядра. Рівняння множинної регресії залежності результату в штовханні ядра від швидкості замаху, кута випуску ядра, висоти викиду та точки викиду виявилося достовірним загалом. Однак достовірний коефіцієнт рівняння регресії має лише швидкість замаху. Кут випуску ядра має тенденцію як визначальний фактор результату в штовханні ядра. Швидкість викиду та висота точки викиду мають достовірні взаємозв'язки з результатом у штовханні ядра, хоча у рівнянні регресії мають недостовірні показники впливу на результат у штовханні ядра.

Висновки. Найбільшу увагу при навчанні штовхачів ядра слід приділяти техніці замаху при штовханні, а саме – швидкості замаху. Другим за значимістю показником є кут випуску ядра рекомендується використання базового рівняння прогнозування, яке визначає очікувані результати при відборі юних спортсменів у штовханні ядра, з високою надійністю отриманих результатів. Ці характеристики рекомендується використовувати в оцінки юних атлетів, а також у процесі тренування та підготовки спортсменів до змагань.

Ключові слова: кінематичні показники, юні спортсмени, штовхання ядра

Аннотация

Хикмат Альматкоори, Ратко Павлович, Ирина Скрипченко, Боучареб Рафахия, Р. Рам Мохан Сингх. Прогностическая ценность кинематических показателей для результата в толкании ядра и отбора начинающих атлетов

Цель: определить наиболее значимые кинематические показатели в спортивном отборе начинающих толкателей ядра.

Материал и методы: это исследование было выполнено на выборке из 9 студентов на четвертом этапе соревнований в Дивизионе 1, которые состоялись в 2017/2018 учебном году на факультете физического воспитания Майсанского университета. Были проанализированы следующие кинематические (биомеханические) показатели: угол выпуска ядра, скорость выброса, высота точки выброса ядра и скорость замаха. Определялись коэффициенты корреляции между кинематическими показателями и результатом в толкании ядра, а также уравнение регрессии зависимости результата в толкании ядра от кнематических показателей. Данные, полученные в исследовании, были представлены в виде среднего арифметического, стандартного отклонения, медианы, коэффициента асимметрии, коэффициента корреляции Пирсона, дисперсионного анализа и линейной регрессии, которое включало коэффициенты вклада каждого анализируемого показателя, стандартную ошибку, достоверность уравнения регрессии в целом и достоверность коэффициентов вклада в результат в толкании ядра каждого кинематического показателя.

Результаты. Показано, что на результат в толкании ядра у начинающих атлетов наибольшее влияние оказывает скорость замаха. Скорость замаха, угол выпуска ядра, скорость выброса и высота точки выброса ядра имеют достоверные взаимосвязи с результатом в толкании ядра. Уравнение множественной регресии зависимости результата в толкании ядра от скорости замаха, угла выпуска ядра, высоты выброса и точки выброса оказалось достоверным в целом. Однако достоверный коэффициент уравнения регрессии имеет только скорость замаха. Угол выпуска ядра имеет тенденцию в качестве определяющего фактора результата в толкании ядра. Скорость выброса и высота точки выброса имеют достоверные взаимосвязи с результатом в толкании ядра, хотя в уравнении регрессии имеют недостоверные показатели влияния на результат в толкании ядра.

Выводы. Наибольшее внимание при обучении начинающих толкателей ядра следует уделять технике замаха при толкании, а именно – скорости замаха. Вторым по значимости показателем является угол выпуска ядра. Рекомендуется использование базового уравнения прогнозирования, которое определяет ожидаемые результаты при отборе юных спортсменов в толкании ядра, с высокой надежностью полученных результатов. Эти характеристики рекомендуется использовать для оценки юных атлетов, а также в процессе тренировки и подготовки спортсменов к соревнованиям.

Ключевые слова: кинематические показатели, юные спортсмены, толкание ядра

Introduction

The shot put is a field event in athletics and each of the events has a specific set of features including the characteristics of the implement used (size weight and aerodynamic qualities), space limitations, and technique requirements which influence the sequence of events and make them unique [1, 2]. The goal in the throwing events is to maximize the measured distance covered by the implement and this distance is determined by several parameters such as height, velocity, angle of release [3, 4], aerodynamic qualities, and environmental factors [5, 6], exploitation of the escape space when the equipment is thrown out and temporary foot position [7, 8]. The release height is a consequence of the athlete's length of the body, length of arm; body mass and it is a prerequisite for a candidate's selection for shot-putting. [1, 9]. The release angle depends on the release height and the release velocity [3,10]. The angle of the release is smaller, the higher the height and the speed of the throw [11]. It is relatively constant for an individual athlete and cannot be changed to improve the result. The release velocity is by far the most important of all the release parameters in determining the distance achieved because the distance is proportional to the square of the release velocity [6, 12].

The shot put competition is one of the athletics activities that is included in the international competitions like the Olympic Games, World Track & Field competitions, and continental Sports meet. Its skill performance is based on the same as other competitions due to mechanical conditions in its performance, despite the difference in the method or style of performing the movement before the final release of the shot. The analysis is the sorting and tabulation of the many data with its main elements, then logically treating them with a balance, with an appropriate standard and axis to shift from their precise quantitative formulas to others with meaningful explanations to solve the problem addressed by the researcher [13]. Biomechanical Knowledge is a "Must" for Coaching, and all movements of men and animals are determined by the laws of mechanics. It is the first task of science is to understand the movements of athletes; therefore it is an indispensable base for coaching. In the throwing events, the factors influencing the performance are governed by the physical laws of the flight phases of the implement and the biomechanical laws of the movement of the system, putter, and implement' before release [14]. Projectiles obey constant acceleration, making them easier to describe and understand (Galileo's equations). Three factors determine trajectory, including horizontal displacement, of a projectile speed of release, angle of release, the height of release. Positive height of release, the optimal angle should be slightly lower than 45°. Theoretically, the optimal angle is about 40-41°, skilled shot-putters use angles of 35-37° [3]. Shot-putting requires great explosive strength, together with the ability to perform precisely timed release of the (*add*) shot as far as possible, but competition regulations restrict the movements in a confined space. The athlete's objective is to project the technique that may be used. The shot must be thrown from the should using one hand and it must be held near to the chin throughout any preliminary movements (IAAF, 2000). In recent years many researchers have studied the techniques of shot put parameters and factors that are crucial for achieving top results, as well as those necessary for optimal performance.

Much research has been performed on the shot put, and several of these studies have examined the theory and practice of determining optimal release conditions, such as release speed, release angle, and release height [3, 10, 15]. Although these parameters directly determine the projected distance of the throw, they do not give any indication of the events leading up to the release. Consequently, they offer limited information to coaches seeking to improve the aspects of technique that will result in the best release parameters [16]. Some other studies have been descriptive and these have ranged from quantitative [17-20] to completely qualitative [21]. Although these studies do provide information about the kinematics of the performance, they too offered limited evidence as to which parameters were most influential on the performance. Also, the relative importance of each critical factor will vary for each athlete depending on such things as gender, anthropometry, strength parameters, throwing technique used (glide or spin), and individual stylistic elements [16].

In their research [22] defined some of the most important kinematic parameters of the rotational shot put technique. They used a 15-segment model of the thrower with 23 defined reference points The results showed that the top result of the throw depends on release velocity, the optimal angle of release, the relation between the rotational motion and acceleration of the final shot, and the angular velocity of the elbow and shoulder joints of the throwing arm. The authors [23] investigated the rotational model of the two techniques of elite shot putters with different anthropometric measures. Differences were found for: release velocity, release height, the maximum angular velocity in the elbow joint of the throwing

hand, the trajectory of the thrower and the shot, torsional rotation in the shoulder joint compared to the axis of the hip joint, maximum force focused on the ball, the kinetic energy independent of the sphere. Critical factors measured in this study included the speed of turning the right foot and the maximum force developed, the angle and height of release, and release velocity during the last phase. These factors are examined in connection with each athlete's throwing distance. A greater angle of a release causes a higher shot flight from the ground, but lower speed. During the flight phase, the shot acts as a projectile in free flight and its path can be calculated by using data on the conditions of release. Authors [3] aims to assess the accuracy of the method of calculating the angle of ejection for throwing shots. With this method the optimal angle of release, which produces the longest distance, is calculated by combining the equation for the range of missiles during free flight with a connection among the release velocity, release length, and angle of release. A crucial finding of the study of [24] is that the swing of the left hand must be performed with an amplitude that allows the pre-stretching of structures that are active in the pushing phase or with an amplitude that does not allow an increase in the shot movement radius. Release parameters are very important for successful performance and are mutually dependent. When the throw is made above the horizontal plane, the length of the throw depends on the height, angle, and velocity of the release [25]

Simple models of throwing were developed to explain the relationship between the release velocity, height, and angle related to the anthropometric measures and motor abilities of athletes [3]. A study by Young, & Li [16] is the first to examine critical parameters for success in elite women shot putters and indicates specific parameters that are important for achieving the highest standard in the event. The results of this study suggest that, among elite shot putters, bigger rear knee flexion at rear foot touch-down and release, increased release speed, a more neutral shoulder-hip angle at release and a larger horizontal release distance were the best predictors of the measured distance. Correlation analysis of this study [16] indicated that measured distance was positively correlated with release speed ($r = 0.97$, $p= 0.0003$) and shoulder-hip separation ($r = 0.72$, $p= 0.06$) and negatively correlated with release angle ($r= -0.74$, $p=0.056$), rear knee angle at rear foot touchdown ($r = -0.93$, $p=0.003$) and rear knee angle at release ($r = -0.76$, $p=0.047$). Greater knee flexion angle at both rear foot touch-down and release along with a neutral shoulder-hip angle at release was Identified as the most critical parameters for success among this sample of elite women shot putters. The research [10] between two throwers Multivariate regression analyses determined that achievable release speed decreases with increasing release angle at about 1.7 ($m \cdot s^{-1}$)/rad and decreases with increasing release height at about 0.8 (m/s)/m, with only small differences in sensitivities between the throwers. Horizontal release distance also decreases with increasing release angle at about 1.7 m/rad and increases with increasing release height at about 1.3 $m \cdot m^{-1}$, again with only small differences between the two throwers. In recent years there have been many researchers studying the techniques of shot put parameters and factors that are crucial for achieving top results, as well as those necessary for optimal performance.

Research [26] was conducted on the finalists of World Championship to determine the influence of anthropometric and kinematic parameters of the throw (release velocity, release height, release angle) on result successfulness in the shot put. A total of 32 competitors were included in the research, out of which 16 were male and 16 were female finalists. Obtained results were processed by multiple regression analysis which confirmed a statistically significant influence of predictors on the result of male shot put finalists ($R=0,793^{**}$, $R^2=0,629$) and female finalists ($R=0,806^{**}$; $R^2=0,650$). The obtained results of regression analysis confirmed that the speed of the throw-out (Vo) was a leading parameter in the successfulness of the finalists' result (Beta(f)=0,691; Beta(m)=0,528] and an inverse relationship with the angle of the throw-out, which can be confirmed by previous research on this subject. Interestingly, the angle of the throw-out in female shot-putters was not defined as a factor of the impact on regression function, while the height of the throw-out recorded slight inversion in comparison to the throw-out angle and the speed as a consequence of the force of gravity. The aim of this study [27] was to determine differences in the parameters of the release of top Serbian athletes. The throwing technique was taken at the Serbian Cup 2011 for the competitors who achieved the best results. The values of the variables were determined by using software for 2D kinematic analysis, "Human", version 6.0 HMA Technology Inc. 2005, United States of America (Human). The first-place contestant scored a higher release speed of 13 $m \cdot s^{-1}$ (13.79 $m \cdot s^{-1}$), while the speed of the second and the third was much lower (11.9 $m \cdot s^{-1}$ and 11.68 $m \cdot s^{-1}$), The maximum height of release was determined for the second-placed competitor (2.22m), then for the first-placed (2.07m) and the third-placed competitor (2.05m), The angle of release for the top-placed competitor was 40.4˚, 42.8˚ for second-placed and 41˚ for the third-placed. In the case of the top-ranked

competitor and the third, there is the possibility of increasing the horizontal length of the shot put.

The organization of kinematics and movement within each stage is jointly accredited within and across each stage, so coaches should consider the athlete's biomechanics [28]. The low local levels in (Iraq) in recent years compared to the progress of international levels may be due to the weak codification of the training programs applied, especially those that depend on building their exercises on the mechanical conditions accompanying the kinetic technical performance of the thrower, including the peripheral velocity of the joint point of the driving arm of the group and the basic kinematic variables related to the moment The shot is released from the player's hand, through which the forward horizontal distance (the archer's Shot put result) is determined [29]. And through a simple comparison of the levels recorded in Olympia, continental and worldwide, which exceeded meters in most international tournaments for the first-placed holders in each championship, as well as the (Iraqi) record recorded more than twenty years ago, of (18.36 m) for the hero Khaled Muhammad Wajih, with the numbers recorded in the last two decades and not exceeding meters for the Iraqi champions in local and international championships, the Iraqi digital low level is undoubtedly evident, that the great decline may be due to the weakness of training programs, which may be limited only by relying on the development of some physical abilities and old methods of developing performance skills The technical and also the qualitative analysis by the coach, which is not commensurate with the size of the great scientific progress that the modern training process has reached, which depends on building its exercises on the foundations and values of biomechanical kinematic analysis programs, and also that the proper and early selection of novice athletes may predict the project of an upcoming champion, and this is what It is produced by the results of scientific research, especially those that depend on the values of the special mechanical variables in the final payment phase of the batch, in addition to the physical capabilities and specifications that it has Suitable [29, 30, 31]. Due to the importance of this competition internationally and its place among other games, especially track and field competitions, the researchers decided to conduct this study, to avoid some of the weaknesses of novice athletes in the future and to enhance and develop the positive points, and thus contribute to the development and improvement of the Shot put result.

Purpose: to determine the most significant kinematic indicators in the sports selection of beginner shot putters.

Materials and methods

Participants

The researchers used the descriptive approach due to its relevance to the nature of the research and chose eight (9) students from the fourth stage of Division (1) for the academic year 2017/2018 at the Faculty of Physical Education, University of Maysan, Iraq.

Procedure

The sample was chosen in the intended method, and they are the best shot put result among their peers, and Table (1) shows the Specification sample.

Table 1

Shows the sample specifications and their homogeneity

Basic variables	Arithmetic mean	Standard deviation	Median	Coefficient of torsion
Age (years)	21.78	0.88	21	1.14
Body Height (cm)	169.56	0.87	170	0.96
Bodyweight (kg)	74.11	1.99	73	0.83
Shot put result (M)	11.947	0.172	11.8	1.6

It is evident from Table 1. that the torsion coefficient for all members of the research sample is homogeneous, because the value of the torsion coefficient in all variables that may affect the results of the research is within (± 3), which indicates its homogeneity.

Statistical Analysis

The data obtained in the study were given as arithmetic mean, standard deviation, median, skew coefficient, Pearson correlation coefficient, analysis of variance and linear regression, constant term, standard error.

Results

To obtain the correlation coefficients between the research variables, the researcher used the simple correlation (Pearson) as a statistical method to achieve this purpose. Table (2) shows the simple correlation coefficients and their contribution ratios between the variables included in the regression of the dependent variable (the numerical level) with the independent variables (kinematics).

Table 2

Mean, standard deviations, correlation coefficient, contribution rate, and the level of significance between the shot put result and some kinematic variables

The kinematics Variables	Mean±Std.Dev.	Simple correlation	Contribution rate	Significance ratio (p)
Angle of Release (degree)	35.444±1,130	0.876	0.767	0.000
Release velocity($m \cdot s^{-1}$)	11.947±0,172	0.913	0.834	0.000
The height of the release point (M)	1.936±0,628	0.923	0.852	0.000
Swing speed ($m \cdot s^{-1}$)	9.849±0,628	0.942	0.887	0.000

The correlation of the Shot put result with the Angle of Release variable (0.876) and the contribution percentage (0.767) and the level of significance (0.000). The correlation of the Shot put result with the Release velocity variable was (0.913) and the contribution percentage (0.834) and the level of significance (0.000), while the correlation of the Shot put result wi variable reached. The height of the Release point was (0.923) and the contribution percentage (0.852) and the level of significance (0.000). The correlation of the Shot put result with the variable peripheral velocity reached (0.942), the contribution percentage (0.887), and the level of significance (0.000).

Table 3

The correlation coefficient, the multiple contribution ratio, and the standard error of the estimation between the shot put result and some kinematic variables

Model	Multiple correlations	Contribution rate	Std error of the estimate
1	0.963	0.927	0.065

Through our observation of Table 3, it becomes clear to us the value of the multiple correlations, as it reached (0.963) and the contribution rate (0.927), and with a standard error rate of (0.065) with the values of the numerical level, and to identify the regression coefficient of the contribution of some independent variables (kinematic) to predict the measurement of (The numerical level) as a dependent variable, the researchers used the test (analysis of variance) as shown in Table (4).

Table 4

Analysis of Variance of the multiple regression to check the quality of compatibility of the multiple linear regression model of the Shot put result and some of the kinematic variables

Model		Sum of squares	Degree of freedom	Average of squares	F	Significance ratio (p)
Shot put result	Regression	0.220	4	0.055	13.75	0.02
	Residual	0.017	8	0.004		
	Total	0.237				

By observing Table 4. it becomes clear to us that the independent variables are suitable for predicting the measurement of the shot put result of players (11.947) through the significance of the value of (F), as it reached (13.75) with an error rate (0.02), and in order to arrive at the equation of the multiple regression lines, the researcher used the test (T-test) as shown in Table 5.

Table 5

The values of the constant limit and the slope (effect) between the numerical plane and some kinematic variables

Model		Unstandardized Coefficients		t	Significance ratio (p)
		B	Standard error		
1	Constant	6.287	2.908	2.162	0.097
Shot put result	Angle of Release (degree)	0.024	0.093	-0.261	0.807
	Release velocity ($m \cdot s^{-1}$)	0.113	0.207	0.549	0.612
	The height of the release point (M)	2.236	2.148	1.041	0.357
	Peripheral velocity ($m \cdot s^{-1}$)	2.341	0.326	2.675	0.046

It can be seen from Table 5. that the variable (height of the starting point) is the first contributing variable, the variable (velocity of departure) the independent variable, the second contributing variable, the variable (peripheral velocity), the independent variable, the third contributing variable, and the variable (the angle of release) of the independent variable, the fourth contributing variable. The predictive regression equation for the numeric plane in terms of the influencing estimates (angle of departure, cruising speed, height of the starting point, and peripheral velocity). Therefore, the predictive equation can be derived using the multiple regression equation as follows:

The predictive value of the numeric plane = 6.287 - (0.024 × the arithmetic mean of the path angle variable) + (0.113 × the arithmetic mean of the path velocity variable) + (2.236 × the arithmetic mean of the starting point height variable) + (0.108 × the arithmetic mean of the path velocity variable). Predictive value of numeric level = 11.952.

This requires the player to be strong and flexible limbs because it contributes significantly with the rest of the physical and mechanical variables to increase the shot speed from the putter's hand to the moment of the final push and through the occurrence of a reverse reaction to the movement of the hip at the moment of stopping due to the large resistance arm represented by the limited front movement [30]. The angle of release is an influential factor in achieving the longest horizontal distance forward that the shot puts, especially if the other basic mechanical conditions in the throwing process are met with it, which is the launch speed that has to do with the horizontal velocity of the player, which he acquires through the kinetic transfer of his center of gravity within the throwing circle towards the throwing sector, and with height The Release point [29]. It is worth noting that some basic mechanical aspects must be studied in motion analysis and, optimal release conditions producing a maximum range for a particular athlete can be determined [10].

Discussion

The importance of sportspersons operation status as a leading factor in high sports performance is doubtless. The offered study includes assessment and correction of the sportsperson's operation status during the competitions, which was based on the multi-factorial express- diagnosis of the functional condition, variation pulsometry, and body impedance analysis.

In the event like shot put, where even the slightest change in the body position right from the starting point to the release of the shot could make a significant difference to performance which in turn can impact a win or a loss. Further, shot put can be said as an event of closed technique where the athlete is clearly and fully aware of what he or she is going to or expected to do. Hence, the athlete can train accordingly and prepare well if he or she can automatize the movement pattern that is best suitable for their body. The athlete will be able to mechanize the technique to such an extent every time the athlete prepares to make a put, the body is completely aware of its position and movement pattern. It must be noted that once the shot is released, there is nothing in the power of the athlete to control it. Hence, the more accurate and perfect the technique and the movement pattern is leading up to the point of release, the more reliable and consistent the athlete's performance will become. This will certainly enable the athlete to plan better, train better, perform better and progress in the best manner possible. This is ultimately the goal of any competitive shot putter,

According to the received data, the multiple linear regression equation was calculated as well as the most significant characteristics of the body impedance analysis were detected. It is mentioned that the analysis is sorting and categorizing the many

data with its main elements, then processing them logically with a balance with an appropriate standard and pivot to switch from their precise quantitative formulas to others of useful meanings to solve the problem addressed by the researcher [13].

As far as the authors know, this is the first study, based on the factor, correlation, and regression analysis aimed at completing the model of highly skilled throwers shot put competition operation status model. Authors [29] studied the body mass indicators of athletes and determined their role in assessing the preparedness of athletes. Authors [32] conducted a systematic review and identified prospects for the future in the use of bioimpedance analysis in sport and exercise. Authors [33] in his studies established a specific profile of an athlete according to the characteristics of body composition: Fat free mass, total body water and fat mass which completely coincides with our studies

Conclusion

It has been shown that the swing speed has the greatest influence on the result in the shot put among beginner athletes. The swing speed, shot angle, shot speed and shot height have significant relationships with the shot put result. The multiple regression equation for the dependence of the shot put result on the swing speed, shot angle, shot height and shot point turned out to be reliable in general. However, only the swing speed has a reliable coefficient of the regression equation. The shot angle tends to be the determining factor in the shot put result. The release rate and the height of the release point have significant correlations with the shot put result, although in the regression equation they have unreliable indicators of influence on the shot put result.

When teaching beginner shot putters, the greatest attention should be paid to the pushing swing technique, namely the swing speed. The second most important indicator is the kernel release angle.

Recommendations

1 – It is important to adopt mechanical foundations in building skill exercises when teaching and training beginners to put the shot.

2 – Predictive equations based on mechanical foundations at the moment of shot put into place for members of the research sample can be used in the process of selecting junior athletes in the shot put competition.

3 – Conducting similar studies on other track and field competitions

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Conflicts of interest

Authors have no conflict of interest to declare.

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Viability and socio-psychological adaptation of athletes of different qualifications in fire and applied sports

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Abstract

Purpose: to study the peculiarities of the relationship between resilience and socio-psychological adaptation to activities in novice athletes; to develop a program of social and psychological training for the development of resilience and optimization of the adaptation process in athletes.
Material and methods. The study involved 42 sportsmen of fire-applied sports at the age from 17 to 20 years. Research methods: theoretical analysis and generalization of scientific literature, system analysis and data interpretation; testing; methods of mathematical statistics.
Results. As a result of the research, a resilience training was developed for novice athletes in order to optimize adaptation processes. The main goals of the training are: achieving a deeper understanding of stressful circumstances, ways to overcome them; finding ways to actively solve problems; constant use of feedback, thereby deepening the self-perception of involvement, control and risk taking. After the training, the level of resilience increased, the maladjustment of the participants decreased.
Conclusions. The article presents a theoretical analysis and empirical study of the problem of the relationship between resilience and socio-psychological adaptation to sports activity of young sportsmen of adolescence. The results obtained in empirical research indicate that the level of resilience is associated with indicators of adaptation. The socio-psychological training has been developed to optimize the process of adaptation to sports activity by increasing the level of vitality. The effectiveness of the developed training program for athletes has been proven.
Key words: beginner athlete, sports activity, vitality, social and psychological adaptation, social and psychological training

Анотація

Афанасьєва Н.Є., Ільїна Ю.Ю., Світлична Н.О. Життєстійкість та соціально-психологічна адаптація спортсменів різної кваліфікації пожежно-прикладного спорту

Мета: дослідити особливості взаємозв'язку життєстійкості та соціально-психологічної адаптації до діяльності у спортсменів-початківців; розробити програму соціально-психологічного тренінгу розвитку життєстійкості та оптимізації процесу адаптації у спортсменів.

Матеріал і методи. В дослідженні взяли участь 42 спортсмени пожежно-прикладного спорту віком від 17 до 20 років.

Методи дослідження: теоретичний аналіз та узагальнення наукової літератури, системний аналіз й інтерпретація даних; тестування; методи математичної статистики.

Результати. У результаті дослідження розроблений тренінг життєстійкості для спортсменів-початківців з метою оптимізації адаптаційних процесів. Основними цілями тренінгу є: досягнення більш глибокого розуміння стресових обставин, шляхів подолання їх; знаходження шляхів активного вирішення проблем; постійне використання зворотного зв'язку, завдяки чому поглиблюється самосприйняття залученості, контролю та прийняття ризику. Після тренінгу підвищився рівень життєстійкості, знизився рівень дезадаптації учасників.

Висновки. У статті представлено теоретичний аналіз та емпіричне дослідження проблеми взаємозв'язку між життєстійкістю та соціально-психологічною адаптацією до спортивної діяльності спортсменів-початківців юнацького віку. Отримані у емпіричному дослідженні результати свідчать, що рівень життєстійкості пов'язаний з показниками адаптації. Розроблено соціально-психологічний тренінг оптимізації процесу адаптації до спортивної діяльності завдяки підвищенню рівня життєстійкості. Доведено ефективність розробленої програми тренінгу для спортсменів-початківців.

Ключові слова: спортсмен-початківець, спортивна діяльність, життєстійкість, соціально-психологічна адаптація, соціально-психологічний тренінг

Аннотация

Афанасьева Н.Е., Ильина Ю.Ю., Светличная Н.А. Жизнестойкость и социально-психологическая адаптация спортсменов различной квалификации пожарно-прикладного спорта

Цель: исследовать особенности взаимосвязи жизнестойкости и социально-психологической адаптации к деятельности у начинающих спортсменов; разработать программу социально-психологического тренинга развития жизнестойкости и оптимизации процесса адаптации у спортсменов.

Материал и методы. В исследовании приняли участие 42 спортсмена пожарно-прикладного спорта в возрасте от 17 до 20 лет. Методы исследования: теоретический анализ и обобщение научной литературы, системный анализ и интерпретация данных; тестирование; методы математической статистики.

Результаты. В результате исследования разработан тренинг жизнестойкости для начинающих спортсменов с целью оптимизации адаптационных процессов. Основными целями тренинга являются: достижение более глубокого понимания стрессовых обстоятельств, путей преодоления их; нахождение путей активного решения проблем; постоянное использование обратной связи, благодаря чему углубляется самовосприятие вовлеченности, контроля и принятия риска. После тренинга повысился уровень жизнестойкости, снизилась дезадаптации участников.

Выводы. В статье представлены теоретический анализ и эмпирическое исследование проблемы взаимосвязи между жизнестойкостью и социально-психологической адаптацией к спортивной деятельности начинающих спортсменов юношеского возраста. Полученные в эмпирическом исследовании результаты свидетельствуют, что уровень жизнестойкости связан с показателями адаптации. Разработан социально-психологический тренинг оптимизации процесса адаптации к спортивной деятельности за счет повышения уровня жизнестойкости. Доказана эффективность разработанной программы тренинга для спортсменов.

Ключевые слова: начинающий спортсмен, спортивная деятельность, жизнестойкость, социально-психологическая адаптация, социально-психологический тренинг

Introduction

Sustainability is a key personality variable that mediates the impact of stressors on physical and psychological health, as well as on the success of the individual. Kulikov [1] in the analysis of viability considers three aspects of psychological stability: resilience, stability; balance, moderation; resistance. In his opinion, resilience is manifested in overcoming difficulties as the ability to maintain faith in themselves, to be confident in themselves, their abilities, as the ability to effectively mental self-regulation. Stability is manifested in the preservation of the individual's ability to function, exercise self-government, develop, adapt. Reduced resilience leads to the fact that, being in a situation of risk, a person overcomes it with negative consequences for mental and physical health, personal development, interpersonal relationships. According to Maddi [2], resilience includes three relatively autonomous components: involvement, control, risk-taking. The expressiveness of these components and vitality in general prevents the emergence of internal tension in stressful situations. Solkova's study [3] showed that resilience affects coping resources by increasing self-efficacy. People who have high resilience rates have a greater sense of competence, high cognitive assessment, developed coping strategies and experience less stress in everyday life. Florian [4] in his study showed that the components of vitality (involvement and control) were predictive of mental health. Involvement has improved mental health, reduced the assessment of threats and the use of emotionally focused coping strategies, and increased the role of secondary reassessment of events. The level of control had a positive effect on mental health, reduced the threat assessment of the event, contributed to the reassessment of the event and encouraged the use of coping strategies focused on solving problems and seeking support.

Thus, research shows that resilience, on the one hand, affects the assessment of the situation - due to the willingness to act actively and confidence in the ability to influence the situation, it is perceived as less traumatic, on the other hand, resilience helps to actively overcome difficulties by producing new constructive behavior. transformation of viability components. Sustainability helps to restore the balance between risk factors and protective factors.

The study focused on the definition of viability as an integrative phenomenon that is associated with resource potential, personal qualities, patterns of behavior and cognitive patterns that are most often used by people in difficult life situations.

Theoretically, the problem of viability of athletes of different qualifications and its relationship with adaptation processes is insufficiently developed. There is still no consensus on what vitality is. This phenomenon in the scientific literature is often replaced by various terms, such as viability, vitality, maturity, and others, so special attention needs to be clarified.

Based on the relevance of the research problem, its lack of development, theoretical and practical significance, the research topic was determined, the object, subject, purpose, hypothesis and objectives of the study were formulated.

Object of research: socio-psychological adaptation to sports activities.

Subject: vitality as a factor of socio-psychological adaptation to the activities of athletes.

Purpose: to investigate the relationship between vitality and socio-psychological adaptation to the activities of novice athletes; to develop a program of socio-psychological training for the development of resilience and optimization of the adaptation process in athletes.

Hypothesis: we proceeded from the assumption that a high level of vitality has a positive effect on the quality and speed of socio-psychological adaptation to the activities of athletes.

Objectives of the study: to analyze modern theoretical approaches to the study of the problem of vitality of athletes at the stage of socio-psychological adaptation to activity; determine the level of viability of novice athletes; to analyze the features of socio-psychological adaptation of athletes to the activity; to study the features of the relationship between vitality and socio-psychological adaptation to the activities of novice athletes; to develop a program of socio-psychological training aimed at developing vitality and optimizing the process of adaptation in novice athletes.

Material and methods

Researched

The study involved 42 athletes in fire and applied sports aged 17 to 20 years (representatives of the national teams of the National University of Civil Defense of Ukraine (Kharkiv) and the Academy of Fire Safety named after the Heroes of Chernobyl (Cherkasy). applied sports is less than 1 year.

Research methods

The main ways of adaptation as an active adaptation of man to the requirements of the activity

experts consider training and education, addiction, selection and formation of individual style of activity.

The purpose of the empirical part of the work is to study the relationship between vitality and socio-psychological adaptation in novice athletes.

Theoretical methods: analysis of scientific literature, generalization of the received information, system analysis and interpretation of data; empirical methods: "Test of viability" Maddi [2]; methods of diagnosis of socio-psychological adaptation K. Rogers, R. Damon; to study the success / failure of adaptation: a questionnaire "Assessment of professional maladaptation" [5]. Methods of mathematical statistics: Student's t-test, Fisher's φ-test, Pearson's correlation coefficient.

Results

S. Maddi's "Sustainability Test" method was used to study the level of viability of novice athletes. The results obtained are presented in table 1.

The data indicate that the indicator "Involvement" is within the standard norm, the indicator "Control" is lower than the norm, the indicator "Risk Acceptance" is much higher than the norm. Thus, it can be stated that the studied novice athletes have an external type of control over life and activities, ie believe that they can not fully influence what happens in their lives, tend to address control to external circumstances and other people.

Table 1

Indicators of viability of novice athletes

Scales	M±σ
Involvement (points)	35.7±12.0
Control (points)	20.2±6.8
Risk acceptance (points)	19.5±6.6

But at the same time they are exposed to unjustified risk, because they believe that any situation (positive or negative) is a source of experience. They prefer to develop through the active acquisition of knowledge from their own experience with their further use. The overall rate of "viability" in the subjects is slightly lower than normal. But the higher the level of resilience, the more it contributes to the assessment of events as less traumatic and successful overcoming of stress.

Socio-psychological adaptation of novice athletes to sports activities was measured using the "Methods of diagnosis of socio-psychological adaptation" and the questionnaire "Assessment of professional maladaptation." The results obtained are presented in tables 2, 3.

Table 2

Indicators of socio-psychological adaptation of novice athletes

Scales	Indexes
Adaptation (%)	60.9
Acceptance of others (%)	59.1
Інтернальність (%)	55.8
Self-acceptance (%)	62.6
Self-acceptor (%)	57.8
The desire to dominate (%)	67.5

The most pronounced indicators of socio-psychological adaptation in the subjects are: the desire to dominate (68.7%), self-acceptance (63.3%) and adaptation (61.1%); the least, although within the norm, are internality (56.0%), emotional comfort (58.3%) and acceptance of others (58.7%). All indicators are in the middle range. In our opinion, the relatively high level of self-acceptance and adaptation in general allows us to make a positive prognosis for the success of socio-psychological adaptation of novice athletes to sports activities. However, the desire to dominate can slow down or even distort this process because it makes the individual less flexible in professional interactions.

Table 3

Indicators of professional maladaptation of novice athletes

№	Sign	Σ балів
1	Deterioration of health	
	Emotional shifts (points)	8.9
	Features of individual mental processes (points)	4.1
	Decreased overall activity (points)	4.9
	Feeling tired (points)	6.3

2	Somato-vegetative disorders (points)	28.8
3	Sleep-wake cycle disorders (points)	7.5
4	Features of social interaction (points)	11.3
5	Decreased motivation to work (points)	4.2
Σ	76.0	

The obtained indicators indicate a pronounced level of maladaptation of the subjects of this group, which requires the mandatory intervention of psychologists and the use of a special program to optimize the process of adaptation to sports activities. Thus, the study of the process of adaptation to sports activities of novice athletes allows us to state that this process continues, has significant deformations, there is a fairly high level of maladaptation.

At the next stage of the study, the relationship between the success of socio-psychological adaptation to sports and the level of vitality of the individual was analyzed. Issues of survival - life, adaptation - self-realization are closely related to individual, situational, moral aspects of the manifestation of vitality, the actualization of certain values and meanings. To study the features of the relationship between viability and various parameters of the adaptation process, a correlation analysis was performed, the results of which are shown in table 4.

Table 4

Indicators of the relationship between viability and the parameters of socio-psychological adaptation to sports activities in novice athletes

Adaptive indicators	Viability
Adaptation (r_s)	0.54**
Acceptance of others (r_s)	0.13
Internality (r_s)	0.08
Self-acceptance (r_s)	0.34*
Emotional comfort (r_s)	0.10
The desire to dominate (r_s)	0.43**
Deterioration of health (r_s)	0.09
Emotional shifts (r_s)	-0.05
Features of individual mental processes (r_s)	0.14
Decreased overall activity (r_s)	-0.49**
Feeling tired (r_s)	-0.16
Somato-vegetative disorders (r_s)	0.07
Sleep-wake cycle disorders (r_s)	-0.22
Features of social interaction (r_s)	0.15
Decreased motivation to work (r_s)	-0.55**

Note:* $p \le 0.05$; ** $p \le 0.01$

These studies allow us to state the presence of both direct and inverse relationship between viability and individual parameters of the adaptation process in novice athletes, namely: a direct relationship at the level of significance established between viability and adaptation ($p \le 0.01$), self-acceptance ($p \le 0.05$), the desire to dominate ($p \le 0.01$); the reverse - between vitality and a decrease in overall activity ($p \le 0.01$), a decrease in motivation to work ($p \le 0.01$). That is, the higher the level of resilience, the easier the process of socio-psychological adaptation to sports in this category of subjects, they have higher self-esteem, strive for leadership and dominance, less prone to ill health and have a higher and sustainable motivation for sports . The obtained data were used in the creation of a training program for novice athletes, the purpose of which is to optimize the process of socio-psychological adaptation to sports activities through the development of vitality of the individual.

In modern psychology, researchers [5] understand training as a multifunctional method of intentional changes in psychological characteristics, characteristics of a person, group and organization in order to harmonize professional and personal life.

Based on the results of psychodiagnostic research, those parameters were identified that in our opinion are subject to psychocorrection and development. These include: all components of viability (involvement, control, risk-taking); self-acceptance, self-esteem, self-attitude in general; leadership qualities, acceptance of responsibility, social activity; sports motivation. Sustainability training is based on the assumption that resilience is not an innate quality, but is formed during life. It is a belief system that can be developed. On the other hand, viability is a hypothetical construct, so there can be no direct impact on it. The main goals of the training are:

1. Awareness of sources of stress, stressful circumstances, ways to overcome them; finding ways to actively solve problems.

2. Use of feedback, which deepens awareness of involvement, control and acceptance of risk.

To achieve them, the most effective is the use of three basic techniques:

1. Reconstruction of situations. When using this technique, the emphasis is on imagination and problem solving. Situations that are perceived as stressful are identified; stressful circumstances are considered in an expanded perspective. Through the reconstruction of the situation, participants learn

about their latent assumptions, which determine how the circumstances are perceived as stressful, what steps can optimize the situation. As part of the reconstruction of situations, the idea of optimal and suboptimal alternatives to the situation is used.

2. Focusing is applied in case of impossibility of direct transformation of stressful circumstances. Technique is the search for unconscious emotional reactions that hinder decision-making by appealing to the "inner content". The purpose of its application is emotional insight, which helps to transform stressful situations into opportunities.

3. Compensatory self-improvement. If the transformation of the situation cannot take place, the emphasis is on another problem that is somehow related to the existing one. Her decision encourages people to pay attention to what can be changed. An additional training technique in the initial stages of its use is the method of paradoxical intention.

The main stages of training:

1) identification of stressful circumstances that need to be addressed;

2) the use of techniques designed to stimulate the imagination;

3) the use of perspective and its understanding to develop an action plan aimed at transforming stressful circumstances into favorable ones; doing homework to apply the acquired skills and discuss the results.

Sustainability training also includes exercises aimed at finding and receiving social support in a stressful situation both in the family and in a sports environment, as well as learning the skills of self-regulation of one's condition and maintaining a healthy lifestyle. Self-regulation skills include: the ability to apply relaxation techniques, monitoring physical condition, the ability to regulate breathing, mastery of certain techniques of meditation and visualization. Training to maintain a healthy lifestyle includes the formation of skills of proper nutrition, training of the cardiovascular system, physical activity, including weight control. The method of feedback is also used in self-observation, observation by others and as a result of interaction with stressful circumstances, recurrence prevention (control during the year).

The main goal of training is to increase the level of vitality, ie the ability to withstand stress, actively transforming it or adapting to it. To achieve this goal, the training analyzes and changes ineffective behavioral strategies in intense sports or personal situations.

Created on the basis of a certain concept, the training model includes various interactive methods of group work that allow participants to master the technologies they need. But since the training cannot be conducted in full accordance with the planned plan, new meaningful parts may appear in the training.

The conceptual basis of sustainability training is the approach to the problem from the standpoint of health psychology. A person can keep himself in stress only if a systematic analysis of the most important areas of human life (physical health - family - work - spiritual values), which will allow everyone to develop their own stress management system.

One of the provisions of the psychology of health shows that everyone can be healthy with certain, appropriate for him features and conditions of life and work. Only man himself can understand and comprehend these factors. Thus, taking into account the individual psychological characteristics of the individual - an important conceptual position in the development of training programs.

Goals and objectives of sustainability training. The following learning tasks were implemented in the training scenario. The first task of the trainer is to inform the participants about the effects of stress on the human body and psyche. In this regard, we introduce participants to the most important concepts of stress theory, such as stressors, adaptive syndrome, frustration, emotional burnout, psychosomatic diseases and more. After the psychologist provides this information, the content of each of these concepts is discussed during exercises or in the form of group thematic discussions. The second task is to teach the participants of the training group to monitor the signs of stress and its consequences in themselves and other people. Practice shows that many of our reactions to stressors are not realized and supplanted. The influence of the stressor, which triggers stressful behavior, often acts as a trigger. It can be a word, a negative opinion, the statements of important people, the peculiarities of the situation or behavior of the interlocutor. Therefore, the third task of the psychologist is to teach participants to be aware of the impact of these stressors, in order to further control their own behavior in stressful situations. Another important task of the training is to teach participants the methods of self-help and self-regulation, which can be used in situations where stress pressure is maximum or prolonged. It is also important for novice athletes to know the technique of helping other people, to regulate their own emotional state. The training includes information about emotional intelligence, the development of which is an important component of sports success. Also - information about the effect of negative states on the perception of life events. For example, we look in

detail at the "anger curve" and ways to correct this condition. Training helps not only to gain knowledge, but also to acquire skills of constructive response to traumatic situations. The training is designed for 40 hours, 5 days for 8 consecutive hours.

After the socio-psychological training, the diagnosis of viability and some parameters of socio-psychological adaptation to sports activities in the group that was trained (group 1) and the group that did not participate in the training (group 2) was conducted. The obtained results are shown in tables 5, 6, 7.

Table 5

Indicators of viability of novice athletes who participated in the training

Scales	1 group (Participated in the training) (n=20)	2 group (Did not participate in the training) (n=22)	t	p- level
Involvement (points)	37.6±12.7	28.3±9.6	2.8	0.067
Control (points)	26.2±8.9	20.4±6.9	2.3	0.055
Risk acceptance (points)	17.5±6.0	14.6±5.0	1.9	0.045

It should be noted that the athletes who participated in the training have much higher indicators of vitality. But only two of them reached the level of statistical significance: involvement ($p \leq 0.01$) and control ($p \leq 0.05$). That is, training affects the development of research self-confidence, increase interest in life and work. In addition, the rate of personality internality is higher, at least in some situations and cases. We consider this to be a positive effect of the conducted psycho-correctional work.

Table 6

Indicators of socio-psychological adaptation of athletes who participated in the training

Scales	1 group (Participated in the training) (n=20)	2 group (Did not participate in the training) (n=22)	ϕ	p- level
Adaptation (%)	63.5	53.8	0.74	0.023
Acceptance of others (%)	72.8	51.2	1.65	0.050
Internality (%)	59.6	43.4	1.24	0.038
Self-acceptance (%)	68.4	52.1	1.25	0.038
Emotional comfort (%)	67.3	44.9	1.71	0.052
The desire to dominate (%)	65.7	55.7	0.76	0.023

The data obtained indicate that athletes who participated in the training have significantly higher indicators such as "acceptance of others" ($p \leq 0.05$) and "emotional comfort" ($p \leq 0.05$). This means that after the training, novice athletes in this group became more friendly to other people, less conflicted and timid in contacts. They feel emotionally comfortable in a variety of situations, almost those that have previously caused them undue stress. We believe that this will help them to adapt more quickly to professional activities and communication.

Table 7

Indicators of professional maladaptation of athletes who participated in the training

Sign	1 group (Participated in the training) (n=20)	2 group (Did not participate in the training) (n=22)	t	p- level
Emotional shifts (points)	6.3±2.2	8.1±2.8	1.26	0.030
Features of individual mental processes (points)	4.8±1.7	5.3±1.9	0.35	0.008
Decreased overall activity (points)	4.4±1.6	6.8±2.4	1.68	0.040

Feeling tired (points)	5.7±2.1	8.5±2.9	1.96	0.047
Somato-vegetative disorders (points)	22.1±7.5	33.6±11.3	2.11	0.050
Sleep-wake cycle disorders (points)	7.2±2.5	10.3±3.6	2.17	0.052
Features of social interaction (points)	9.4±3.3	12.6±4.3	2.24	0.053
Decreased motivation to work (points)	4.1±1.5	6.3±2.2	1.54	0.037
Σ	64.0±21.5	91.5±30.6	1.66	0.039

For novice athletes who participated in the training, the overall level of maladaptation is moderate, ie lower than for those athletes who did not participate in the training. In addition, there were significant differences in the following signs of maladaptation: somato-vegetative disorders ($p \leq 0.05$), sleep-wake cycle disorders ($p \leq 0.05$), features of social interaction ($p \leq 0.05$).

Discussion

In foreign psychological literature, resilience is seen as an important personal quality that determines a person's ability to self-preservation and effective activity in overcoming life obstacles (stress, crisis, adverse social circumstances) and maintaining an active life position. Researchers [6, 7, 8, 9, 10, 11, 12, 13, 14] consider vitality as an integrative phenomenon that correlates with personal anxiety, psychological well-being, optimism, strategies for overcoming stressful situations, locus of control and more. At the same time, the identification of additional factors that may affect the level of vitality of the individual is still relevant. Thus, vitality can be a determinant of socio-psychological adaptation to sports activities of the individual.

Adaptation in a broad sense is interpreted as a process of interaction of the individual with the environment, which leads to the transformation of the environment in accordance with the needs, values of the individual or the dependence of the individual on the environment [15, 16, 17]. The main stages of adaptation to sports activities include: acquaintance, ie personal information about the new situation in general, the criteria for evaluating various actions, standards, norms of behavior, etc .; adaptation, ie reorientation of the individual, accompanied by the recognition of a new system of values while maintaining the old attitudes; assimilation - adaptation to the environment, identification with a new group; identification - identification of personal goals with the goals of the community [18, 19, 20, 21]. The fundamental difference between the functional system of socio-psychological adaptation of the individual from all other systems that are self-regulating is the presence of mechanisms of conscious self-regulation.

Human resilience means its ability to use its own resources, including physical resources: the level of physical fitness and mental health; psychological resources: intellectual abilities, emotional and volitional regulation; personal resources: self-esteem and self-esteem, life meanings, attitudes, system of motives, material resources that affect access to information, legal, medical and other forms of assistance, social resources: support for family, friends, social status [22, 23 , 24].

According to researchers [25], the vitality of the individual is:

- a certain resource, potential, which may include various psychological properties and may be in demand by the situation;
- an integral psychological property of the individual, which develops on the basis of attitudes of active interaction with life situations;
- integral ability to socio-psychological adaptation based on the dynamics of semantic self-regulation.

There is also the dynamism of this personal education, its relationship with the natural properties of man and his skills.

Larina [26] defines vitality as a system of personal beliefs that promotes the readiness of the subject to be interested in participating in situations of increased complexity, control them, manage them, be able to perceive even negative events as experiences and successfully cope with them. Therefore, according to Titarenko et al. [27], a feature of a viable personality is a holistic system of interaction with the world; a resilient person has resilient beliefs (involvement, control, risk), leads a resilient lifestyle (maintains his physical and mental health), uses resilient coping to overcome stressful and difficult life situations.

Socio-psychological adaptation to sports is considered in psychology the central period of human development, personality in general, the manifestation of various interests, among which

sports interests are more important [28, 29]. Beginner athletes experience their formation and development through a combination of several crises: age; individual life, which include crises of unrealization, devastation, hopelessness; professional training; external, global, existential, associated with the instability of the present and the uncertainty of the future. But this period remains the most favorable for the formation of vitality and overcoming stress. Sustainable coping with stress is an active, healthy coping that increases a person's stress resistance, which is based on involvement in the situation, the desire to subdue it (control over the situation), the ability to boldly solve life problems (risk taking), actualizes search behavior and self-realization potential [30, 31].

Thus, the vitality of the individual in sports can help improve physical and mental health, successful adaptation to stressful situations with the level of transadaptation associated with self-realization, self-affirmation.

Psychological studies of Ukrainian scientists [32, 33, 34, 35, 36, 37] found that athletes with a high level of success of socio-psychological adaptation are characterized by: positive mental states, the presence of stable motives, lack of character accentuations or their presence without signs of manifestation, low level of personal anxiety and high efficiency of sports activities. Athletes with an average level of socio-psychological adaptation are characterized mainly by positive mental states, the presence of relatively stable motives, average level of personal anxiety, the presence of character accentuations that positively affect activities (hyperthymic, demonstrative), and generally satisfactory level of sports performance. The low level of success of socio-psychological adaptation is due to various motives and mental states, medium or high level of personal anxiety, the presence of character accentuations (anxious, excited, stuck, dysthymic) with signs of their negative manifestation and insufficient success in sports.

Also Krucevich et al. [38] found that the dynamics of the process of socio-psychological adaptation of young athletes to the activity is characterized by changes in the levels of their individual psychological characteristics, which largely determine the success of adaptation. This suggests that high and medium levels of success of socio-psychological adaptation can be formed by targeted influence or arise spontaneously, in the latter case they need further improvement. The low level of individual psychological characteristics excludes the possibility of spontaneous levels of socio-psychological adaptation, adequate to the requirements of sports activities.

Conclusions

1. A study of the level of viability of novice athletes and the process of their socio-psychological adaptation to sports activities showed that: the indicator "Involvement" is within the standard norm, the indicator "Control" is below normal, the indicator "Risk Acceptance" is much higher than normal . That is, the studied athletes have an external type of control over life and activities. Meanwhile, they are at undue risk because they believe that any situation (positive or negative) is a source of experience. They want to develop through the active acquisition of knowledge from their own experience with their further use. The overall rate of "viability" in the subjects is slightly lower than normal.

2. The most pronounced indicators of socio-psychological adaptation in the subjects are: the desire to dominate, self-acceptance and adaptation; least of all, although within the norm - internality, emotional comfort and acceptance of others. All indicators are in the middle range.

3. Analysis of the relationship between vitality and socio-psychological adaptation to sports revealed the presence of both direct and inverse relationship between viability and individual parameters of the adaptation process in novice athletes, namely: a direct relationship at the level of significance established between vitality and adaptation, self-acceptance, the desire to dominate; the reverse is between vitality and a decrease in overall activity, a decrease in motivation to work.

4. Developed training program for the development of vitality of athletes at the stage of socio-psychological adaptation to sports activities is based on theoretical and methodological principles proposed by Muddy. Its main goals are: to achieve a deeper understanding of stressful situations, ways to overcome them; finding ways to actively solve problems; constant use of feedback, which deepens the self-perception of involvement, control and risk-taking. Beginner athletes who participated in the training have much higher indicators of vitality. But only two of them reached the level of statistical significance: involvement and control. The data also indicate that they have significantly higher indicators such as "acceptance of others" and "emotional comfort". The overall level of maladaptation is moderate. In addition, significant differences in the indicators of such signs of maladaptation: somato-vegetative disorders, sleep-wake cycle disorders, features of social interaction. Thus, we believe that the developed training is effective and we can recommend it for use in the psychological support of novice athletes at the stage of socio-psychological adaptation to sports activities.

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Conflict of interest

Authors state that there is no conflict of interest

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The relationship between the effectiveness of performing technical elements and indicators of static and dynamic balance in young acrobats 6-7 years old

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Abstract

Purpose: to determine the relationship between the performance of basic elements and indicators of static and dynamic balance in the training process of young acrobats 6-7 years.
Material and methods. The study involved 16 young acrobats at the stage of initial training (age 6-7 years). All parents of the participants gave written consent for the participation of children in the study. The study involved testing the technique of performing basic elements of sports acrobatics and assessing the static and dynamic balance of young athletes. The relationship between (swallow, shoulder blade, forward squat, wheel (sideways overturning), bridges) and static and dynamic equilibrium tests was determined. Spearman's rank correlation coefficient method was used as a method of statistical analysis.
Results. It is established that the largest relationship between the performance of basic elements and static balance in the basic exercises of young acrobats have: Romberg's test with the elements "Swallow", "Stand on the shoulders", "Bridge"; Biryuk test with elements "Swallow", "Wheel", "Bridge"; balance "Swallow" with elements "Swallow", "Wheel"; static equilibrium test with the elements "Swallow", "Rack on the shoulders", "Rolling forward with a squat", "Wheel". Reliable values of the correlation coefficient were established between the tests of dynamic balance and the basic elements of sports acrobatics in young athletes 6-7 years, namely: "Swallow", "Flip forward with a squat", "Wheel" and "Bridge". The analysis of special tests of static and dynamic balance in mastering the basic elements of acrobatics at the first stage of long-term training makes it possible to use them to determine the level of coordination capabilities of young athletes and further improve the use of acrobatic exercises.
Conclusions. A reliable relationship between the performance of basic exercises and indicators of static and dynamic balance in young acrobats at the initial stage of training. It is shown that the level of static and dynamic balance is of great importance for the assimilation and improvement of basic elements of technology by young acrobats 6-7 years. Static and dynamic balance tests can be used to individually build training programs and young acrobats. It is shown that sports acrobatics is a significant means of developing the balance of children 6-7 years.
Key words: young acrobats, primary education, basic elements, tests

Анотація

Черних Т., Мулик В., Мулик К., Скалій О., Островський А., Скалій Т. Взаємозв'язок між ефективністю виконання технічних елементів і показниками статичної та динамічної рівноваги у юних акробатів 6-7 років
Мета: визначити взаємозв'язок між показниками техніки виконання базових елементів та показниками статичної і динамічної рівноваги в тренувальному процесі юних акробатів 6-7 років.
Матеріал і методи. У дослідженні брало участь 16 юних акробатів на етапі початкової підготовки (вік 6-7 років). Всі батьки учасників дали письмову згоду на участь дітей в дослідженні. Дослідження передбачало проведення тестування з техніки виконання базових елементів спортивної акробатики та оцінки статичної та динамічної рівноваги юних спортсменів. Було визначено взаємозв'язок між (ластівка, стійка на лопатках, перекид вперед з упору присівши, колесо (перевороти боком), міст) та тестів статичної й динамічної рівноваги. В якості методів статистичного аналізу застосовувався метод коефіцієнту рангової кореляції Спірмена.
Результати. Встановлено, що найбільший взаємозв'язок між показниками техніки виконання базових елементів та показниками статичної рівноваги у базових вправах юних акробатів мають: проба Ромберга з елементами «Ластівка», «Стійка на лопатках», «Міст»; проба Бірюк з елементами «Ластівка», «Колесо», «Міст»; рівновага «Ластівка» з елементами «Ластівка», «Колесо»; тест статичної рівноваги з елементами «Ластівка», «Стійка на лопатках», «Перекид вперед з упору присівши», «Колесо». Достовірні значення коефіцієнту кореляції встановлено між тестами динамічної рівноваги і базовими елементами спортивної акробатики у юних спортсменів 6-7 років, а саме: «Ластівка», «Перекид вперед з упору присівши», «Колесо» та «Міст». Проведений аналіз спеціальних тестів статичної і динамічної рівноваги при засвоєнні базових елементів акробатики на першому етапі багаторічної підготовки дає можливість використовувати їх для визначення рівня координаційних можливостей юних спортсменів та подальшого удосконалення у використанні зв'язок акробатичних вправ.
Висновки. Визначено достовірний взаємозв'язок між показниками техніки виконання базових вправ та показниками статичної та динамічної рівноваги у юних акробатів на початковому етапі підготовки. Показано, що рівень статичної та динамічної рівноваги має велике значення для засвоєння та удосконалення базових елементів техніки юними акробатами 6-7 років. Тести на статичну та динамічну рівновагу можуть бути застосовані для індивідуальної побудови програм тренувань та юних акробатів. Показано, що спортивна акробатика є значущим засобом розвитку рівноваги дітей 6-7 років.
Ключові слова: юні акробати, початкове навчання, базові елементи, тести

Аннотация

Черных Т., Мулик В., Мулик Е., Скалий А., Островский А., Скалий Т. Взаимосвязь между эффективностью выполнения технических элементов и показателями статического и динамического равновесия у юных акробатов 6-7 лет
Цель: определить взаимосвязь между показателями техники выполнения базовых элементов и показателями статической и динамической равновесия в тренировочном процессе юных акробатов 6-7 лет.
Материал и методы. В исследовании принимало участие 16 юных акробатов на этапе начальной подготовки (возраст 6-7 лет). Все родители участников дали письменное согласие на участие детей в исследовании. Исследование предусматривало проведение тестирования по технике выполнения базовых элементов спортивной акробатике и оценки статической и динамической равновесия юных спортсменов. Было определено взаимосвязь между (ласточка, стойка на лопатках, кувырок вперед из упора присев, колесо (переворот боком), городов) и тестов статической и динамической равновесия. В качестве методов статистического анализа применялся метод коэффициента ранговой корреляции Спирмена.
Результаты. Установлено, что наибольший взаимосвязь между показателями техники выполнения базовых элементов и показателями статического равновесия в базовых упражнениях юных акробатов имеют: проба Ромберга с элементами «Ласточка», «Стойка на лопатках», «Мост»; проба Бирюк с элементами «Ласточка», «Колесо», «Мост»; равновесие «Ласточка» с элементами «Ласточка», «Колесо»; тест статического равновесия с элементами «Ласточка», «Стойка на лопатках», «Кувырок вперед из упора присев», «Колесо». Достоверные значения коэффициента корреляции установлено между тестами динамического равновесия и базовыми элементами спортивной акробатике у юных спортсменов 6-7 лет, а именно: «Ласточка», «Кувырок вперед из упора присев», «Колесо» и «Мост». Проведенный анализ специальных тестов статической и динамической равновесия при усвоении базовых элементов акробатики на первом этапе многолетней подготовки дает возможность использовать их для определения уровня координационных возможностей юных спортсменов и дальнейшего совершенствования в использовании связь акробатических упражнений.
Выводы. Определены достоверная взаимосвязь между показателями техники выполнения базовых упражнений и показателями статической и динамической равновесия у юных акробатов на начальном этапе подготовки. Показано, что уровень статической и динамической равновесия имеет большое значение для усвоения и совершенствования базовых элементов техники юными акробатами 6-7 лет. Тесты на статическую и динамическую равновесие могут быть использованы для индивидуального построения программ тренировок и юных акробатов. Показано, что спортивная акробатика является значимым средством развития равновесия детей 6-7 лет.
Ключевые слова: юные акробаты, начальное обучение, базовые элементы тесты

Introduction

Currently, there are several approaches to the methodology of teaching complex coordination exercises, the main of which is the use of holistic and separate methods that depend on the complexity of the exercises [1, 2]. Along with this, there is a statement [3, 4] that the mastery of the technique of individual elements depends on the level of development of motor skills that ensure their implementation. Therefore, you should pay attention to the motor skills that are inherent in performing each basic acrobatic exercise.

At the beginning of mastering an element of technique, you need to show "dexterity", ie the implementation of each element that is learned, because in the process of execution there are difficulties of various kinds associated with the violation of the structure of movements and efforts to be overcome. Over time, when forming a skill, when in general the structure of movements is mastered, it is already a question of coordination of movements, which provides: regulation of dynamic and spatio-temporal parameters of movements; static and dynamic equilibrium; rhythmic movements; orientation in space and time; intramuscular and intermuscular coordination; changes in the direction of movement and motor program of action [5]. The structure of coordination actions presented by Platonov [6] and other scientists [7, 8] is fully inherent in sports acrobatics, but also needs to be supplemented with regard to the basic performance of the exercise in the interaction of the athlete and the support area (treadmill and mother) and unsupported performance. exercises.

Insufficient level of individual motor quality during exercise can be a factor limiting the effectiveness of motor actions. Thus, dexterity, as well as coordination of movements, significantly depends on motor (motor, muscular) memory, which is due to the properties of the central nervous system to memorize movements and perform them [9, 10].

The results of research [11–13] have been confirmed that sports acrobatics is a complex coordination sport. Competitive activity in sports acrobatics is associated with maintaining balance and rotation of the body with and without support. Sports acrobatics contains various technical elements: supports, racks, flights, throws, landings. The current level of achievements in sports acrobatics makes higher demands on the training of young athletes. As there is a significant rejuvenation of national teams in acrobatics, children begin to engage in acrobatics at an early age (6-7 years) and after 3-4 years participate in competitions of various levels. The process of rapid change and rejuvenation of groups of initial training in sports acrobatics and the constant increase in the complexity of acrobatic exercises requires the latest approaches to the process of training athletes in the initial stages [11–13].

At the initial stage first of all mastering of structure of movements (both in static poses, and in dynamics of performance), and structure of efforts at the kept poses is required. Only after mastering the individual components of special poses is it possible to move to a dynamic effort during the performance, first of individual exercises, and then in combination. Therefore, there is a need to determine motor actions and motor qualities (due to individual muscle groups), as well as the level of their manifestation when performing a particular exercise.

Purpose: to determine the relationship between the performance of the basic elements and the indicators of static and dynamic balance in the training process of young acrobats 6-7 years.

Material and methods

Participants

The study involved 16 young acrobats at the stage of initial training, engaged in a comprehensive children's sports school №6 Slobidsky district of Kharkiv. The age of athletes was 6.5 ± 0.13 years. All parents of the participants gave written consent for the participation of children in the study.

The study was conducted in accordance with the WMA Declaration of Helsinki - Ethical Principles for Medical Research with Human Participation, 2013. The study protocol was approved by the Ethics Committee of the Kharkiv State Academy of Physical Culture. (The research was conducted in compliance with WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects, 2013. The study protocol was approved by the Ethical Committee of Kharkov State Academy of Physical Culture).

Procedure

The study involved testing a set of basic exercises of sports acrobatics and assessing the static and dynamic balance of young athletes. The study also identified the relationship between the use of basic exercises and static and dynamic balance tests.

The test battery consisted of 5 basic exercises of sports acrobatics, the technique of which was determined by expert evaluation on a 10-point scale, which is given in table. 1.

Table 1

Criteria for evaluating the technique of performing basic elements of sports acrobatics

Points	Evaluation criteria
10	the exercise is performed without errors, with emphasis on each element of movement
9	the exercise is performed without errors, but one of the elements is indistinctly marked
8	the exercise is performed without errors, but several elements are indistinctly marked
7	the exercise is performed correctly, but there is an error that does not affect the structure of the movement
6	the exercise is done mostly correctly, but there are a few minor mistakes that somewhat distort the structure of the movement
5	the exercise is generally done correctly, but there is a gross error that distorts the structure of the movement
4	the exercise is mostly performed, but with a failure to perform in the cycle, stopping the movement and subsequent continuation
3	the exercise is performed with stops, comprehension of errors and subsequent reproduction
2	the structure of the exercise is completely broken, only some elements of the technique are performed in one of the cycles
1	the child cannot perform the exercise

Swallow. Starting position on one leg, the other set back 90 °, torso tilted forward, arms to the sides.

Rack on the shoulders. From the starting position lying on your back, hands down, palms on the floor, lift your legs and pelvis up. With the legs stretched up, focus your hands under your back. The rack on the shoulder blades can be performed from the stop by squatting backwards, from the saddle with straight legs by rolling backwards.

Rolling forward with a squat. Squatting from the stop, push off with your feet, bend your arms, tilt your head to your chest, leaning on your shoulders, grab your shins, group up and roll over.

Wheel (turn sideways). From the main rack lift the right leg to the side, arms to the sides. Put the right foot and, pushing off, make a swing with the left foot. Consistently first put the right, then left hand and go through the rack on his hands, legs apart. Get up first on the left, then the right leg. In order not to get out of the plane, put your hands on the line of the legs.

Bridge. Performed by leaning back from a standing position with legs apart and constantly stretching his arms to the support. It is possible to perform this element from a supine position. Simultaneously bending the legs and arms and placing them on the support, and then straightening them, perform the position of the cities.

The test battery for static and dynamic equilibrium assessment consisted of 5 samples.

Romberg's test is complicated: vertical posture of the body of the hand forward, feet on one line "heel-toe" - 10 s with open and 10 s with closed eyes. Allows you to assess the quality of coordination of the vertical position of the body, the level of neuromuscular activity. Stability time (s) was estimated.

Biryuk test: vertical body posture with closed feet standing on tiptoes, arms up, eyes closed. Allows you to assess the level of formation of the skill of maintaining body balance in difficult conditions. The time (c) of maintaining the position of the body was recorded.

Equilibrium "swallow": standing on one leg, the other set back 90 °, torso tilted forward, arms to the sides, eyes closed. The time (c) of preservation of a pose was fixed.

Static equilibrium: standing on one leg, the other bent, and her heel touching the knee joint, the whole foot pressed to the shin of the supporting leg. Small fluctuations in the torso were not taken into account. The time (c) of preservation of a pose was fixed.

Dynamic equilibrium: stepping on the spot, young athletes performed 10 turns on the spot (360□) with simultaneous tilts of the head (30-35 °). Then you need to walk a 5-meter distance. The deviation from a straight line in centimeters (cm) was estimated.

Statistical analysis

Experimental data were processed using conventional methods of mathematical statistics [10]. When evaluating the technique of basic exercises of sports acrobatics and assessing the static and dynamic balance of young athletes, we used statistical indicators such as: arithmetic mean ($\bar{x}$), standard deviation (S) and coefficient of variation (V), the normality of the distribution of differences was determined by using the Chi-Square test.

Correlation analysis was used to determine the presence or absence of a relationship between the studied indicators. Because the analysis of correlation fields showed a monotonic nonlinear relationship between the indicators, we used the Spearman rank correlation coefficient (r), which allowed us to determine the degree of relationship between the data that do not comply with the law of normal distribution.

Mathematical data processing was performed using research programs Microsoft Excell's Data Analysis and SPSS-17.

Results

For successful mastering by athletes of basic exercises of sports acrobatics at a stage of initial preparation along with working off of technical actions it is necessary to pay attention and performance of special exercises for improvement of systems of an organism which are responsible for balance of a body of athletes. Increasing the ability of athletes to maintain body balance will significantly improve the efficiency of the training process of athletes.

Initially, the test scores were checked for compliance with the normal distribution of the Chi-Square test. It was determined that all indicators of testing of the analyzed sample of athletes correspond to the normal distribution ($p > 0.05$) in terms of asymptomatic significance and significance in the Monte Carlo test (table 2).

The basis of all types of acrobatics at the initial stage of training is the individual mastery of the basic elements of technology: swallow, stand on the shoulders, rolling forward with a squat, wheel (sideways turn), bridges. Our research identified preparatory exercises for learning individual elements, and established their correlation with psychophysiological indicators, the results of which are shown in table 3. Along with this, it was very important to establish the relationship (ie effectiveness) of each exercise for learning basic elements of technology. It was taken into account that for the effective use of the basic elements, special preparatory exercises must correspond to them in the structure of movements, the structure of efforts and the formation of a unified functional system to ensure its implementation.

Table 2

The results of the test "Chi-Square" for compliance with the normal distribution of testing indicators of young acrobats 6-7 years

Indexes	Chi-Square	df	Asymp. Sig.	Monte Carlo Sig.
Swallow, points	4.077	15	0.538	0.601a
Rack on the shoulders, points	3.024	15	0.576	0.614a
Rolling forward with a squat, points	3.566	15	0.438	0.501a
Wheel (turn sideways), points	3.671	15	0.685	0.734a
Bridge, points	4.012	15	0.512	0.618a
The Romberg test is complicated, s	8.236	15	0.314	0.457a
Sample "Biryuk", s	4.047	15	0.219	0.325a
Equilibrium "Swallow", s	16.582	15	0.453	0.541a
Static equilibrium, s	7.363	15	0.671	0.712a
Dynamic equilibrium, cm	7.482	15	0.218	0.315a

Note: a. Based on 10000 sampled tables with starting seed 299883525

Table 3

Indicators of technique of performing basic elements of sports acrobatics and the level of static and dynamic balance of young acrobats (n = 16)

Tests	$\bar{x}$	S	V
Swallow, points	6.2	0.91	15%
Rack on the shoulders, points	5.1	0.89	17%
Rolling forward with a squat, points	5.2	1.11	21%
Wheel (turn sideways), points	5.0	0.97	19%
Bridge, points	5.4	0.96	18%
The Romberg test is complicated, s	14.4	1.09	8%
Sample "Biryuk", s	5.3	0.81	15%
Equilibrium "Swallow", s	24.4	2.45	10%
Static equilibrium, s	11.4	1.86	16%
Dynamic equilibrium, cm	12.2	3.66	30%

The correlation analysis of the relationship between special exercises and tests that reflect the assessment of static and dynamic balance of young acrobats in the initial training stage is presented in Table 4.

Table 4

Relationship between indicators of technique of performing basic elements and indicators of static and dynamic balance of young acrobats at the stage of initial training (n = 16)

№	Basic elements	Equilibrium tests				
		The Romberg test is complicated, s	Sample "Biryuk", s	Equilibrium "Swallow", s	Static equilibrium, s	Dynamic equilibrium, cm
1	Swallow, points	0.64	0.68	0.88	0.65	0.65
2	Rack on the shoulders, points	0.48	0.46	0.42	0.51	0.49
3	Rolling forward with a squat, points	0.31	0.40	0.36	0.77	0.75
4	Wheel (turn sideways), points	0.42	0.58	0.57	0.61	0.64
5	Bridge, points	0.48	0.51	0.42	0.51	0.56

Analyzing the results of the correlation, to determine the level of manifestation of qualities during the exercise, the swallow should be used as tests of static equilibrium, the coefficients of which were: Romberg test (r = 0.64), Biryuk test (r = 0.68), equilibrium "swallow" (r = 0.88), tests of static (r = 0.65) and dynamic (r = 0.65) equilibrium.

The stand on the shoulders with support under the waist involves getting out of the supine position due to motor actions with the feet in the position of the stand on the shoulders (ie the exercise consists of both dynamic movement and static holding of the stand) has the highest correlation with the static balance test (r = 0.51), which is divided into the time of readiness to perform the test and the time of fixation of equilibrium and stabilization of stability.

Performing the exercise roll forward from the stop squatting has 2 components: the first - from a standing position, arms up - through the stop standing bent forward forward from a supine position, arms up; the second - from the stop squatting - roll forward in grouping in the position of the stop squatting. This exercise has a dynamic nature of execution, which does not involve static fixation of the position. Therefore, the quality of performance significantly correlates with tests of static (r = 0.77) and dynamic (r = 0.75) equilibrium.

Wheel exercise has a dynamic nature of performance, which requires additional (advanced) use of preparatory exercises related to reaching the

vertical position of the body and fixing the standing position (with the support of a trainer, leaning against a wall, etc.), and the provisions that apply when performing predominantly dynamic equilibrium (r = 0.64). Along with this, the average level of correlation of the exercise of the wheel, associated with static equilibrium performance Biryuk (r = 0.58), balance "swallow" (r = 0.57) and static balance test (r = 0.61).

The urban exercise also involves two stages of assimilation. Simplified involves from a supine position, arms up - bridge (legs straighten), return to the position of the legs apart, arms out to the side.

A more complex (basic) option is performed from a standing position, arms up, slowly tilt back (with the support of the coach) and accept the position of the cities. The assessment of static equilibrium is determined by using the Biryuk test and the static equilibrium test (r = 0.51), while the indicators of dynamic equilibrium during the execution of the bridge have more significant correlation indicators (r = 0.56).

Discussion

As far as we know, our study is one of the first in terms of determining the impact of static and dynamic equilibrium on the quality of performance of technical elements by young acrobats 6-7 years. We found a reliable relationship between the performance of basic exercises and the indicators of statistical and dynamic balance in young acrobats at the initial stage of training. Thus, the goal set in this study was achieved. In addition, the analysis of special tests of static and dynamic balance in mastering the basic elements of acrobatics in the first stage of long-term training makes it possible to use them to determine the level of coordination capabilities of young athletes and further improve the use of acrobatic exercises.

Recent scientific studies suggest that regular physical activity of the child, even at the recreational level, can be a significant contribution to the development of physical qualities and, above all, balance [14 – 16]. Also, many authors study the development of balance in children through the introduction of special coordination exercises [17, 18]. One of the areas of research is to study the influence of basic elements of technology on static and dynamic equilibrium in acrobatics [19]. At the same time, there are studies that report differences in body position when performing basic exercises in young athletes of different ages [20, 21]. We found the influence of the level of static and dynamic equilibrium on the quality of basic elements of technique in young acrobats 6-7 years. These are relatively new facts, as far as we know. In addition, data were confirmed [21, 22] on the high impact of acrobatics on the development of balance in children 6-7 years.

At the initial stage of training, sports selection is aimed at highlighting the qualities and indicators that determine success in this sport. An important place is occupied by the selection of tests and samples that allow you to assess these qualities. Thus, a set of psychophysiological tests is used to predict success in various types of martial arts. In different types of struggle they include coordination of movements, and in shock martial arts - the speed of reaction to different types of stimuli [22].

Physical development is a leading factor in assessing the condition of athletes, forecasting the growth of sportsmanship and analysis of the effectiveness of training. Different indices can be used for this. The use of a battery of specific and nonspecific indices for the analysis of features of physical development of martial arts athletes is substantiated. indices allow us to assess the specific impact of training on the body of athletes. Simplicity, informativeness, validity and availability of indices allow to recommend their use in monitoring the functional state of athletes [23].

The problem of assessing the technique of performing any competitive exercise is a priority in any type of sports and professional activities [24, 25]. Its essence is that it is necessary not just to determine the movement of the body or its individual biokinematic components, but to carry out these actions with minimal energy costs.

We have considered this problem and its solution on the example of determining the level of mastering the basic elements of acrobatics at the initial stage of the training process using static and dynamic equilibrium tests. It is known that the basis of all types of acrobatics is the individual assimilation of the basic elements of such exercises as: "swallow", standing on the shoulders, rolling forward with a squat, bridges. One of the tasks of our study was to establish a correlation between the use of each exercise to master the technique of basic elements. Therefore, in the training process, it is advisable to use special training exercises, which should correspond to the structure of movement, the structure of efforts and mechanisms of formation of a unified functional system that ensures their implementation.

The solution of the tasks facing the athlete is carried out by performing certain movements related to the practical implementation of free motor actions, which are performed in accordance with the tasks of sports and the rules of competition. The main task of

the process of learning the technique of movements involves the development of effective methods that meet training plans and take into account the objectives of the lesson, information about the morphological structure of the organism, the laws of its functioning in development.

In this regard, our research has made it possible to determine the most effective for the use of various exercises through static and dynamic balance tests, which are most consistent with the basic exercises of novice athletes in sports acrobatics.

Conclusions

1. It is established that the largest relationship between the performance of basic elements and indicators of static balance in the basic exercises of young acrobats have: Romberg's test with the elements "Swallow", "Stand on the shoulders", "Bridge"; Biryuk test with elements "Swallow", "Wheel", "Bridge"; balance "Swallow" with elements "Swallow", "Wheel"; static equilibrium test with the elements "Swallow", "Rack on the shoulders", "Rolling forward with a squat", "Wheel". Reliable values of the correlation coefficient were established between the tests of dynamic balance and the basic elements of sports acrobatics in young athletes 6-7 years, namely: "Swallow", "Flip forward with a squat", "Wheel" and "Bridge". The analysis of special tests of static and dynamic balance in mastering the basic elements of acrobatics at the first stage of long-term training makes it possible to use them to determine the level of coordination capabilities of young athletes and further improve the use of acrobatic exercises.

2. The reliable interrelation between indicators of technique of performance of basic exercises and indicators of static and dynamic balance at young acrobats at an initial stage of preparation is defined. It is shown that the level of static and dynamic balance is of great importance for the assimilation and improvement of basic elements of technology by young acrobats 6-7 years. Static and dynamic balance tests can be used to individually build training programs and young acrobats. It is shown that sports acrobatics is a significant means of developing the balance of children 6-7 years.

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Conflict of interest

The authors declare that there is no conflict of interest

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Competitive activity of weightlifters at the XXXII Olympic Games 2020 in Tokyo: results and prospects

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Abstract

Purpose: to study the indicators of the competitive activity of the strongest weightlifters in the world at the Games of the XXXII Olympiad 2020 and to identify trends for further increasing their sports results, taking into account weight categories and gender differences.

Material and methods. By studying scientific literature, Internet resources, competition protocols, pedagogical observations, video recordings of competitions, we analyzed the achievements of 140 weightlifters who took part in the Games of the XXXII Olympiad 2020 in Tokyo and the number of countries they represented. All indicators of competitive activity and age characteristics were grouped according to the following principle: among the top 10 weightlifters in each weight category, as well as separately among the prize-winners of competitions among men and women.

Results. The sports results of the top 10 weightlifters of each weight category among men and women who took part in competitions, age characteristics, the rate of achievements in a sports career, the level of approaches implementation and international competition were analyzed.

Conclusions. Based on the analysis of the number of countries and licenses received by the athletes of these countries, world and Olympic records, the effectiveness of the performances of the world's leading weightlifters at the Olympic Games is shown. The optimal age for achieving the highest results, the age of the beginning of the sport for the prize-winners of the competition, the rate of achieving maximum results in a sports career, sports results, the level of implementation of competitive approaches, the rate of increase in achievements in competitive exercises, the value of starting results, the level of international competition in each weight category in men and women, the characteristics of the dynamics of the results of the most titled athletes during their sports career, who took part in the Olympic Games, are given.

Key words: dynamics of results, realization of achievements, age and sex differences, weightlifters, indicators of competitive activity

Анотація

Олешко В.Г., Яанг Тангксун, Торохтій О.П., Пуцов С.О. Змагальна діяльність важкоатлетів на XXXII Олімпійських Іграх 2020 у Токіо: підсумки і перспективи

Мета. Вивчити показники змагальної діяльності найсильніших важкоатлетів світу на Іграх XXXII Олімпіади 2020 та визначити тенденції подальшого підвищення їхніх спортивних результатів із урахування вагових категорій й статевих відмінностей.

Матеріал та методи. Шляхом вивчення наукової літератури, Інтернет ресурсів, протоколів змагань, педагогічних спостережень, відеозаписів змагань нами аналізувались досягнення 140 важкоатлетів, які брали участь у Іграх XXXII Олімпіади 2020 в Токіо та кількість країн, котрі вони представляли. Усі показники змагальної діяльності та вікові характеристики групувалися за таким принципом: у 10 кращих важкоатлетів у кожній ваговій категорії, а також окремо у призерів змагань серед чоловіків та жінок.

Результати. Проаналізовано змагальні результати у 10 кращих важкоатлетів кожної вагової категорії у чоловіків та жінок, що брали участь у змаганнях, вікові характеристики, темпи досягнень за спортивну кар'єру, рівень реалізації спроб та міжнародної конкуренції.

Висновки. На засадах аналізу кількості країн та ліцензій, отриманих спортсменами цих країн, світових та олімпійських рекордів показана ефективність виступів провідних важкоатлетів світу на Олімпійських іграх.. Встановлено оптимальний вік досягнення найвищих результатів, вік початку занять видом спорту у призерів змагань, темпи досягнення максимальних результатів за спортивну кар'єру, спортивні результати, рівень реалізації змагальних спроб, темпи зростання досягнень у змагальних вправах, величини стартових результатів, рівень міжнародної конкуренції у кожній ваговій категорії у чоловіків та жінок, наведено характеристику динаміки результатів у найбільш титулованих спортсменів протягом спортивної кар'єри, які брали участь в Олімпійських іграх.

Ключові слова: динаміка результатів, реалізація досягнень, вікові та статеві відмінності, важкоатлети, показники змагальної діяльності

Аннотация

Олешко В.Г., Яанг Т., Торохтий А.П., Пуцов С.А. Соревновательная деятельность тяжелоатлетов на XXXII Олимпийских Играх 2020 в Токио: итоги и перспективы

Цель. Изучить показатели соревновательной деятельности сильнейших тяжелоатлетов мира на Играх XXXII Олимпиады 2020 и выявить тенденции дальнейшего повышения их спортивных результатов с учетом весовых категорий и половых отличий.

Материал и методы. Путем изучения научной литературы, Интернет ресурсов, протоколов соревнований, педагогических наблюдений, видеозаписей соревнований нами анализировались достижения 140 тяжелоатлетов, принявших участие в Играх XXXII Олимпиады 2020 в Токио и количество стран, которые они представляли. Все показатели соревновательной деятельности и возрастные характеристики группировались по следующему принципу: у 10 лучших тяжелоатлетов в каждой весовой категории, а также отдельно у призеров соревнований среди мужчин и женщин.

Результаты. Проанализированы спортивные результаты у 10 лучших тяжелоатлетов каждой весовой категории у мужчин и женщин, которые принимали участие в соревнованиях, возрастные характеристики, темпы достижений за спортивную карьеру, уровень реализации подходов и международной конкуренции.

Выводы. На основе анализа количества стран и лицензий, полученных спортсменами этих стран, мировых и олимпийских рекордов показана эффективность выступлений ведущих тяжелоатлетов мира на ОИ. Установлен оптимальный возраст достижения наивысших результатов, возраст начала занятий видом спорта у призеров соревнований, темпы достижения максимальных результатов за спортивною карьеру, спортивные результаты, уровень реализации соревновательных подходов, темпы повышение достижений в соревновательных упражнениях, величины стартовых результатов, уровень международной конкуренции в каждой весовой категории у мужчин и женщин, дана характеристика динамики результатов у наиболее титулованных спортсменов на протяжении спортивной карьеры, принявших участие в ОИ.

Ключевые слова: динамика результатов, реализация достижений, возрастные и половые отличия, тяжелоатлеты, показатели соревновательной деятельности

Introduction

Weightlifting, as an Olympic sport, has always attracted the attention of specialists and scientists all over the world with the high sporting achievements of weightlifters of men and women. This also applied to the indicators of competitive activity among athletes of different sexes and groups of weight categories, especially at the largest world forum of the four years - the Olympic Games [1, 2, 3, 4]. Such competitive activity of the world's strongest weightlifters has always been accompanied by a large number of world and Olympic records set at these competitions [5, 6, 7, 8]. In addition, over the past 20 years, weightlifters of China, who are constantly among the leaders and win the largest number of Olympic medals, amaze with their successes at the Olympic Games [9, 10, 11, 12].

Many specialists from various sports have been involved in the study of the competitive activity of highly qualified athletes at the main competitions for four years [13, 14, 15, 16]. However, the influence of external factors (the COVID-2019 epidemic and the intensive work of the IOC to identify unscrupulous athletes who used pharmacological drugs prohibited by WADA made adjustments to the results of the competitive struggle at the Olympic Games. Many countries and athletes were unable to obtain licenses for these Games and were missing Therefore, the weightlifting competition at the Games of the XXXII Olympiad 2020 in Tokyo (Japan) contained many unforeseen situations and brought interesting, and in many ways, unexpected results. weight and height differences, which will help many coaches and specialists to find hidden reserves for increasing athletes' athletic achievements in future competitions.

Weightlifting competitions at the Games of the XXXII Olympiad 2020 in Tokyo were held in a difficult period for the world sports community due to some external influences that influenced their results and the training of many athletes. Here are some of them [17, 18, 19, 20]:

1. They passed a year later than they should have been in 2020 due to the COVID-2019 epidemic in the world.

2. The selection system for weightlifters for the Games of the XXXII Olympiad 2020 in Tokyo was violated due to the postponement of many international competitions, therefore the number of licenses issued for athletes and individual countries was constantly adjusted until the start of the Games.

3. Athletes who were previously disqualified due to positive doping tests were not admitted to the Games of the Olympics.

3. The number of official delegations from countries was greatly reduced, so not all athletes' coaches were able to help them during these competitions.

Purpose: to study the indicators of the competitive activity of the strongest weightlifters in the world at the Games of the XXXII Olympiad 2020 and to identify the prospects for further increasing their sports achievements.

Material and methods

Methods

Analysis of scientific literature, Internet resources, competition protocols, pedagogical observations, video recordings of competitions, analysis and synthesis of age indicators, sports results; methods of mathematical statistics.

We have analyzed the following indicators of weightlifters' competitive activity [3, 5, 10, 11].

1. The number of countries that took part in the Games of the Olympics and the number of licenses received by athletes from these countries.

2. The number of medals won by individual countries and athletes.

3. Sports results shown at the Olympic Games and their dynamics.

4. The number of world and Olympic records set by weightlifters at the Olympic Games.

5. Age of achievement of the highest results and the beginning of the sport among the prize-winners of the competitions among men and women.

6. The rate of increase in achievements in individual exercises, starting results and the level of implementation of competitive approaches among the winners of the Olympic Games of different sex and groups of weight categories.

7. The level of international competition among athletes in weight categories, depending on gender differences.

8. Characteristics of the dynamics of results among the most titled athletes who took part in the Olympic Games.

To participate in the 2021 Olympics. The Tokyo IOC provided the IWF with a quota of 196 weightlifters (98 men and 98 women) to compete in 7 weight classes for men and women. The maximum number of athletes in a discipline is 14, provided that the NOCs will single out only one athlete in each weight category.

Athletes who applied for participation in the Olympic Games had to take part in at least 6 international starts according to the IWF calendar.

The IWF qualifiers were divided into three levels: gold, silver and bronze. For participation in qualifying competitions at each level, athletes received certain points, which then allowed them to enter the 14 best athletes of their "own" weight category: for men they were up to 61, 67, 73, 81, 96, 109, +109 kg; in women up to 49, 55, 59, 64, 76, 87, +87 kg [9]:

We analyzed the indicators of competitive activity and age characteristics of the 10 best weightlifters of each weight category, the total number of athletes was 140 people.

Statistical analysis

Since the sample sizes of the winners of the XXXII Olympic Games in Tokyo among men and women in each weight category I, II and III were very small (n = 9 and n = 6), the study used nonparametric statistics. The following statistical indicators were determined: arithmetic mean, standard deviation S, median, lower and upper quartiles of Me (25%; 75%). The statistical significance of the difference p between the results of men and women in weight categories I and II, II and III, as well as between men and women in each weight category I, II and III was determined using the Mann-Whitney U-test, as the most powerful among the nonparametric for two independent samples. The applied statistical program Statistica 10.0 (StatSoft, USA) was used.

Results

The results of competitive activity at the Games of the XXXII Olympiad 2020 among men and women are presented below. First, we analyzed the number of licenses obtained by the leading weightlifting countries in preparation for the Games of the XXXII Olympiad in 2020, since they reflect the level of preparatory work of the coaches of the national teams of these countries, as well as the effectiveness of this work (Table 1).

Table 1

Number of licenses obtained by leading countries in weightlifting and their implementation

Country	Men	Women	Total licenses	Number of medals won	The level of their implementation,%
China	4	4	8	8	100
USA	4	4	8	2	25
The Republic of Korea	3	4	7	-	0
Taiwan	3	4	7	2	28
United Kingdom	-	4	4	1	25
Canada	-	4	4	1	25
Ecuador	-	4	4	2	50
Georgia	4	-	4	2	50
Japan	4	3	7	1	14
Italy	3	-	3	2	67
Indonesia	3	-	3	2	67
Spain	3	-	3	-	0
Tunisia	3	-	3	-	0
Turkmenistan	3	-	3	1	33
France	-	3	3	-	0
Dominican Republic	-	3	3	2	67
Cuba	-	3	3	-	0
Australia	-	3	3	-	0

Data analysis table 1 shows that in terms of the number of licenses received and the level of their implementation at the Games of the XXXII Olympiad 2020 in Tokyo, the national teams of the following countries performed most successfully among men: China (100% of medals from the number of licenses), Italy, Indonesia, the Dominican Republic (67.0 %), Ecuador and Georgia (50.0% each). The most unsuccessful athletes at the 2020 Olympics were athletes from such countries: the Republic of Korea, Spain, France, Cuba, although the athletes of these countries have always been winners of world weightlifting forums.

Further, the number of medals won by male and female weightlifters at the Games of the XXXII Olympiad 2020 is analyzed (Tables 2 and 3).

Table 2

Prize-winners of the XXXII Olympic Games 2020 in Tokyo among men

Country	Medals			Total:
	Gold	Silver	Bronze	
China	4	-	-	4
Georgia	1	-	1	2
Qatar	1	-	-	1
Uzbekistan	1	-	-	1
Venezuela	-	2	-	2
Indonesia	-	1	1	2
Colombia	-	1	-	1
Dominica	-	1	-	1
Armenia	-	1	-	1
Iran	-	1	-	1
Italy	-	-	2	2
Kazakhstan	-	-	1	1
Latvia	-	-	1	1
Syria	-	-	1	1

Weight category up to 61 kg

Men. The Olympic champion was 28-year-old athlete Li Fabin (China) with a combined combined result of 313.0 kg. Eleven kg in total was lost to him by a 32-year-old athlete from Indonesia - Eko Yuli Iravan - 302.0 kg. He was a medalist at four Olympic Games: at the age of 19, he won a bronze medal at the Olympic Games in Beijing (2008), then again a bronze medal at the Olympic Games in London (2012), then silver in Rio de Janeiro (2016) and now in Tokyo - silver medal. Igor Son from Kazakhstan won a bronze medal in this weight category - 294.0 kg, respectively.

Weight category up to 67 kg

The 28-year-old athlete Chen Lijun (China) became the champion of the Olympic Games with the result in the combined combined event - 332.0 kg. Only 1 kg was lost to him by an athlete from Colombia - Luis Mosquera Lozano - 331.0 kg, he was already the bronze medalist of the Games of the XXXI Olympiad in Rio de Janeiro (2016) with the result in the combined event - 338 kg. The bronze medal was won by Mirko Zanni from Italy - 322.0 kg, respectively.

Weight category up to 73 kg

The 27-year-old athlete Shi Jiyun (China) became the champion of the Olympic Games with the maximum result in the combined event in his sports career - 364.0 kg and a new world record. For 18 kg less was lifted by the silver medalist of the Games from Venezuela - Julio Ruben Mayora Pernia - 346.0 kg and the bronze medal was received by Rahmat Erwin Abdulla from Indonesia - 342.0 kg, who lost 22 kg to the champion in the combined event.

Weight category up to 81 kg. One of the oldest athletes of the Games, 37 years old Liu Xiaojong (China), became the champion of the Olympic Games with the result in the combined event - 374.0 kg. He is a participant in two more Olympic Games: in London (2012) he had a gold medal (379 kg), in Rio de Janeiro (2016) a silver medal (379 kg), and he had his first international start back in 2009. The silver medal was won by an athlete from the Dominican Republic - Zacarias Bonnat Michel - 367.0 kg, a bronze medal from Antonio Pizzolato from Italy - 365.0 kg, respectively.

Weight category up to 96 kg

The 23-year-old athlete Fares Ibrahim Elbach (Qatar) became the champion of the Olympic Games with the result in the combined event - 402.0 kg. By 15 kg less than the champion showed a 21-year-old athlete from Venezuela - Keidomar Vallenilla Sanchez - 387.0 kg. And a bronze medal with the same result was won by Anton Plesnov from Georgia - 387.0 kg.

Weight category up to 109 kg

The Olympic champion was 21-year-old athlete Akbar Dzhuraev (Uzbekistan) with the result in the combined combined event - 430.0 kg. The second silver medal in his sports career was won by an athlete from Armenia - Simon Martirosyan - 423.0 kg, he received the first at the Olympic Games in Rio de Janeiro (2016). He is also the 2014 Youth

Olympic Games champion. Bronze medal for Arturs Plesnieks from Latvia - 410.0 kg, he is also a participant in two more Olympics: in London - he took 5th place, in Rio de Janeiro - 8th place, respectively.

Weight category over 109 kg

The Olympic champion became a 27-year-old athlete, 197 cm tall Lasha Talakhadze (Georgia) with the result in the combined event - 488.0 kg, simultaneously setting three world and Olympic records in the snatch - 223.0 kg, clean and jerk - 265.0 kg and the sum of the double event. A 22-year-old athlete from Iran, Ali Davudi, showed 47 kg less, he had a silver medal - 441.0 kg and a bronze medal from a 27-year-old athlete Man Asaad from Syria - 424.0 kg, respectively.

Table 3

Winners of the XXXII Olympic Games 2020 in Tokyo among women

Country	Medals			Total:
	Gold	Silver	Bronze	
China	3	1	-	4
Ecuador	1	1	-	2
Taiwan	1	-	1	2
Philippines	1	-	-	1
Canada	1	-	-	1
USA	-	1	1	2
India	-	1	-	1
Turkmenistan	-	1	-	1
Italy	-	1	-	1
United Kingdom	-	1	-	1
Indonesia	-	-	1	1
Kazakhstan	-	-	1	1
Japan	-	-	1	1
Mexico	-	-	1	1
Dominican Republic	-	-	1	1

Weight category up to 49 kg. Hu Jihai (China) became the champion of the Olympic Games with the result in the combined event - 210.0 kg, at the same time setting three OPs in the snatch - 94.0 kg, clean and jerk - 116 kg and the combined event. The silver medal was won by an athlete from India - Chanu Saykom Mirabai - 202.0 kg and a bronze medal from Windy Kantika Aisah from Indonesia - 194.0 kg, respectively.

Weight category up to 55 kg

The 30-year-old athlete Hidilin Diaz (Philippines) became the champion of the Olympic Games with the result in the combined event - 224.0 kg, simultaneously setting two OP in the clean and jerk - 127.0 kg and in the combined event. The athlete was a participant in three more Olympic Games: in Beijing (2008) she took 10th place, in London (2012) she received a zero mark, in Rio de Janeiro (2016) - she won a silver medal. The silver medal in Tokyo was won by the Chinese woman Liao Cuyun - 213.0 kg, and the bronze medal from Zulfiya Chinshanlo from Kazakhstan - 213.0 kg. In this weight category, an athlete from Ukraine Kamila Konotop competed, who took the honorable fifth place with a result in the combined combined event - 206.0 kg.

Weight category up to 59 kg

27-year-old Go Xing-Chun (Taiwan) became the champion of the Olympic Games with the result in the combined event - 236.0 kg, simultaneously setting three Olympic records in the snatch - 103.0 kg, clean and jerk - 133.0 kg and the total of biathlon. This athlete already had a bronze medal at the Olympic Games in Rio de Janeiro (2016). An athlete from Turkmenistan, Polina Guryeva, lost nineteen kg in total in the combined event - 217.0 kg, and the bronze medal from Mikiko Ando from Japan - 214.0 kg, respectively.

Weight category up to 64 kg

The Olympic champion was 28-year-old athlete Made Sharron (Canada) with a combined combined result of 236.0 kg. The silver medal was won by a 34-year-old athlete from Italy - Georgia Bordignon - 232.0 kg, for her it was already the second Olympics: in Rio de Janeiro (2016) she took 6th place. Chen Wen-Hu from Taiwan lost only 2 kg to the second place - 230.0 kg, respectively.

Weight category up to 76 kg

The Olympic champion was Nacy Dahomes Barrera (Ecuador) with a combined combined result of 263.0 kg. This was her second Olympics: at the Games in Rio de Janeiro, she took 7th place. The silver medal was won by the athlete from the United States - Catherine-Elizabeth Nye - 249.0 kg, and the bronze medal from Aremi Fuentes Zavala from Mexico - 245.0 kg, respectively.

Weight category up to 87 kg. 27-year-old athlete Wang Joyu from China became the champion of the Olympic Games with the result in the combined event - 270.0 kg. The silver medal was won by a 24-year-old athlete from Ecuador - Tamara Salazar

Arche - 263.0 kg, and the bronze medal from Crismeri Santana Peguero from the Dominican Republic - 256.0 kg, respectively.

Weight category over 87 kg

The Olympic champion was a 21-year-old athlete from China Li Wenwen with the result in the combined event - 320.0 kg, simultaneously setting three Olympic records in the snatch - 140.0 kg, clean and jerk - 180.0 kg and in the combined event. Silver medalist from Great Britain - Emily Campbell - 283.0 kg lost 37 kg in total. One kg less and the third place was taken by Sara Robles from the USA - 282.0 kg.

Below are the indicators of the competitive activity of the winners of the Games of the XXXII Olympiad in Tokyo among men and women (Tables 4 and 5).

Table 4

Indicators of the competitive activity of the winners of the XXXII Olympic Games in Tokyo among men

Weight category, kg	Position	Age, years	Start of sports, years	The rate of achievement of the maximum result, years
up to 61 kg	1	28	10	16
	2	32	12	11
	3	22	10	13
$\bar{x}$		27	11	13
up to 67 kg	1	28	10	16
	2	26	7	19
	3	23	14	10
$\bar{x}$		26	10	15
up to 73 kg	1	27	12	14
	2	25	10	15
	3	31	11	20
$\bar{x}$		28	11	16
up to 81 kg	1	37	14	14
	2	25	16	9
	3	24	16	9
$\bar{x}$		29	15	11
up to 96 kg	1	23	9	12
	2	21	11	11
	3	25	11	12
$\bar{x}$		23	10	12
up to 109 kg	1	21	*10*	12
	2	24	12	9
	3	29	9	20
$\bar{x}$		25	10	14
over 109 kg	1	27	11	17
	2	22	11	11
	3	27	10	17
$\bar{x}$		25	11	15

Table 5

Indicators of the competitive activity of the winners of the XXXII Olympic Games in Tokyo among women

Weight category, kg	Position	Age, years	Start of sports, years	The rate of achievement of the maximum result, years
up to 49 kg	1	24	12	12
	2	26	14	12

	3	19	9	10
$\bar{x}$		23	12	11
up to 55 kg	1	30	11	19
	2	26	11	13
	3	28	9	12
$\bar{x}$		28	10	15
up to 59 kg	1	27	10	18
	2	21	12	10
	3	28	16	11
$\bar{x}$		25	13	13
up to 64 kg	1	28	19	8
	2	34	15	19
	3	24	8	16
$\bar{x}$		29	14	14
up to 76 kg	1	23	11	12
	2	22	16	6
	3	28	14	11
$\bar{x}$		24	14	10
up to 87 kg	1	27	11	14
	2	24	16	8
	3	29	14	9
$\bar{x}$		27	14	10
over 87 kg	1	21	12	8
	2	27	20	7
	3	33	20	10
$\bar{x}$		27	17	8

Analysis of the rate of increase in achievements in individual exercises among the winners of the Olympic Games of different sexes and groups of weight categories allows coaches to determine which of the exercises lags behind in the preparation of an athlete or has an advantage. We calculated the ratio of competitive results (snatch to clean and jerk taken as 100%) among the winners of the 2020 Olympics in three groups of weight categories: for men, group 1 - weight categories up to 61, 67 and 73 kg; 2nd group - up to 81 and 96 kg; 3rd group - up to 109 and over 109 kg; for women - 1st group - up to 49, 55 and 59 kg; 2nd group - 64 and 76 kg; 3rd group - 87 and over 87 kg (Table 6).

Table 6

The ratio of competitive results among prize-winners Olympic Games 2020 in Tokyo (1-3 position), %

Weight category group	Results in snatch, clean and jerk,%							
	Men, n = 21				Women, n = 21			
	n	$\bar{x}$	S	Me (25%; 75%)	n	$\bar{x}$	S	Me (25%; 75%)
First, n = 18	9	81.5	2.1	81.9 (80.3; 83.0)	9	77.2	2.2	76.9 (76.4; 78.3)
Second, n = 12	6	82.1	2.3	82.9 (80.6; 84.0)	6	80.5	1.0	80.8 (80.2; 81.2)
Third, n = 12	6	82.7	2.6	83.5 (81.6; 84.1)	6	79.2	3.4	78.9 (76.3; 82.2)
$\bar{x}$	21	82.0	2.2	82.5 (80.3; 83.9)	21	78.7	2.7	78.8 (76.4; 81.0)
Statistical significance of the difference between men and women							U	74.5
							p	0.001

Data analysis table 6 indicates that the ratio of achievements in snatch to clean and jerk among men of different groups of weight categories is 82.0 ± 2.2% in the middle. Whereas in women this ratio decreases by 3.3% towards the push and is 78.7 ± 2.7% ($p < 0.001$). Thus, in men, the increase in the results in competitive exercises is carried out mainly due to the increase in achievements in the snatch and

clean and jerk, and in women, on the contrary, to a greater extent due to the results in the clean and jerk. Earlier V.G. Oleshko [10] developed model ratios of achievements in competitive exercises for highly qualified weightlifters, which amounted to 82 84%, and for women 78-81%, which corresponds to the achievements of the winners of the Games of the XXXII Olympiad.

We analyzed the starting results of the winners of the Games of the XXXII Olympiad in Tokyo, which were calculated as the difference between the athlete's initial approach and his maximum achievement in the exercise at these competitions (Table 7).

Table 7

Starting result of weightlifters-prize-winners Games of the XXXII Olympiad 2020 in Tokyo, %

The exercise	Gender	Group	Starting result of athletes in groups of weight categories,%									
			Statistical indicator				Significance of the difference between:					
							I и II		II и III		men and women	
			n	$\bar{x}$	S	Me (25%; 75%)	U	p	U	p	U	p
Snatch	Men	I	9	95.3	2.5	96.1 (94.0; 97.2)	11.0	0.066				
		II	6	97.4	0.5	97.4 (97.0; 97.7)			5.0	0.041		
		III	6	95.3	1.7	95.6 (94.3; 95.8)						
	Women	I	9	95.6	1.7	95.7 (94.7; 97.1)	14.0	0.145			35.50	0.666
		II	6	96.2	1.8	96.1 (95.1; 97.8)			18.0	1.000		0.002
		III	6	95.1	1.6	95.7 (94.6; 95.8)					14.5	0.589
lean and jerk	Men	I	9	95.5	1.4	95.8 (94.8; 96.7)	20.0	0.456				
		II	6	94.3	0.6	94.2 (94.1; 94.4)			13.5	0.485		
		III	6	94.7	1.6	94.7 (93.4; 95.8)						
	Women	I	9	94.3	2.7	93.9 (93.6; 95.8)	15.5	0.181			30.0	0.387
		II	6	95.8	1.7	95.7 (94.6; 97.4)			11.0	0.310	13.0	0.485
		III	6	94.3	2.7	94.5 (93.2; 96.3)					15.0	0.699

Data analysis table. 7 shows that in men of three groups of weight categories, the value of starting results is less than the achieved achievement in the snatch - by 4.7–7.6%, and in the clean and jerk, respectively - by 3.4–4.9%. For women, the difference between the results in the snatch is slightly less than for men - 4.5–5.7%, but this difference is slightly larger in the clean and jerk - 4.2–5.8%.

The values of the starting results in men significantly differ in the snatch between the athletes of the II and III groups of weight categories - 2.1% ($p < 0.05$), respectively. In clean and jerk, both between male athletes, as well as between athletes of groups II and III, statistically significant differences were not noted ($p > 0.05$). There are also differences between men and women: but only among the athletes of the II group in the snatch - 1.2% ($p < 0.05$).

One of the important components of the stability of technical and tactical actions of weightlifters in the structure of competitive activity is the level of implementation of the planned results at the main starts of the annual macrocycle. Below are the indicators of the level of implementation of competitive results among the winners of the Games of the XXXII Olympiad 2020 in Tokyo in each weight category (Table 8).

Table 8

Realization of competitive results among weightlifters-prize-winners of the Games of the XXXII Olympiad 2020 in Tokyo, **%**

Weight category, kg	Implementation of approaches	
	snatch	clean and jerk
men		
up to 61	55.0	55.0
up to 67	44.0	55.0
up to 73	77.7	66.0
up to 81	55.0	66.3
up to 96	77.3	55.0
up to 109	66.0	66.3
over 109	88.7	77.3
$\bar{x}$	66.2	62.9
women		
up to 49	66.3	88.7
up to 55	66.3	77.7
up to 59	66.0	77.3
up to 64	88.7	66.3
up to 76	77.3	77.3
up to 87	77.3	66.3
over 87	77.3	77.3
$\bar{x}$	74.2	75.8

Further, the indicators of the level of international competition among weightlifters who took part in the Games of the XXXII Olympiad 2020 in Tokyo are analyzed (Table 9).

Table 9

Indicators of international competition among weightlifters at Games of the XXXII Olympiad 2020 in Tokyo

Weight category, kg	Performance in the top 10 athletes in the weight category			
	density of results		places in the combined event with a difference of 1 kg	their number, %
	absolute, kg	relative, %		
men				
up to 61	48,0	15,3	6,7;	20
up to 67	34,0	10,3	1,2; 3,4,5; 8,9	70
up to 73	41,0	11,3	3,4; 4,5	40
up to 81	57,0	15,3	5,6;	20
up to 96	52,0	11,5	2,3,4; 7,8,9	60
up to 109	59,0	13,7	4,5; 7,8	40
over 109	107,0	22,0	4,5; 7,8	40
women				
up to 49	43,0	20,5	4,5; 6,7,8	50
up to 55	38,0	17,0	1,2; 3,4; 5,6; 8,9	80
up to 59	38,0	16,1	3,4; 6,7; 8,9,10	70
up to 64	19,0	8,1	4,5,6; 7,8,9	60
up to 76	60,0	22,8	4,5; 8,9	40
up to 87	45,0	16,7	5,6	20
over 87	100,0	31,3	2,3; 6,7	40

Analysis of the tributes table. 9 shows that male weightlifters had the highest density of competitive results at the Olympics in the weight categories up to 67, 73 and 96 kg, with a difference

between the results from 1st to 10th place - 10.3; 11.3 and 11.5%, and in the first category there were 70% of the results in the combined event with a difference of 1 kg. Among female weightlifters, the highest density of competitive results is observed in weight categories up to 64, 59 and 55 kg, respectively, with a difference in results from 1 to 10 places - 8.1; 16.1 and 17.0%. In the weight category up to 55 kg, 80.0% of the results were found, with a difference of 1 kg between them.

Discussion

Data analysis table 4 shows that the average age of the winners of the XXXII Olympic Games in Tokyo among men ranges from 23 to 29 years. Moreover, in this group of weightlifters, the youngest medalists of the Games were Akbar Juraev from Uzbekistan and an athlete from Venezuela - Keidomar Valenilla Sanchez - 21 years old, and the 37-year-old athlete Liu Xiaojong from China became the oldest medalist of the Games.

As for the age of starting to practice the sport, the fluctuations here are from 10 to 15 years. Moreover, most of the athletes who began to practice at the age of 15-16 came to the sport substantially prepared, i.e. from other sports. So, for example, the silver medalist of the Tokyo Games -

Zacarias Bonnat Michel from the Dominican Republic played baseball, taekwondo and wrestling before weightlifting. The data obtained are consistent with the research results obtained by the authors earlier [5, 10, 17, 21].

The pace of achieving maximum results in the shortest possible time characterizes the prospects of this or that weightlifter. For winners of the Tokyo Games, they range from 11 to 16 years. The most promising weightlifters among the winners of the Olympic Games in Tokyo are representatives of the weight categories up to 81 and 109 kg: this is an athlete from the Dominican Republic - Zacarias Bonnat Michel and Antonio Pizzolato from Italy, as well as an athlete from Iran Ali Davudi, respectively. They spent 9 years on achieving their maximum results, respectively. According to the data of other authors [5, 10, 17, 22], the terms of achieving maximum results for a sports career among the most talented weightlifters range on average from 8 to 12 years. In other cases, some athletes exceed these deadlines significantly. So, for example, Rahmat Abdulla from Indonesia and Arturs Plesnieks from

Latvia spent 20 years to achieve their maximum results, respectively.

Data analysis table. 5 shows that the average age of the winners of the XXXII Olympic Games in Tokyo among women ranges from 23 to 29 years. Moreover, the youngest medalist of the Games was Windy Eisah from Indonesia - 19 years old, and the oldest athlete Georgia Bordignon from Italy - 34 years old. As for the age of starting weightlifting, in women, on average, it becomes from 10 to 14 years. At the age of 8, she began weightlifting Chen Wen-Hu from Taiwan, and among those who later began to practice the sport, one can note the champion of the Games in the category up to 64 kg Made Sharron from Canada, she began classes at the age of 19, although before that for three years she was engaged in a circus, and then cross-fit. Catherine-Elisabeth Nye from the USA also became involved in weightlifting at the age of 16, after doing gymnastics and cross-fit.

The rate of achievement of maximum results in women ranges from 8 to 15 years, they are somewhat lower than in men. The most promising weightlifters among the winners of the Tokyo Olympics are representatives of weight categories up to 76 and over 87 kg: these are athletes from the United States - Catherine-Elizabeth Nye (6 years to achieve maximum result) and Emily Campbell from Great Britain (7 years, respectively). Whereas the champion of the Games in the category up to 55 kg Hidilin Diaz from the Philippines spent 19 years on this path, and the champion of the Games Gu Xing-Chun from Taiwan, respectively, 18 years. These data are consistent with the results obtained by other authors earlier [5, 10, 17].

Data analysis table. 7 shows that the values of starting results for athletes of different groups of weight categories have a greater number of differences than between athletes of different sex. Moreover, athletes, both men and women, order a lower starting weight for the first approach in the clean and jerk of the bar than in the snatch. These data are consistent with the results of studies carried out by other authors [5, 12, 22].

Data analysis table. 8 shows that men performed more consistently in the snatch than in the clean and jerk (66.2 versus 62.9%), while women, on the contrary, performed better in the clean and jerk than in the snatch (75.8 versus 74.2%). The highest level of realization of competitive approaches is observed among men in the snatch in the weight categories up to 73, 96 and over 109 kg, and at the point - up to 81, 109 and over 109 kg, i.e. predominantly in medium and heavy weight categories. Among women, the most stable performance in the snatch was shown by the athletes in the weight categories up to 64, 76, 87 and over 87 kg (i.e. in the medium and heavy categories), and in the clean and jerk - up to 49, 55, 59, 76 and over 87 kg (in light, medium and heavy categories). It should also be noted that women's level of implementation in the snatch and clean and jerk is on average much higher than that of men. This is due to the significantly higher weight that men lift at competitions by 1 kg of body weight. Our data confirm the trend obtained by other researchers [4, 7, 18, 22].

Data analysis table. 9 shows that the highest level of international competition at the Games of the XXXII Olympiad 2020 in Tokyo was among men and women in the light and middle weight categories. The most interesting thing is that the lowest level of international competition at these Games was for men and women in the heavy weight categories - over 109 and 87 kg, respectively, they had the greatest difference in results between 1 and 10 places - 107 and 100 kg, respectively. Practical experience shows that the level of international competition varies significantly, depending on the rank of the competition. At the Games of the Olympics, it is significantly higher than at other international competitions [2, 4, 8, 12].

During the Games, 55 Olympic records were set by weightlifters: 30 Olympic records were set by men, including 4 world records (3 world records were set by Lasha Talakhadze from Georgia – in snatch, clean and jerk and total combined), women set 25 Olympic records, but not one world.

The study of the indicators of the competitive activity of the world's strongest weightlifters at the Games of the XXXII Olympiad 2020 made it possible to reveal the hidden reserves of elite athletes and showed the prospects for further increasing their sports achievements.

Conclusions

1. The number of licenses received and the level of their implementation shows the level of preparedness of weightlifters from the leading national teams of the world for the Games of the XXXII Olympiad 2020 in Tokyo. The most successful teams were from China (out of 8 licenses, 100% sold), Italy, Indonesia, and the Dominican Republic (out of 3 licenses, 2 were sold at 67.0%, respectively). The most unsuccessful athletes at these Olympic Games were: the Republic of Korea (7 licenses, 0 implementation), Spain, France, Cuba (3 licenses each, 0 implementation).

2. Among the countries of medalists in men, weightlifters from China were the most successful -

4 gold medals, Georgia, Venezuela, Indonesia, Italy - 2 medals, respectively. Among women, the most successful teams were from China - 4 medals (3 gold and 1 silver), Ecuador, Taiwan, USA (2 medals each).

3. The average age of the winners of the XXXII Olympic Games in Tokyo among men ranges from 25 to 29 years. The youngest winners of the Games were Akbar Juraev from Uzbekistan and Keidomar Valenilla Sanchez from Venezuela at the age of 21, and the 37-year-old athlete from China Liu Xiaojong became the oldest medalist of the Games. The average age of Olympic winners in Tokyo among women ranges from 23 to 29 years. Among the winners of the Games, the youngest was Windy Eisah from Indonesia - 19 years old, and the oldest athlete Georgia Bordignon from Italy - 34 years old. If we compare the average age of all winners of the Games among men and women, then it is the same and amounts to 26.1 years.

4. The age at which men begin weightlifting ranges on average from 10 to 15 years. Moreover, most of the weightlifters who began to engage in the sport at the age of 15-16 came substantially prepared, thanks to classes in other sports. For example, the silver medalist of the Tokyo Games - Zacarias Bonnat Michel from the Dominican Republic before weightlifting was involved in baseball, taekwondo and wrestling. The age at which women start weightlifting is on average 10 to 14 years. Earlier than everyone else, Chen Wen-Hu from Taiwan began weightlifting (at the age of 8), and later of all - the champion of the Games in the category up to 64 kg Made Sharron from Canada (at the age of 19), although before that she was engaged in a circus for three years, and then cross-fit.

5. The rate of achievement of maximum results indicates the prospects of this or that weightlifter. For the winners of the Tokyo Games among men, they range from 11 to 16 years old. The highest rates of achieving maximum results were among weightlifters in weight categories up to 81 and 109 kg: these are athletes from the Dominican Republic - Zacarias Bonnat Michel and Antonio Pizzolato from Italy, as well as an athlete from Iran Ali Davudi for 9 years, respectively. Whereas, Rahmat Abdulla from Indonesia in the weight category up to 73 kg and Arturs Plesnieks from Latvia in the weight category up to 109 kg spent 20 years to achieve their maximum results, respectively.

6. Increase of achievements in snatch and clean and jerk among highly qualified weightlifters should take place proportionally on the basis of the following model ratios: for men - 82 84%, and for women - 78 81% (VG Oleshko [4]). The ratio of achievements in the snatch to clean and jerk among men of different groups of weight categories among the Olympic winners in Tokyo in the middle is 82.0 ± 2.2%, for women it is less by 3.3% and is 78.7 ± 2.7% ($p < 0.001$). Thus, in men, the increase in results in competitive exercises occurs proportionally both in the snatch and in the clean and jerk, and in women, on the contrary, to a greater extent due to the increase in the results in the clean and jerk.

7. The values of the starting results for the Olympic winners in Tokyo among men and women have some differences. In men, they are in three groups of weight categories less by 4.7–7.6%, from the achieved achievement in the snatch, and by 3.4–4.9%, respectively, from the realized achievement in the clean and jerk. For women, the starting results are slightly lower in the snatch than for men - 4.5–5.7%, but more in the clean and jerk - 4.2–5.8%. In men, they significantly differ in the snatch between athletes of the II and III groups - 2.1% ($p < 0.05$), in the clean and jerk both between men and women of the I, II and III groups, statistically significant differences were not noted ($p > 0,05$). Differences in starting results were established between men and women: among athletes of the II group in the snatch - 1.2% ($p < 0.05$). Thus, it can be noted that male athletes are more careful in determining the starting results in the snatch than in the clean and jerk, while women reduce the starting results in the snatch and clean and jerk by the same amount.

8. Olympic winners in Tokyo in men showed more accomplished approaches in the snatch than in the clean and jerk (66.2 versus 62.9%), and women, on the contrary, achieved more accomplishments in the clean and jerk than in the snatch (75.8 versus 74, 2%). The highest level of realization among men in the snatch was obtained in the weight categories up to 73, 96 and over 109 kg, and at the point - up to 81, 109 and over 109 kg, i.e. in medium and heavy weight categories, respectively. Among women, the most stable performance in the snatch was shown by athletes in the weight categories up to 64, 76, 87 and over 87 kg (i.e. in the middle and heavy categories), and in the clean and jerk - up to 49, 55, 59, 76 and over 87 kg (in light, medium and heavy categories). In women, the level of realization in the snatch and clean and jerk is, on average, significantly higher than that of men, this is due to the significantly higher weight that men lift at competitions by 1 kg of body weight.

9. For male weightlifters, the highest density of competitive results at the Olympic Games in Tokyo was in the weight categories up to 67, 73 and 96 kg, with the smallest difference between the results from 1st to 10th places - 10.3; 11.3 and 11.5%, respectively. Moreover, in the first weight category, 70% of the results were with a difference of 1 kg.

Among women, the highest density of competitive results was observed in weight categories up to 64, 59 and 55 kg with a minimum difference in results from 1st to 10th places - 8.1; 16.1 and 17.0%, respectively. In the weight category up to 55 kg, 80.0% of the results were found with a difference of 1 kg. Thus, the highest level of international competition at the Games of the XXXII Olympiad 2020 in Tokyo was among men and women in the light and middle weight categories. And the lowest level of international competition at these Games was for men and women in the heavyweight weight categories - over 109 and 87 kg, respectively, where there was the greatest difference in results between 1 and 10 places - 107 and 100 kg, respectively.

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Conflict of interests

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ORIGINAL ARTICLES. PHYSICAL EDUCATION

Structural validity of the physical fitness test battery

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Abstract

Purpose: of the study was to examine the validity of the Army Combat Fitness Test tests on a sample of air defense personnel in the Ukrainian Ground Forces.
Material and methods. The respondents to this study were 271 air defense servicemen of the ground forces aged 18 to 40 years (73 cadets of the Ivan Kozhedub Kharkiv National Air Force University and 198 military personnel). The structural validity was evaluated using a confirmatory factor analysis.
Results. Compliance was achieved with the two-factor model obtained in the course of exploratory factor analysis, as evidenced by the following indixes: $\chi 2$ (8, Critical N = 465.29) = 10.43; $\chi 2$ / df = 1.303; Non-Normed Fit Index = 0.98; Normed Fit Index = 0.97; Root Mean Square Error of Approximation = 0.035 (90 Percent Confidence Interval for Root Mean Square Error of Approximation = (0.0; 0.088), Comparative Fit Index = 0.99. In addition, all factor loadings were statistically significant at the $p < 0.01$ level, that indicates that these two factors were well designed at every stage. Correlation between factors was weak, which confirms the discriminant validity of the test. The significant correlation found between the items and the overall test score confirmed the validity of the test.
Conclusions. It was found that Army Combat Fitness Test is a suitable tool for evaluating the physical fitness condition of air defense personnel into the Ground Forces. The dilemmas about the possible use of Army Combat Fitness Test for all age groups of military personnel regardless of gender require further study.
Key words: validity, physical fitness, confirmatory factor analysis, military personnel

Анотація

Палевич С., Кирпенко В., Піддубний А., Божко С., Цимбалюк Ж., Майкл Ентоні Мартінес Велес, Федеріко Анібал Мартінес Велес, Хорхе Армандо Морета Вінуеса, Федеріко Антоніо Мартінес Леон. Структурна валідність батареї тестів для перевірки фізичної підготовленості

Мета: перевірити обґрунтованість тестів на бойову працездатність армії на вибірці особового складу протиповітряної оборони Сухопутних військ України.

Матеріал і методи. Респондентом у цьому дослідженні був 271 військовослужбовець протиповітряної оборони сухопутних військ віком від 18 до 40 років (73 курсанти Харківського національного університету повітряних сил імені Івана Кожедуба та 198 військовослужбовців). Структурну валідність оцінювали за допомогою підтверджувального факторного аналізу.

Результати. Відповідність досягнуто двофакторної моделі, отриманої в ході дослідницького факторного аналізу, про що свідчать такі індекси: χ2 (8, Критичний N = 465,29) = 10,43; χ2 / df = 1,303; Ненормований індекс придатності = 0,98; Нормований індекс підгонки = 0,97; Середньоквадратична похибка апроксимації = 0,035 (90-відсотковий довірчий інтервал для середньої квадратичної похибки апроксимації = (0,0; 0,088), індекс порівняльної відповідності = 0,99. Крім того, усі факторні навантаження були статистично значущими на рівні p < 0,01). вказує, що ці два фактори були добре розроблені на кожному етапі. Кореляція між факторами була слабкою, що підтверджує дискримінантну валідність тесту. Значна кореляція, виявлена між пунктами та загальним результатом тесту, підтвердила валідність тесту.

Висновки. Виявлено, що тест на бойову працездатність армії є підходящим інструментом для оцінки фізичної підготовленості особового складу протиповітряної оборони Сухопутних військ. Дилеми щодо можливого використання армійського тесту на бойову придатність для всіх вікових груп військовослужбовців незалежно від статі потребують подальшого вивчення.

Ключові слова: валідність, фізична підготовленість, підтверджувальний факторний аналіз, військовослужбовці

Аннатоция

Палевич С., Кирпенко В., Поддубный А., Божко С., Цымбалюк Ж., Майкл Антони Мартинес Велес, Федерико Анибал Мартинес Велес, Хорхе Армандо Морета Винуэза, Федерико Антонио Мартинес Леон. Структурная валидность батареи тестов для проверки физической подготовленности

Цель: проверка достоверности тестов армейской боевой пригодности на выборке личного состава противовоздушной обороны в Сухопутных войсках Украины.

Материал и методы. В исследовании приняли участие 271 военнослужащий ПВО сухопутных войск в возрасте от 18 до 40 лет (73 курсанта Харьковского национального университета ВВС имени Ивана Кожедуба и 198 военнослужащих). Структурная валидность оценивалась с помощью подтверждающего факторного анализа.

Результаты. Соответствие достигнуто с помощью двухфакторной модели, полученной в ходе исследовательского факторного анализа, о чем свидетельствуют следующие индексы: χ2 (8, Critical N = 465,29) = 10,43; χ2 / df = 1,303; Ненормированный индекс соответствия = 0,98; Нормированный индекс соответствия = 0,97; Среднеквадратичная ошибка аппроксимации = 0,035 (90-процентный доверительный интервал для среднеквадратичной ошибки аппроксимации = (0,0; 0,088), сравнительный индекс соответствия = 0,99. Кроме того, все факторные нагрузки были статистически значимыми на уровне p <0,01, что указывает на то, что эти два фактора были хорошо разработаны на каждом этапе. Корреляция между факторами была слабой, что подтверждает дискриминантную валидность теста. Существенная корреляция, обнаруженная между элементами и общей оценкой теста, подтвердила валидность теста.

Выводы. Было обнаружено, что армейский тест боевой пригодности является подходящим инструментом для оценки физического состояния личного состава ПВО в Сухопутных войсках. Дилеммы о возможности использования армейского теста боевой пригодности для всех возрастных групп военнослужащих, независимо от пола, требуют дальнейшего изучения.

Ключевые слова: валидность, физическая подготовленность, подтверждающий факторный анализ, военнослужащие.

Introduction

The lack of a process for evaluating the achievement of the necessary level of physical readines of the Armed Forces of Ukraine personnel may lead to a discrepancy between the level of physical readiness of the military personnel and the requirements for physical condition, training and coherence of units its necessary for the implementation of combat capabilities [1, 2].

Thereby, monitoring and evaluating motor skills development is an important goal for unit commanders. Controlling the process ensures the timely receipt of objective information about the state of physical fitness of military personnel. This task is solved by the system of verification and evaluation of physical fitness [3]. The model focuses on assessment technology, tests and regulatory requirements that determine the level (quality) of qualification [4, 5].

Nowadays, the armies of the leading nations of the world are considering a wide and varied range of research areas for the concept of «readiness». The existing tests have been criticized for lack of evidence to support their link to military fitness for every soldier. The fitness tests, Established in 1980, fitness tests proposed in 2002 and 2010 were not implemented because they were not validated [6, 7, 8] and have been revalued [8, 9, 10]. Since October 2020, the U.S. Army Physical Fitness School and the U.S. Army Center for Initial Military Training have been validating the Army Combat Fitness Test tests [11, 12].

The Army Combat Fitness Test test evaluates five components of physical fitness such as muscle and aerobic endurance, muscle strength, speed / agility and explosive strength [2, 13] The strongest argument for the new test is that it has a high correlation between Army Combat Fitness Test exercises and ground combat requirements [10]. It does not imply gender and age differences [11, 12, 14].

An objective evaluation of the readiness of military personnel, determines the need to validate the Army Combat Fitness Test tests for the Armed Forces of Ukraine. Ensuring the implementation of the acquired combat capabilities to perform into combat missions, achieving compatibility with the armed forces of NATO member states.

Matherials and methods

Participants

The participants in this study were 271 air defense military personnel of the ground forces between 18 to 40 years (73 cadets of the Ivan Kozhedub Kharkiv National Air Force University and 198 military personnel). The data, showing the sample subdivided into age groups, are presented in Table 1. All of the military personnel had been individually evaluated for the physical fitness verification procedure in accordance with the requirements of the Army Combat Fitness Test [11]. The evaluation was conducted during the period of the year 2020.

Table 1

Demographic characteristics of participants (n = 243)

Sex	Up to 25 years old	Up to 30 years old	Up to 35 years old	Up to 40 years old	Total
Male (number)	148	79	22	5	254
Female (number)	-	17	-	-	17
Total (number)	148	96	22	5	271

For various reasons, 28 soldiers did not pass the test. Only those subjects who completed all tests were included in the analysis of validity (n = 243).

Data collection measuring instrument

The participants completed the Army Combat Fitness Test training and testing program during the 4th and 5th courses at the Ivan Kozhedub Kharkiv National Air Force University and during the baseline period in the army. The participants performed the exercises in the following order:

1. 3 Repetition maximum deadlift;
2. Standing power throw;
3. Hand release push-up – arm extension;
4. Sprint-drag-carry;
5. Leg tuck;
6. Two-mile run.

Detailed instructions about the Army Combat Fitness Test test is available at Army

Combat Fitness Test 3.0: Exploring a more inclusive scoring assessment, planks stay [11]. Each participant voluntarily provided a written informed consent prior to participation.

Statistical analysis

Statistical analysis of the results was carried out using STATISTICA 10.0. The normal distribution was evaluated using the Shapiro-Wilk criterion (W). For the entire sample, the parameters of the descriptive statistics were calculated. Parametric indicators are presented as $\bar{x} \pm S$, where $\bar{x}$ (Mean) is the average, S is the standard deviation.

To compare the mean values of the results of the test items by representatives of different age groups and gender, the procedure of one-way analysis of variance (Anova) in SPSS Statistics 17.0 was carried out according to Fisher's exact test. The compared variances of distributions of values statistically do not differ significantly if the p-level of Levene's test is > 0.05. If $F_{obs.} \leq F_{cr}$ all measurement results belong to one general population. The F_{stat} will be close to 1 at a significance level of p> 0.05. If $F_{obs.} > F_{cr}$ an alternative hypothesis is accepted. F_{stat} will be much more than 1. Scheffe's method was performed when a significant difference was found by analysis of variance.

Correlation analysis was used to establish a quantitative measure of strength and direction of the probabilistic relationship between test items and the overall standard score [15]. When evaluating the strength of the relationship between correlation and coefficients, a scale was used that differentiates both positive and negative correlations into three levels. From 0.01 to 0.29 − weak positive correlation, from 0.30 to 0.69 − moderate positive correlation, from 0.70 to 1.00 − strong positive correlation. From -0.01 to -0.29 − weak negative correlation, from -0.30 to -0.69 − moderate negative correlation, from -0.70 to -1.00 trong negative correlation [16].

To evaluate the validity of the test, the primary data matrix containing the cadets' scores was subjected to exploratory principal component analysis followed by varimax rotation of the selected factors and Kaiser-Meyer-Olkin's test standards in SPSS Statistics 17.0 to evaluate the constructive validity of the test. To evaluate the quality of the model, the following indixes were used: the Kaiser-Meyer-Olkin's sample adequacy method and Bartlett's sphericity method. The Kaiser-Meyer-Olkin's sample adequacy method is a value that characterizes the degree of applicability of factor analysis to a given sample (≥ 0.9 − unconditional adequacy; (0.8; 0.9) − high; (0.7; 0.8) − acceptable; (0.6; 0.7) − satisfactory; (0.5; 0.6) − low; < 0.5 − factor analysis is not applicable to the sample). Bartlett's sphericity method is a multidimensional normality test for the distribution of variables. Significance level $p < 0.05$ indicates that the data are quite acceptable for factor analysis [2, 15].

Confirmatory factor analysis was performed in LISREL 8.8 to test the internal structure of the two-factor model [17]. The following indixes were used to evaluate the degree of conformity of the model: $\chi 2$ (chi-square), quotient $\chi 2$ and *df* does not exceed 2 ($\chi 2 / df < 2$), not normalized fit index (Non-Normed Fit Index ≥ 0.90), normalized fit index (Non Fit Index ≥ 0, 90) and root mean square error of approximation (Root Mean Square Error of Approximation ≤ 0.05). Since the value of $\chi 2$ depends on the sample size and, with large sample sizes, can be reliable even for insufficiently suitable models, an additional reliability indicator called the comparative fit index (0 < Comparative Fit Index <1) was calculated. The model is considered to be consistent with the data obtained if the Comparative Fit Index exceeds 0.95 (for the many authors, values of at least 0.85 are also acceptable).

Statistical significance was evaluated with 95% confi-dence intervals. Analyses were performed using SPSS version 17, and statistical significance was set at an alpha level of 0,05.

All parameters of validity were calculated using standard scores.

Results

The analysis of the hypothesis about the normality of the distribution of the results of the Army Combat Fitness Test test tasks is presented in Table 2. The statistics of the W test are insignificant. The hypothesis about the normal distribution of the values of the variable is accepted.

Baseline scores for individual Army Combat Fitness Test assignments are shown in Table 3. The results were directly compared between each age group to test for the perceived lack of gender and age differences for the test takers.

Once we analyzed the results. It should be noted that the lowest results for female military personnel are shown in the 3 Repetition maximum deadlift exercise. with 76 % not meeting the threshold level. 41 % performed below the threshold level in Standing power throw and Two-mile run exercises. The best result at the level of 81-82 points is shown in the Sprint-drag-carry. Hand release push-up – arm extension and Leg tuck tasks. Overall. more than one female soldier did not fully complete the Army Combat Fitness Test test as required.

Table 2

Normality analysis of the distribution of the results of the Army Combat Fitness Test tasks

Army Combat Fitness Test tasks	Mean	Median	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	Shapiro-Wslk W	p
3Repetition maximum deadlift (conventional units)	76.28	76	10.385	0.148	0.148	-0.395	0.990	0.070
Standing power throw (conventional units)	77.26	77	7.838	0.109	0.148	0.536	0.989	0.055
Hand release push-up – arm extension (conventional units)	67.60	67	11.637	0.427	0.148	-0.211	0.991	0.120
Sprint-drag-carry (conventional units)	74.66	74	9.700	0.212	0.148	-0.109	0.990	0.070
Leg tuck (conventional units)	82.59	83	10.320	-0.353	0.148	-0.213	0.992	0.120
Two-mile run (conventional units)	70.88	71	10.333	0.112	0.148	0.385	0.995	0.159

Table 3

Evaluation of the results of the Army Combat Fitness Test tasks

Army Combat Fitness Test Task	$\bar{x}$ (S)				
	Male				Female
	Up to 25 years old (n = 148)	Up to 30 years old (n = 79)	Up to 35 years old (n = 22)	Up to 40 years old (n = 5)	Up to 30 years old (n =17)
3 Repetition maximum deadlift (conventional units)	67.81 (10.99)	70 (12.83)	66.14 (11.14)	69 (7.71)	56.11 (4.58)
Standing power throw (conventional units)	77.44 (10.30)	76.81 (9.77)	76.27 (9.63)	76.8 (8.35)	63.59 (7.6)
Hand release push-up–arm extension (conventional units)	83.22 (9.79)	83.82 (9.58)	83.55 (10.68)	88 (8.03)	68.64 (8.68)
Sprint-drag-carry (conventional units)	77.89 (7.61)	77.84 (7.80)	78.18 (7.28)	73.6 (3.71)	68.94 (7.18)

Leg tuck (conventional units)	75.04 (8.99)	75.73 (10.88)	73.68(7.66)	78.4 (13.30)	66.41 (7.75)
Two-mile run (conventional units)	70.99 (10.21)	71.13 (11.03)	74.18(7.45)	78 (6.36)	62.47 (7.89)
Total Army Combat Fitness Test	452.12 (31.42)	455 (33.61)	452 (28.6)	463.8 (31.22)	386.18 (15.40)

In men under 40. none of the participants reached the maximum result of (100 points) in any task. Most of the maximum results were shown by men under 30 years old in Hand release push-up – arm extension (6.3 %), Leg tuck (2.5 %), Two-mile run (2.5 %), 3 Repetition maximum deadlift (1.2 %) tasks. The Hand release push-up – arm extension task was completed most successfully in all groups (4.7 %; $\bar{x}$ = 83.53. S = 9.74). 22.51 % of the personnel did not fulfill the threshold level in one or more assignments.

The results of the Anova analysis (Table 4) confirm significant statistically differences in the average group results of the Army Combat Fitness Test test tasks performed by women and representatives of different age groups of men ((Sig. = 0.000) − the variances for the groups of men and women do not statistically significantly differ (< 0.05). Analysis of variance is correct)).

Table 4

ANOVA Analysis Results Analysis of variance of the results of the Army Combat Fitness Test test tasks performed by female and representatives of different age groups of male

Army Combat Fitness Test tasks	ANOVA	
	F	Significance (Sig.)
3 Repetition maximum deadlift	5.429	0.000
Standing power throw	7.527	0.000
Hand release push-up – arm extension	9.667	0.000
Sprint-drag-carry	5.879	0.000
Leg tuck	3.767	0.005
Two-mile run	4.172	0.003
Total Army Combat Fitness Test	18.721	0.000

Multiple comparisons of the average performance of female and male military personnel during the test and Total Army Combat Fitness Test are presented in Table 5.

Table 5

Multiple comparisons of the average results of the test items and Total Army Combat Fitness Test of female and male of different age groups (according to Scheffe's method)

Army Combat Fitness Test tasks	Age	Average difference	Standard error	Significance (Sig.)	95% confidence interval	
					Bottom line	Upper bound
Standing power throw	Up to 25 years old	-13.85*	2.54	0.000	-21.73	-5.97
	Up to 30 years old	-13.22*	2.65	0.000	-21.45	-4.99
	Up to 35 years old	-12.68*	3.20	0.004	-22.62	-2.75
	Up to 40 years old	-13.21	5.05	0.147	-28.86	2.44
Sprint-drag-carry	Up to 25 years old	-8.95*	1.94	0.000	-14.96	-2.94
	Up to 30 years old	-8.89*	2.02	0.001	-15.17	-2.62
	Up to 35 years old	-9.24*	2.44	0.007	-16.82	-1.66
	Up to 40 years old	-4.66	3.85	0.833	-16.60	7.29
3 Repetition maximum deadlift	Up to 25 years old	-11.69*	2.89	0.003	-20.65	-2.74
	Up to 30 years old	-13.88*	3.01	0.000	-23.23	-4.53
	Up to 35 years old	-10.02	3.64	0.112	-21.31	1.27
	Up to 40 years old	-12.88	5.74	0.286	-30.67	4.91
Leg tuck	Up to 25 years old	-8.64*	2.43	0.015	-16.19	-1.09
	Up to 30 years old	-9.32*	2.54	0.010	-17.20	-1.44
	Up to 35 years old	-7.27	3.07	0.234	-16.79	2.25
	Up to 40 years old	-11.99	4.84	0.192	-26.99	3.01
Hand release push-up – arm extension	Up to 25 years old	-14.57*	2.49	0.000	-22.29	-6.85
	Up to 30 years old	-15.18*	2.60	0.000	-23.23	-7.12
	Up to 35 years old	-14.90*	3.14	0.000	-24.63	-5.17
	Up to 40 years old	-19.35*	4.94	0.005	-34.68	-4.02
Two-mile run	Up to 25 years old	-8.52*	2.59	0.031	-16.54	-0.49

	Up to 30 years old	-8.66*	2.70	0.038	-17.03	-0.28
	Up to 35 years old	-11.71*	3.26	0.013	-21.83	-1.59
	Up to 40 years old	-15.53	5.14	0.061	-31.47	0.41
Total Army Combat Fitness Test	Up to 25 years old	-65.95*	7.97	0.000	-90.69	-41.19
	Up to 30 years old	-68.81*	8.33	0.000	-94.65	-42.98
	Up to 35 years old	-65.82*	10.06	0.000	-97.03	-34.62
	Up to 40 years old	-77.62*	15.85	0.000	-126.78	-28.46

Note: * The average difference is significant at the level 0.05

The data in Table 4 do not reveal significant differences between the average difference in the results shown by male and female military personnel under 40 years old in performing Standing power throw, Sprint-drag-carry, 3 Repetition maximum deadlift. Leg tuck and Two-mile run test items. since the significance for all pairs of groups is greater than 0.05. There was no statistically significant difference with men under 35 years old in the 3 Repetition maximum deadlift and Leg tuck tasks. All other results in women differ significantly from those for men.

Anova's analysis. which is presented in Table 6. does not confirm statistically significant differences in the results of performing test items by representatives of different age groups in men. Levene's method for testing the hypothesis of equality of variances shows that the sample means are obtained from populations with the same general means. The calculated value of F does not exceed the critical value of F with a significance value of $p > 0.05$.

Table 6

ANOVA Analysis Results for men Analysis of variance of results of perfoming test items by representatives of different age groups of male

Army Combat Fitness Test tasks	Dispersion uniformity criterion		ANOVA	
	Levene's Statistics	Significance (Sig.)	F	Significance (Sig.)
3 Repetition maximum deadlift	1.184	0.317	0.916	0.434
Standing power throw	0.316	0.814	0.129	0.943
Hand release push-up – arm extension	0.174	0.914	0.423	0.737
Sprint-drag-carry	0.680	0.565	0.536	0.658
Leg tuck	1.894	0.131	0.461	0.710
Two-mile run	1.857	0.137	1.335	0.263
Total Army Combat Fitness Test	0.191	0.902	0.333	0.801

The exploratory factor analysis procedure showed:

1) as a result of using the Kaiser-Meyer-Olkin's sample adequacy method. an acceptable adequacy of the factor analysis applicability to the values of this sample was established (criterion value = 0.763);

2) as a result of using the Bartlett's sphericity method. it was found that the data are acceptable for carrying out the factor analysis procedure with them (χ2-square = 179.91. p value ≤ 0.001);

3) after using the Kaiser's method. we found that the first two factors are greater than one (1 - 3.099; 2 - 1.338). This means that it is optimal to single out two factors;

4) using R. Cattell's method for screening. we found that on the graph of normalized simple stress. the inflection point is at the value 3. This confirms the conclusion formulated as a result of using the Kaiser's method that two factors were distinguished in the structure;

5) the correlation matrix of 6 variables was subjected to a principal component analysis procedure. 2 factors were extracted with own value greater than one. These factors were rotated according to the varimax method.

The first factor can be interpreted as «Endurance (cardio-respiratory endurance. muscular endurance (upper body. lower body. whole body / trunk)», since the variables associated with this phenomenon have the highest loads on it: «Two- mile run = 0.892, Leg tuck = 0.889, Hand release push-up - arm extension = 0.873).

The second factor can be interpreted as «Strength (upper body, lower body, whole body / trunk) and mobility», since the variables associated with this phenomenon have the highest loads on it: «Sprint-drag-carry» = 0.841; «Standing power throw» = 0.768; «3 Repetition maximum deadlift» = 0.764.

The factors obtained as a result of the varimax rotation explain 73.95 % of the total variance:

a) the factor «Enduranc» explains 41.077 % of the total variance;

b) the «Strength and Mobility» factor explains 32.873 % of the total variance.

As a result. two unimodal factors were obtained. These factors describe 73.95 % of the total total variance.

To check the internal structure of the two-factor model. we used the procedure of the confidential (confirmatory) factor analysis. implemented in the LISREL 8.8 program. The set of relationships in the model is shown in the path diagram (Figure 1). To assess the agreement of the two-factor model. the maximum likelihood method was used. The evaluation of the original model showed that the model was consistent with the data, as evidenced by the following indixes: $\chi 2$ (8. Critical N = 465.29) = 10.43; $\chi 2$ / df = 1.303; Non-Normed Fit Index = 0.98; Normed Fit Index = 0.97; Root Mean Square Error of Approximation = 0.035 (90 Percent Confidence Interval for Root Mean Square Error of Approximation = (0.0; 0.088)). Comparative Fit Index = 0.99. In addition. all factor loadings were statistically significant at the $p < 0.01$ level. This suggests that these two factors were well designed.

As a result of the correlation analysis (Table 7). a strong positive relationship was established between the factors Sprint-drag-carry and Standing power throw (r = 0.842) and a weak positive relationship between Standing power throw and 3 Repetition maximum deadlift (r = 0.257), Standing power throw and Two-mile run (r = 0.267), Sprint-drag-carry and 3 Repetition maximum deadlift (r = 0.267), Sprint-drag-carry and Two-mile run (r = 0.245, 3 Repetition maximum deadlift and Two-mile run (r = 0.153, Hand release push-up – arm extension and Two-mile run (r = 0.296). While Standing power throw, Sprint-drag-carry, 3 Repetition maximum deadlift factors did not correlate with Leg tuck, Hand release push-up – arm extension. All test items were significantly correlated with the total standard score in the range from r = 0.425 to r = 0.674 at $p < 0.01$.

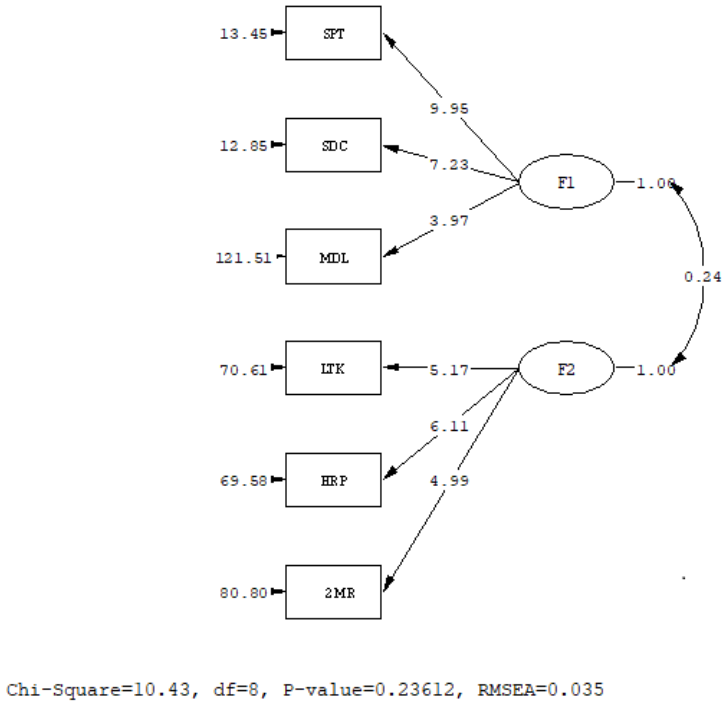

Fig. 1. Path diagram of Army Combat Fitness Test. Two-factor confirmatory factor analysis model. Satisfactory match statistics supporting a two-factor model

Table 7

Correlation between tasks and total test score

Army Combat Fitness Test tasks	Standing power throw	Sprint-drag-carry	3 Repetition maximum deadlift	Leg tuck	Hand release push-up – arm extension	Two-mile run
Sprint-drag-carry	0.842**					
3 Repetition maximum deadlift	0.257**	0.267**				
Leg tuck	0.031	-0.006	-0.027			
Hand release push-up – arm extension	0.09	0.072	-0.027	0.211**		
Two-mile run	0.267**	0.245**	0.153*	0.278**	0.296**	
Total Army Combat Fitness Test	0.674**	0.643**	0.536**	0.425**	0.460**	0.568**

Notes: ** Correlation is significant at the 0.01 level (two-sided); * Correlation is significant at the 0.05 level (two-sided)

Discussion

The purpose of this study was to determine the structural validity of the Army Combat Fitness Test test battery for evaluating the physical condition on a sample of air defense personnel of the Air Force grounded forces of the Army of Ukraine. To date. a wealth of scientific experience has been accumulated in the development of tests for evaluating the individual level of physical fitness condition of military personnel of various categories [18, 19, 20] and age [21, 22]. However the problem is that the nature and conditions of combat activities of personnel change with the development of military affairs [1, 23].

At the same time, the workloads experienced by military personnel in modern combat are changing. The present study showed a significant difference in the average group performance of the Army Combat Fitness Test test items by women and representatives of different age groups in men. Excluding the results of male military personnel from 35 to 40 years old on Standing power throw , Sprint-drag-carry , 3 Repetition maximum deadlift, Leg tuck and Two-mile run . There was no statistically significant difference in the results of men under 35 and in the 3 Repetition maximum deadlift and Leg tuck tasks. 76 % of them did not meet the threshold level in the 3 Repetition maximum deadlift exercise. In Standing power throw and Two-mile run exercises. 41 % of them showed results below the threshold level. Overall. no female military personnel completed the Army Combat Fitness Test test as required. These results are in contrast to the U.S. Army's data. which shows that 54 percent of female soldiers failed the new Army's combat fitness test. up from 7 percent of men in the second quarter of 2020 [24].

The data raises concerns that the crossfit test is difficult for women. The performance imbalance is rooted primarily in one of the test's six events. the leg tuck. which requires troops to hang from a pullup bar with their arms extended before lifting themselves up using abdominal and arm muscles. Therefore, it must have an alternative to Leg tuck new task plank [14]. The plank is an alternate assessment that may be used. The plank helps build core strength that promotes back health and helps reduce injuries.

Failed to fulfill the threshold level in one or more tasks 22.51 % of the military personnel out of all tested. This situation can be explained by poor physical activity in their free time. Among the reasons that prevent military personnel from exercising in their free time are: family responsibilities. working hours, lack of equipment, unsafe environment, lack of company, housework and lack of financial resources. It is assumed that Army Combat Fitness Test is a way to standardize the military's physical conditioning. in which the technical aspects of physical conditioning that people have undergone can be noted [25, 26].

Anova's analysis does not confirm statistically significant differences in the results of the test items performed by representatives of different age groups of men. This confirms that the Army Combat Fitness Test was designed to more accurately predict the combat readiness of male military personnel regardless of the age. The performance requirements for each test item can be adjusted for military specialties and other factors. Some of these factors may or may not be used as variables for the final version of the new Army Fitness Standard, which will be known as the Army Combat Fitness Test for Army of Ukraine.

Matos et al [27] point out that fitness is essential to the readiness of the military provides the best conditions for their daily life. Improving physical fitness contributes to a significant increase in the combat readiness of military personnel. Physically healthy people are more resistant to disease and recover from injury faster than people who are not physically fit [1, 5, 28]. It is important to note that physically healthy people have high levels of self-confidence and motivation. In other words. well-trained military personnel are better able to withstand extreme combat situations [27, 28]. The results of this study show the problems in the organization of physical training classes with military personnel. The most difficult tasks for the military were the 3 Repetition maximum deadlift and Two-mile run tasks. So 18.45 % did not meet the threshold level in the 3 Repetition maximum deadlift task and 9.23 % in the Two-mile run.

Training of the Ukrainian Armed Forces in peacetime is organized according to training standards and is evaluated through pedagogical tests. Pedagogical tests are tests of achievement. They are designed to determine the extent to which military personnel have completed training objectives. The test should measure what has been taught and learned, nothing more. nothing less. According to military scientists for the test to be valid. the teacher must clearly understand the learning objectives. Our research has confirmed the opinion of military scientists [12, 24] that when testing activities of a certain level, the test tasks must correspond to just such a level of complexity so that they cannot be performed by means of activities of a lower level [29, 30].

The results are consistent with the findings of other researchers that the military is required not

only for general enduranc, strength and speed. They require cardio-respiratory endurance, muscular endurance (upper body, lower body, whole body / trunk), muscular strength (upper body, lower body, whole body / trunk) and mobility [16, 31].

A factor-analytical study is carried out to classify fitness tests according to the ability to measure physical qualities. Factor analysis identified 3 [32] to 14 [33] physical ability or physical skill factors that can be measured using fitness tests. In our case, it is necessary to find out the structural components of the physical fitness of the air defense personnel of the Air force grounded forces of the Army of Ukraine.

To develop a theoretical model of physical fitness, a pilot study was carried out. The sample of which consisted of 73 cadets of the Ivan Kozhedub Kharkiv National Air Force University. The results of the study were subjected to quantitative and qualitative analysis. Model building began with determining the ability of individual test items to evaluate physical qualities. Each task was assigned to a specific category based on its usual interpretation in the literature (FM-21-20). In this case, the Two-mile run test was classified as an indicator of «aerobic capacity» or endurance. Leg tuck and Hand release push-up - arm extension were classified as indicators of muscular endurance (upper body, lower bod, whole body / trunk). 3 Repetition maximum deadlift and Standing power throw are muscular strength (upper body, lower body, whole body / trunk). Sprint-drag-carry is an indicator of muscular endurance and strength as well as mobility.

Factor analysis revealed two factors. One of these is determined mainly by variables related to cardio-respiratory and muscular endurance. Variables have the highest loads on it («Two-mile run» = 0.892; «Leg tuck» = 0.889; «Hand release push-up – arm extension» = 0.873). Another factor is determined by variables related to strength and mobility («Sprint-drag-carry» = 0.841; «Standing power throw» = 0.768; «3 Repetition maximum deadlift » = 0.764).

The next step in the analysis is confirmatory factor analysis. This analysis is necessary to confirm the structure of factors. which was revealed at the first stage in the course of the explanatory factor analysis. Standard classifications were used as the basis for confirmatory factor analysis models. The test items were acceptable indicators of cardio-respiratory and muscular endurance. strength and mobility. The estimation of the corresponding factor structure was carried out by the maximum likelihood method using the LISREL 8.8 program. A model with two factors that are weakly correlated with each other was obtained as a result of the analysis. In our case (see Fig. 1) the indicator $\chi^2 = 10.43$ ($p = 0.236$) is not statistically significant. This indicates good consistency of the model with the data. Indicators Goodness-of-fit statistic = 0.99 (> 0.95) and Root Mean Square Error of Approximation = 0.035 (< 0.07), Non Fit Index = 0.97 (> 0.95). Thereb, the proposed factor model provides good consistency with experimental data. All 6 test tasks were acceptable indicators of the indicated structure of the physical fitness of military personnel of the Air force grounded forces of the Army of Ukraine.

Causal models relate to physical ability and performance of physical tasks. Earlier work has shown that there may be bias in these models [34, 35].

The accuracy of the test battery can be improved by enabling multiple indicators for cardio-respiratory and muscular endurance. Strength, and mobility if possible. This model confirms these findings from Report No. 11-52 by the Office of Naval Research. Arlington.

Test items use the same factor because they are correlated. The sum of the standardized scores on two or more tests will allow a more accurate evaluation of true ability [27].

The correlation between the factors in the present study was weak. which confirmed the discriminant validity of the test. On the other hand. a significant correlation was found between the items and the overall test score. This correlation further confirmed the validity of the test.

The relationship between test items can be used to develop training programs. It can be used to prepare soldiers for tasks that require physical fitness endurance.

The limitation of the present study was not to use data from all military personnel. This is because 22.51 % of the military did not meet the threshold level on one or more missions or due to health restrictions.

Conclusion

We have found that Army Combat Fitness Test is a suitable tool for evaluating the physical fitness condition of the Air Force personnel in the ground forces. Army Combat Fitness Test missions are intuitive and easy to complete by all male military personnel. The dilemmas about the possible use of Army Combat Fitness Test for all age groups of military personnel regardless of gender. raised here. as well as in other studies. require further study.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLES. PHYSICAL EDUCATION

Change of psychophysiological indices in female students of creative occupations

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Abstract

Purpose: studying the dynamics of psychophysiological indices of creative occupation female students.
Material: the study involved 120 female students. Reactive qualities, level of static and dynamic equilibrium, orientational qualities, speed of operative thinking, volume of rote memorization, attention distribution, level of accuracy, attention speed and switching, accuracy of task performance were assessed.
Results: a decrease in the indices of the accuracy of reproducing motion amplitude and a given value of effort, those of response to vertically falling object and those of static and dynamic equilibrium was revealed. An improvement in the dynamics of nervous processes and the ability to constructive praxis was noted. The decrease in the level of development of motor qualities, professional skills, physical fitness, and health is observed already in the 1st year of study. The authors believe that the pedagogical influences should be started from the 1st course and continued until the end of the study. In the process of physical education classes, the physical exercises aimed at improving the professionally significant psychophysiological properties of students should be used. It is they that restrain the negative effect of increasing the intensity of educational classes simultaneously contributing to an increase in the development level of almost all motor qualities and health.
Conclusions: uneven decrease of most psychophysiological indices negatively affects both the level of female student motor preparation and professional abilities of the future designers. The findings give ground for the development of the methods for improving motor qualities and psychophysiological properties professionally significant for students-designers. Taking into account the future profession specifics and the health indices will allow more precise planning of the content of physical education classes.
Keywords: designers, psychophysiological indices, female students, professional abilities

Анотація

Коробейнікова Л.Г., Джаміль М.С.А., Цинарскі В.Дж., Улізко В.М. Зміна психофізіологічних показників у студенток творчих професій

Мета - дослідити динаміку психофізіологічних показників студенток творчих професій.

Матеріал і методи: у дослідженні взяло участь 120 студенток у віці от18 до 22 років. Оцінювалися реагувальні якості, рівень статичної і динамічної рівноваги, орієнтаційні якості, швидкість оперативного мислення, обсяг механічного запам'ятовування, розподіл уваги, рівень точності, швидкість та перемикання уваги, точність виконання завдання.

Результати: встановлено зниження показників точності відтворення амплітуди руху і заданої величини зусилля, показника реакції на предмет, що вертикально падає, показників статичної і динамічної рівноваги. Відмічено поліпшення показників динамічності нервових процесів і здатності до конструктивного праксису. Динаміка результатів комплексного тесту, який оцінював орієнтаційні, реагувальні та диференціальні якості у студенток, вказує на те, що найкращі значення мають місце на I курсі, найгірші - на IV курсі. Нерівномірне зниження більшості психофізіологічних показників негативно відображається не лише на рівні рухової підготовки студенток, але і на професійних здібностях, зокрема, майбутніх дизайнерів.

Висновки: Встановлено зниження більшості показників, які характеризують кінестетичні, орієнтаційні та реагувальні якості студенток університету в процесі навчання. Цілеспрямоване вдосконалення кінестетичних, реагувальних якостей на заняттях з фізичного виховання за допомогою спеціалізованої методики дає можливість не лише призупинити негативну динаміку психофізіологічних показників молодого організму, але і покращити їх. Зрештою це позитивно відображається на професійній майстерності майбутнього фахівця творчої професії.

Ключові слова: дизайнери, психофізіологічні показники, студентки, професійні здібності

Аннотация

Коробейникова Л.Г., Джамиль М.С.А., Цынарски В.Дж., Улизко В.М. Изменение психофизиологических показателей у студенток творческих профессий

Цель - исследовать динамику психофизиологических показателей студенток творческих профессий.

Материал и методы: в исследовании приняло участие 120 студенток в возрасте от18 до 22 лет. Оценивались реагирующие качества, уровень статического и динамического равновесия, ориетанционные качества, быстрота оперативного мышления, объём механического запоминания, распределение внимания, уровень точности, быстрота и переключение внимания, точность выполнения задания.

Результаты: установлено снижение показателей точности воспроизведения амплитуды движения и заданной величины усилия, показателя реакции на вертикально падающий предмет, показателей статического и динамического равновесия. Отмечено улучшение показателей динамичности нервных процессов и способности к конструктивному праксису. Динамика результатов комплексного теста, который оценивал ориентационные, реагирующие и дифферентационные качества у студенток, указывает на то, что наилучшие значения имеют место на I курсе, наихудшие – на IV курсе. Неравноменое снижение большинства психофизиологических показателей негативно отражается не только на уровне двигательной подготовки студенток, но и на профессиональных способностях, в частности, будущих дизайнеров.

Выводы: Установлено снижение большинства показателей, которые характеризуют кинестетические, орентационные и реагирующие качества студенток университета в процессе обучения. Целенаправленное совершенствование кинестетических, ориетационных и реагирующих качеств на занятиях по физическому воспитанию с помощью специализированной методики позволяет не только приостановить негативную динамику психофизиологических показателей молодого организма, но и улучших их. В конечном итоге это положительно отражается на профессиональном мастерстве будущего специалиста творческой профессии.

Ключевые слова: дизайнеры, психофизиологические показатели, студентки, профессиональные способности

Introduction

Professional activity is the most important area of human life. The success of professional preparation depends on a number of factors including adequate physical education of future professionals. The successfulness of any professional activity is directly related to the development of these or those motor and psychomotor qualities [1]. The profession of designer requires a number of skills to accurately differentiate, reproduce and measure spatial, strength and temporal parameters of motion, muscular efforts, balance, distribution and intensity of attention as well as sufficient spatial orientation. Market relations have made the competition for a working place among graduates more acute [2]. Priority at the job market is given to those specialists possessing good professional qualities along with a high level of psychophysiological conditions, efficiency, endurance, health, ability to quickly and adequately solve complex professional tasks [3, 4].

Design is a project practice that requires an organic combination of figurative and systemic beginnings from the professional thinking [5]. The dominant types of designers' activities are: the creation of new projects of man of today subject environment; development of artistic design projects of household and industrial products and the like. The main activity types also include the development of new clothing models; development of details of exterior interior design; selection of material for product manufacture; control for the design realization at the stages of projecting, manufacturing, testing; development of technical documentation for the designed products (sketches, drawing designs, drawings, diagrams, models); development of landscaping projects and design of building facades [6].

The designer should have creative, artistic abilities, and be able to convey the intention by means of graphic image; she should have a developed spatial-figurative thinking, steady attention, ability to switch and distribute attention, visual memory, good eyesight and a good eye. The demands placed on the profession force out to pay attention to them during specialist preparation at the university [7].

The profession of a designer is characterized by mental tension, monotony of working posture (most often sitting), extreme restriction of movements, a great load on mental and psychical processes that serve them (perception, memory, attention, etc.). However, at the present stage the most peculiar feature of the designer's activity is the expansion of the scope of activity (from the idea embodied in paper (drawing) to the study of the properties of finishing materials and the manufacture of individual elements of the design project).

A large percentage of the designer's working time is taken by mental and psychomotor processes related to the solution of the main professional tasks [8]. These are: the ability to use visual memory, the ability to orientate in space and distribute attention, the ability to reproduce the given object parameters schematically, the ability to assess and differentiate strength and spatial motion parameters performed with small amplitude, the accuracy of the actions performed [9]. These psychomotor actions take at the average 37% of working time. During performing these actions, the main coordination and psychomotor manifestations are actions that actively use kinesthetic qualities (reproduction, evaluation, measurement of spatial parameters), orientational qualities, accuracy of the task performance, the ability to constructive praxis, the ability to distribute attention [10].

Today's students studying creative specialties have to spend a lot of time at the computer. Fixed static posture, minimal monotonous movements of the upper extremities as well as constant eyestrain negatively influence human well-being [11]. High level of study load in the face of low motor activity and long-term maintenance of uniform static posture is one of the factors of physical development delay and psychophysiological state of the body [12, 13]. Motor activity restriction has a negative impact on human health [14].

In many papers [15, 16, 17, 18] attention is paid to possible health deviations, decrease of general physical and mental work capacity, initial disorders in the activity of a number of the body functional systems. In particular, K.A. Sydorova et al. [19] investigated the temperament, speed of response of rural and urban female students. In studies of different authors [20, 21] the data of simple and complex visuomotor responses and operative memory were analyzed, whereas. Kostiunin [22] also investigated the functional mobility of nervous processes, the tapping-test, the responses to a moving object. Researchers tend to rather extensively analyze different set of psychophysiological indices of students in the dynamics. Study of Barybina [1] concludes that there exists the relationship between psychophysiological indices and individualization

of physical education at the university. Moreover, none of the researchers was able to analyze the influence of psychophysiological indices dynamics on professional qualities of the future profession and, as a consequence, the expediency of specialized physical education in order to improve these indices.

We assume that the use of a complex of modern methods for studying the functional indices of external respiration, the level of physical health, and the general state of the autonomic nervous system of university students will permit to implement a new approach to solving the issue of programming physical education classes with account for the specialty specifics. Taking into consideration the future profession specifics and the health indices will allow more precise planning of the content of physical education classes.

The purpose of the work is to study the dynamics of psychophysiological indices of female I-IV year students-designers.

Materials and Methods

Participants

120 female students aged 18-22 years were tested. In the research analyzer of motor-coordination reactions ADKR-2 was used.

Organization of study

The level of female students' accuracy was assessed by the following tests: 1) accuracy of reproduction of pre-set value of force was determined with the help of electronic hand dynamometer "EH101"; 2) accuracy of reproduction of pre-set amplitude of arms' movements was measured by kinematometer of Zhukovskiy.

Responsive qualities were assessed by the following tests:

1) test for quickness ("Catching of rule");

2) determination of reaction to moving object. For this test computer program "Neurosoft NS-PsychoTest" [20] was used;

3) test for quickness of vision motor response (simple and complex) ("Neurosoft NS-PsychoTest" [15]);

4) test for quickness of reaction ("Catching of stick");

5) complex test: determining the accuracy of multidirectional speed-strength motions per a certain time (computer program "Neurosoft NS-PsychoTest" [20]).

The following tests were used to estimate orientational qualities 1) "Labyrinth" test; 2) "Dribbling" test; 3) "Target hitting" test.

For evaluation of psychophysiological qualities of female students-designers the following tests were utilized:1) distribution of attention ("Finding of numbers"); 2) volume of rote memorization ("Quantity of men figures"); 3) distribution of attention and quickness of operational thinking ("Assembly of puzzles during certain period of time"); 4) quickness of operational thinking ("Koss's cubes"); 5) on special device we determined: quickness, re-switching and concentration of attention; accuracy of fulfillment of pre-set task.

Romberg's test (posture of "Stork") was used to test static balance; 2) dynamic balance was assessed by "Turns on gymnastic bench" test.

Statistical analysis

While processing the experimental data, we determined the average values of the indices and their errors (X±m), the degree of difference in the means and the significance of differences (t, p), the dispersion value around the mean (σ, CV), and the degree of interrelation between the studied indices (r).

While conducting complex pedagogical, biomechanical and biological examinations with participation of athletes, we adhered to the legislation of Ukraine on health protection, the Helsinki Declaration of 2000, the Directive No. 86/609 of the European Society on the participation of people in biomedical researches.

Results

In the course of testing the ability to accurately reproduce a given spatial amplitude of hand motion, the dynamics of this index changes on dominant hand has been examined in female I-IV year students without visual control (Table 1). The best values of the accuracy of reproducing hand movement amplitude were observed in the I-II year students, whereas the worst - in the IV year students. The magnitude of error during test performance trended upward to the IV year of study. The measure of decrease of values of the studied index from the I to the IV course constitutes 20%. This indicates the deterioration of this quality in female students-designers by the end of their studies at the university.

Testing the index of accuracy of reproducing a given value of effort demonstrated its increase from the I to the IV course. The magnitude of the error increase and deterioration of this index to the IV year constituted 40%. The worst result according to the studied index takes place at the IV course, since the deviation from the set value of strength effort constituted almost 3 kg. The best index was noted in the first year students. Thereafter, a negative dynamics in the level of development of the ability to accurately reproduce the given value of effort was observed.

Table 1

Psychophysiological indices of female students-designers during studies at the university

Index	Unit of measurement	Years of study			
		1	2	3	4
Accuracy of movement amplitude reproduction	error, degrees	3.50	3.70	3.80	4.20
Accuracy of reproducing the given value of effort	kg	2.00	2.40	2.60	2.80
Speed of response ("Stick catching" test)	time, ms	240	260	261	266
Speed of response ("Ruler catching" test)	cm	15.70	14.60	16.60	17.10
Accurate responses to moving object	number of times	2.00	2.80	2.90	2.40
Antedating responses to moving object	number of times	9.60	10.40	9.40	8.40
Deferred responses to moving object	number of times	8.10	10.60	9.60	8.80
Speed of simple visuomotor response	time, ms	218	249	255	296
Speed of complex visuomotor response	time, ms	474	451	443	424
Total time of complex visuomotor response	time, ms	467	451	444	423
Static balance	time, s	20.20	17.70	14.80	12.00
Dynamic balance	time, s	12.36	10.16	9.24	8.39

The index of speed of response development in female students was the best in the first year and the worst - in the fourth year. This index dynamics shows a steady tendency to decrease from the I to the IV year. This is indicative of a deterioration in the responsive qualities of students by the end of their studies at the university.

Testing the index of the reaction to vertically falling object ("Ruler catching"), in students-designers indicates that the best results are presented in the II year, whereas the worst - in the IV year. The dynamics of this index has a stable tendency to decrease from the II to the IV year by 17.1%. This indicates deterioration in the responsive qualities of female students by the end of their studies at the university.

Analysis of changes in the index of accurate responses to moving object of female students showed that its best values occur in the II and the III year, whereas the worst – in the I and the IV year. The definitions of "best" and "worst" are quite arbitrary, given the ratio of accurate responses shown by students in comparison with the total number of responses suggested to them during testing. Of suggested 20 responses, students managed to show only 2-3 accurate ones on the average. This is extremely negative index to characterize one of the most important qualities of a designer. In the dynamics there is a slight improvement of this index from the II to the III year. However, before the 4th year there is a 14.3% decline of the index as compared to the IInd year. The change of this index indicates a decrease in the students' responsive qualities by the end of their studies at the university.

The study revealed that the highest value of the index of antedating responses in female students-designers is observed in the I year. Of 20 suggested responses the subjects demonstrated 9 antedating ones on the average. The lowest values of this index were revealed in 4 year students, who demonstrated 8 antedating responses of 20

suggested ones. The index decrease from the 1 year to the 4 year constituted 12.5%.

On the whole, the number of deferred responses shown by female students, compared to the total number suggested during testing, is quite high in all years of study. This is extremely negative index to characterize one of the most significant qualities of future designers – ability to see an object in space, in motion. Absolute speed of response is not the main index in response to a moving object. It is its timeliness closely related to the attention concentration that is significant.

Table 2

Psychophysiological indices of female students-designers during studies at the university

Index	Unit of measurement	Years of study			
		1	2	3	4
Ability to orientate in small space	time, s	44.00	46.30	48.20	52.10
Accuracy of spatial orientation	mm	1.30	1.80	1.60	1.40
Orientational, responsive and differentiational qualities	points	13	19	16	18
Orientational qualities ("Dribbling" test)	number of times	58	62	55	52
Orientational qualities ("Shots at target" test)	number of times	8.9	8.70	7.10	6.30
Speed of operative thinking	points	43.70	47.70	51.10	53.20
Attention distribution	c.u.	6.00	6.60	5.60	4.30
Volume of operative memory	number	6.70	5.60	4.30	3.00
Attention distribution and speed of operative thinking	minutes	11.18	13.83	17.12	19.08
Speed of attention switching and focusing	number of errors	0.74	0.82	0.78	0.72
Attention speed	number	11.18	13.83	17.12	19.08
Attention accuracy	number of errors	0.91	1.20	0.83	0.63
Complex test	c.u.	10.10	11.30	11.50	11.70

Changes in the index of the time of simple vision motor response (SVMR) of female students have a negative dynamics as well.

The best value of the index of time of simple vision motor response in female students was revealed in the first year, whereas the worst - in the fourth year. The dynamics of decrease of studied index constituted 35.8%. This indicates deterioration in the responsive qualities of students by the end of their studies at the university.

In contrast to the previous indices reflecting sensory motor reaction, the results of complex vision motor response (CVMR) evaluation indicate a process of improving the indices of this quality from the I to the IV year. The best value of studied index was observed in the four year students, whereas the worst - in the first year ones. The overall improvement of this index constituted 10.5%.

Detected changes in the time of CVMR among students were reflected on the total time of CVMR. The best value of the index of the total time of CVMR was noted in the fourth year students, whereas the worst - in the first year ones. The total time of CVMR decreased from the I to the IV year by 9.4% by the end of the study.

Analysis demonstrated stable negative dynamics of Romberg's test ("Stork" posture) index from the I to the III year of study. This indicates the decrease in the level of development of ability to maintain balance in female students. The index decrease from the I to the IV year of study constituted 40.6%. This is a negative factor.

Studies have demonstrated a stable negative dynamics of the indices of dynamic balance in female students from the I to the IV year of study. This indicates a decrease in the level of development of their ability to maintain dynamic balance. The decrease constituted 32%. This is a negative factor.

Data of the "Labyrinth" test for determining orientation qualities with account for the time and accuracy of task performance indicate that the best time of passing the labyrinth was demonstrated by the first year students, whereas the worst - by the fourth year ones. The time of the labyrinth passing increases by 18.4% (Table 2).

Analysis of the dynamics of accurate spatial orientation indices indicates (Table 2) the lack of significant changes in the ability to accurately perform motor tasks during college years. The best values of spatial orientation

accuracy index were found in the first year students, whereas the worst - in the second year ones.

Spatial orientation abilities, kinesthetic qualities, work of the visual analyzer, sensory experience ("Shots at target" test) are gradually decreased from course to course. The decrease of indices from the I to the IV year constitutes 29.2%.

The dynamics of the complex test results, which evaluated the orientational, responsive, and differentiational qualities of female students, indicates that the best values are peculiar for the first year students, whereas the worst - for the fourth year ones. In general, the index decrease from the I to the IV year constituted 15.8%. The deterioration of the complex test index occurred at the expense of increase in the time of task performance. The complex test results characterize general negative change in studied psychophysiological indices of kinesthetic, responsive and orientational qualities of female students in the process of their studies at the university.

After carrying out the correlation analysis, a correlation matrix was built. In this matrix, the information received was analyzed taking into account the nature, number and degree of closeness of the relationships obtained. Only statistically significant indicators were evaluated. It was revealed that all the indicators of professional qualities of future designers studied by us are interrelated with indicators of certain types of motor qualities. The analysis made it possible to reveal the ambiguous nature of the relationships for various types of professional qualities of future designers.

Correlation analysis revealed the dependence of the indicator reflecting the level of attention distribution ("search for numbers" test) among design students with the indicator of the "Labyrinth" test, which characterizes orientational qualities, to perform motor tasks accurately and quickly. In this case, the correlation coefficient is 0.51 and reflects a moderate level of connection between the studied indicators. It should be noted that when performing the "Labyrinth" test, the time and accuracy of the task is evaluated, just like when performing the "search for numbers" test. Activities of a similar nature take place in the professional work of designers (for example, when performing small and precise movements with a brush, when preparing markings and drawings).

Table 4 presents the analysis of the correlation matrix of the parameters of the level of attention development, working memory, the speed of memorization and the accuracy of reproduction of the information received with the indicators of the "Labyrinth" tests, complex visual-motor reaction, the "Catching the ruler" test, which characterize the response, kinesthetic and orientation qualities. The analysis of the relationship between professional qualities and indicators of the level of development of response and kinesthetic qualities among female designers indicates the possibility of influencing the development of professional skills. The level of connection between the parameters is average, the correlation coefficients vary in the range from 0.51-0.62.

The revealed nature of the interrelationships testifies to the importance of professional qualities among female designers-students for a quick and effective solution of problems associated with the need for accurate perception in the shortest possible time and keeping a large volume of spatial and other information in memory.

One of the most important subjects in training at all departments of the Faculty of Design is the discipline "Painting". Painting is the art of depicting objects with paints. They study this subject from I to IV courses. When giving marks in this discipline, the following are taken into account: the execution of the drawing is naturalistic or proportionally, the figure is shown in the figure, and the correctness of the composition. The analysis of the relationship between the indicator of success among design students in the discipline "Painting" with the indicator of the kinesthetic test revealed an average degree of closeness of parameters (correlation coefficient 0.53).

Drawing is the art of depicting objects with graphic material. During the training, the ability to build objects, simulate volume, quality of shading, and the ability to correctly place a drawing on paper are assessed. The work is done with a pencil and other soft materials such as charcoal. Since this is a very fragile material, you need to feel the pressure on it from the hand. The analysis of interconnection of the indicator of student-designers' success in the discipline of their professional training "Drawing" revealed a relationship with the indicators of the level of kinesthetic qualities of the accuracy of hand movements and the ability to assess orientation in space. The tightness of correlations of the studied parameters is average - from 0.52 to 0.54. This testifies to the importance of improving the kinesthetic and orientation qualities of female students for their future professional activities.

Table 3

Relationships between indicators of attention, speed and accuracy of information reproduction with indicators of kinesthetic qualities of female students

Index	r
Orientation quality ("Labyrinth" test)	0.51
Differential-orientation quality ("Catching of rule" test)	0.55
Responsive quality (CVMR test, right hand)	0.62
Responsive quality (CVMR test)	0.53
Responsive quality ("Catching of stick" test)	0.54
Comprehensive test	0.61
Distribution of attention ("Finding of numbers" test)	0.59
Differential quality (Accuracy of reproduction of the set	0.63

Table 4

Relationships between indicators of quickness, switching and concentration of attention with indicators of kinesthetic qualities of female students

Index	r
Responsive quality (complex CVMR test)	0,64
Responsive quality ("Catching of stick" test)	0,74
Responsive quality (simple VMR test)	0,68
Responsive quality (тест " Reaction is a	0,71
Distribution of attention ("Finding of	0,62
Memory volume ("Number of men" test)	0,57
Distribution of attention and speed of operational thinking	0,66
Speed of operational thinking	0,58
Differential quality (Accuracy of	0,64
Differential quality (Accuracy of	0,63
Differential-orientation quality ("Hitting the	0,57

Discussion

The correlation analysis of the links between the indicators of development of professionally significant qualities of future designers and the level of development of psychophysiological indicators showed that they are in close interaction. Thus, the hypothesis of our study was confirmed. The goal set in the work was achieved.

A connection was revealed between the indicators of fine motor skills of the working hand with the indicator of the speed of operational thinking. the average correlation is 0.65. The test for the speed of operational thinking is a complex one, which reflects not only the level of development of motor skills, but also shows the component of mental processes. This skill is very important for future designers. Thus, it is necessary to improve the students' ability to speed of operational thinking in the learning process, the ability to quickly and accurately respond to the task received and perform it in strict accordance with the set goal.

The general level of professionalism of female design students was assessed using the assessment score, the ratio of the accuracy of reproduction of a standard drawing to the time of its execution. Correlation analysis revealed the relationship of this indicator with indicators of the development of kinesthetic and qualities. Analysis of the result obtained indicates the presence of a correlation - 0.63. The connection between the indicators of the professionalism of female students and the level of sensory response is high, the correlation coefficient is 0.71.

Table 4 presents the analysis of the correlation matrix of the relationship between the indicator of the development of speed, switching and concentration of attention with the indicators of other tests. The analysis of the connection

between attention, memory and accuracy of reproduction of the information received with the indicators of tests of the level of development of kinesthetic qualities among female students was carried out. The analysis shows that by developing coordination qualities one can influence the development of professional skills. The level of correlations is average, the correlation coefficients are from 0.57-0.74.

Human creative activity is accompanied by a change in the functional state of the body different organs and systems. The degree of conditioned responses is reduced, the response to different intensity stimuli is smoothed out, the time of response is increased, and the attention span is reduced. Low intensity work increases excitability of the visual analyzer. The systems of direct memorization and concentration of attention are subjected to the greatest load. Creative labor proceeds with low level of motor activity. This leads to conditions for increased fatigue, decreased work capacity and feeling unwell.

Our study expands the data on investigation of the psychophysiological indices of university students. In contrast to the previous studies of a number of authors, we have analyzed rather wide range of psychophysiological indices in the dynamics from the I to the IV year of study, and in the context of the relationship with the future profession [23 – 25].

Analysis of the results of studying psychophysiological indices of university female students-designers showed an ambiguous character from the I to the IV course. A decrease in the accuracy of reproducing motion amplitude, a given amount of effort, response to vertically falling object, and indices of static and dynamic equilibrium was revealed. This compares to data reported by other researchers [26, 27, 28].

An improvement in the dynamics of nervous processes and the ability to constructive praxis should be noted. Similar changes were reported by different authors [29 – 34].

The study confirms the conclusions of specialists [35 – 37] that uneven decrease of most psychophysiological indices negatively affects not only the level of students' motor training, but also professional abilities of future designers, in particular [38].

The impact of physical education at universities on the processes of motor quality development and improvement of professionally important psychophysiological characteristics is becoming extremely topical today.

Our studies have shown for the first time that the design students have low a level of health indices. This indicates that during graduation from the university, these indices will decrease by 2-3 times. Thus, young specialists of Ukraine who are starting to pursue their profession are already sick and feeble. Their immune system is low. They are more susceptible to various diseases (including COVID-19) than other segments of the population.

The results obtained should be taken into account by all university teachers who conduct physical education classes with students.

Conclusions

1. A decrease of most indices characterizing kinesthetic, orientational and responsive qualities of university female students in the learning process has been established. Task-oriented improvement of kinesthetic, orientational and responsive qualities in physical education classes by means of specialized methods allows not only to suspend the negative dynamics of psychophysiological indices of young body, but also to improve them. Ultimately, this has a positive impact on the professional skills of future creative profession specialist. The obtained experimental results give ground for the development of the methods for improving motor qualities and psychophysiological properties professionally significant for students-designers.
2. The decrease in the level of development of motor qualities, professional skills, physical fitness, and health is observed already in the 1st year of study. Pedagogical influences should be started from the 1st course and continued until the end of the study.
3. In the process of physical education classes, the physical exercises aimed at improving the professionally significant psychophysiological properties of students should be used. It is they that restrain the negative effect of increasing the intensity of educational classes simultaneously contributing to an increase in the development level of almost all motor qualities and health. For the successful professional growth of design students, it is necessary to develop kinesthetic, speed, differential and orientation qualities.

Conflicts of interest

The authors declare that there is no conflict of interests.

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ORIGINAL ARTICLES. PHYSICAL EDUCATION

Physical development and physical preparedness monitoring of lyceum students of different ages

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Abstract

Purpose: to analyze the results of monitoring the physical development and physical preparedness of students of the Lyceum

Materials and methods: The analysis of materials on this issue was carried out based on the results of the implementation of the national educational initiative "Our New School" in accordance with the plan for the modernization of general education [3], according to which in 2019-2020 in secondary schools of Ivano-Frankivsk, the physical development of schoolchildren and schoolgirls was monitored 100 lyceum students 11-17 years old were examined, who were divided into 2 groups according to their academic performance: 1 gr. consisted of 50 lyceum students (35 girls and 15 boys) with high academic performance (average score 4.75), in the composition of 2 gr. it included 50 lyceum students - "lagging behind" (average score 3.5) (25 girls and 25 boys).

Results: monitoring showed that, regardless of the group, lyceum students have an average level of physical development (girls - 62.1%, boys - 57.8%). Only 13.8% of girls and 14.4% of boys have a high level of physical development. Almost a quarter of high school students (23.9% of girls and 27.5% of boys) have a low level of physical development, and there are almost 2 times more such students than lyceum students with a high level of physical development.

Conclusion: Summarizing the above, it should be noted that when implementing the results of monitoring physical development, there are two main directions: 1. Correction of deviations identified during monitoring in the state of development of physical condition. 2. Using student monitoring as a basis for creating a sports selection system. Based on this, we can conclude that an important component and subject of monitoring is the physical health of lyceum students, mainly in educational institutions, which contributes to monitoring and management decisions on making adjustments to the educational process.

Key words: physical development, lyceum students, physical training

Анотація

Сергій Л. Попель, Роман І. Файчак, Ірина Г. Цап, Пшемислав Бежга, Юрій А. Лисенко, Збігнєв Слівінський. Моніторинг фізичного розвитку і фізичної підготовленості ліцеїстів різного віку
Мета: проаналізувати результати моніторингу фізичного розвитку та фізичної підготовленості студентів ліцею
Матеріал і методи: Аналіз матеріалів з даної проблеми проводився за результатами реалізації національної освітньої ініціативи «Наша Нова школа» відповідно до плану модернізації загальної освіти [3], згідно з яким в 2019-2020 рр. у загальноосвітніх школах Івано-Франківська проводився моніторинг фізичного розвитку школярів і школярок. Обстежено 100 ліцеїстів 11-17 років, які по успішності були розділені на 2 групи: 1 гр. складалася з 50 ліцеїстів (35 дівчаток і 15 хлопчиків) з високою успішністю (середній бал 4,75), в складі 2 гр. в нього увійшли 50 ліцеїстів-«відстаючих» (середній бал 3,5) (25 дівчаток і 25 хлопчиків). Результати: моніторинг показав, що незалежно від групи у ліцеїстів середній рівень фізичного розвитку (дівчатка – 62,1%, хлопчики – 57,8%). Лише 13,8% дівчаток і 14,4% хлопчиків мають високий рівень фізичного розвитку. Майже чверть старшокласників (23,9% дівчаток і 27,5% хлопчиків) мають низький рівень фізичного розвитку, а таких ліцеїстів майже в 2 рази більше, ніж ліцеїстів з високим рівнем фізичного розвитку.
Висновок: Резюмуючи вищевикладене, слід зазначити, що при реалізації результатів моніторингу фізичного розвитку виділяють два основних напрямки: 1. Корекція відхилень, виявлених в ході моніторингу, в стані розвитку фізичного стану. 2. Використання моніторингу студентів як основи для створення системи спортивного відбору. Виходячи з цього, можна зробити висновок, що важливою складовою і предметом моніторингу є фізичне здоров'я ліцеїстів, в основному в освітніх установах, що сприяє моніторингу та управлінським рішенням щодо внесення коригувань в навчальний процес.
Ключові слова: фізичний розвиток, ліцеїсти, фізична підготовка

Аннотация

Сергей Л. Попель, Роман И. Файчак, Ирина Г. Цап, Пшемислав Бежга, Юрий А. Лисенко, Збигнев Сливинский. Мониторинг физического развития и физической подготовленности лицеистов разного возраста
Цель: проанализировать результаты мониторинга физического развития и физической подготовленности студентов лицея
Материал и методы: Анализ материалов по данной проблеме проводился по результатам реализации национальной образовательной инициативы «Наша Новая школа» в соответствии с планом модернизации общего образования, согласно которому в 2019-2020 гг. в общеобразовательных школах Ивано-Франковска проводился мониторинг физического развития школьников и школьниц. Обследовано 100 лицеистов 11-17 лет, которые по успеваемости были разделены на 2 группы: 1 гр. состояла из 50 лицеистов (35 девочек и 15 мальчиков) с высокой успеваемостью (средний балл 4,75), в составе 2 гр. в него вошли 50 лицеистов-«отстающих» (средний балл 3,5) (25 девочек и 25 мальчиков).
Результаты: мониторинг показал, что независимо от группы у лицеистов средний уровень физического развития (девочки - 62,1%, мальчики - 57,8%). Лишь 13,8% девочек и 14,4% мальчиков имеют высокий уровень физического развития. Почти четверть старшеклассников (23,9% девочек и 27,5% мальчиков) имеют низкий уровень физического развития, а таких лицеистов почти в 2 раза больше, чем лицеистов с высоким уровнем физического развития.
Вывод: Резюмируя вышеизложенное, следует отметить, что при реализации результатов мониторинга физического развития выделяют два основных направления: 1. Коррекция отклонений, выявленных в ходе мониторинга, в состоянии развития физического состояния. 2. Использование мониторинга студентов как основы для создания системы спортивного отбора. Исходя из этого, можно сделать вывод, что важной составляющей и предметом мониторинга является физическое здоровье лицеистов, в основном в образовательных учреждениях, что способствует мониторингу и управленческим решениям по внесению корректировок в учебный процесс.
Ключевые слова: физическое развитие, лицеисты, физическая подготовка

Introduction

In recent years, the situation with the health of the population in Ukraine has worsened. According to statistics, 50% of children have poor health, 75% of children under the age of 14 have chronic diseases, only 10% of school graduates can be called healthy. The overall incidence of children under 14 years of age increased by 16%, at the age of 15-17 years - by 18%. Against this background, the level of physical development of children decreases [1]. The current provision has updated the work on the implementation of monitoring research in various fields of activity and at various levels, including in the field of physical culture and sports in order to increase the efficiency of the process of physical education of schoolchildren. Adolescent physical development monitoring is a complex information-analytical and prognostically important system that includes monitoring of health and physical development and its assessment along with analysis at the level of an individual or social group, in order to predict future health both for the individual and for the whole group of persons united on a territorial basis or nature of activity. Such monitoring allows to prevent negative tendencies of physical development of children and adolescents [2].

Purpose: to analyze the results of monitoring of physical development of lyceum students of technical and mathematical lyceum № 2 in Ivano-Frankivsk, Ukraine.

Materials and methods

The analysis of materials on this issue was conducted based on the results of the implementation of the national educational initiative "Our New School" in accordance with the plan of modernization of general education [3] according to which in 2019-2020. Ivano-Frankivsk secondary schools monitored physical development and schoolchildren. 100 lyceum students aged 11-17 years were examined, who were divided into 2 groups according to the level of success: 1 gr. consisted of 50 lyceum students (35 girls and 15 boys) with a high level of success (average grade point average 4.75), consisting of 2 gr. included 50 "failing" lyceum students (average grade point average 3.5) (25 girls and 25 boys).

Results

Results of the monitoring showed that regardless of the group, lyceum students have an average level of physical development (girls - 62.1%, boys - 57.8%). Only 13.8% of girls and 14.4% of boys have a high level of physical development. Almost a quarter of high school students (23.9% of girls and 27.5% of boys) have low levels of physical development and such lyceum students are almost 2 times more than lyceum students with a high level of physical development.

The monitoring revealed intergroup differences in the indicators of physical development lyceum students, which belong to different success groups. Thus, the high level of physical development girls 1 group is higher than 2 group. The boys have 2 group this figure is lower than the boys 1 group.

Number of lyceum students 2 group with an average level of physical development, more than their peers 1 group. It should be noted that high school students 2 group with a low level of physical development is observed in more than 1 group. Analysis of the dynamics of the level of physical development by individual educational indicators shows a sharp decline in the number of lyceum students with an average level of physical development and on increasing the number of lyceum students with low levels of physical development in the transition from one age group to another

In the senior school age the indicator of low level of physical development is more often found at girls. It was found that almost 26% more girls with an average level of physical development. Boys of senior school age with a low level of physical development are 2.5 times more than boys of primary school age.

Physical development is an important indicator of human health, the close relationship between them, scientists have long observed [4]. The purpose of monitoring physical development is to obtain the information necessary to improve the management of the process of physical education, and thus improve its quality. Among the main conditional physical qualities, which were monitored, include speed, endurance, and strength. The analysis of indicators of physical development of lyceum students allowed to state low indicators of level of development of separate physical qualities (fig. 5), especially endurance. In general, in the lyceum in all age groups, lyceum students meet the age standards for strength and speed-power qualities. At the same time at girls indicators

of endurance and force qualities (3.3 ± 0.12 and 4.1 ± 0.14 points accordingly) are higher, than at boys (2.9 ± 0.11 and 3.5 ± 0.13 points in accordance).

Discussion

Physical training of lyceum students at all stages of education should be aimed at strengthening health, developing motor skills and abilities, fostering moral and volitional qualities, developing the ability to use and introduce the knowledge gained into the practice of further professional activity. The found ratios of physical training of lyceum students established by us confirm the data of other authors [5–9] on the age characteristics of the development of individual physical qualities necessary for the harmonious development of the body of adolescents of 6-17 years old. Thus, the results of monitoring allow to state the insufficient level of physical fitness of lyceum students (first of all those qualities that determine the state of physical health). We can agree with the opinion of [4] that the reason for this situation is not so much the material and technical base of the educational institution, as the professional qualities of a physical education teacher, evidence of this is the fact that within one school, the performance of students who are engaged in different teachers, differ significantly. Thus, the study allows us to make the following generalizations. The pedagogical heritage of R. Steiner [16] contains many important healthy theoretical provisions, the implementation of which will contribute to the effectiveness of health care in the modern educational process. First of all, it concerns the need to focus school activities on human nature and identify special care for the preservation and development of personal potential and abilities of the child, so that the school process as a necessary and mandatory component is filled with "therapeutic", ie aimed at spiritual and mental -body health aspect [10 – 15]. We see prospects for further research in the analysis of the implementation of healthy ideas of [16] in the practice of modern lyceums. As [16] emphasizes, an important aspect of the educational process is the personality-oriented formation of the child's personality, which involves taking into account the age and individual characteristics of the child, his current condition. In order to implement these requirements, R. Steiner developed specific forms and methods of teaching, namely: rhythmic construction of school classes, teaching basic subjects in cycles of "immersion" (the method of "epochs"), differentiation of educational material according to students' temperaments, learning without standard textbooks, specific methods of work of schoolchildren with workbooks, special work on the technique of memorization, systematic control over learning outcomes without the use of a grading system. As [16] emphasizes, an important aspect of the educational process is the personality-oriented formation of the child's personality, which involves taking into account the age and individual characteristics of the child, his current condition. In order to implement these requirements, [16] developed specific forms and methods of teaching, namely: rhythmic construction of school classes, teaching basic subjects in cycles of "immersion" (the method of "epochs"), differentiation of educational material according to students' temperaments, learning without standard textbooks, specific methods of work of schoolchildren with workbooks, special work on the technique of memorization, systematic control over learning outcomes without the use of a grading system. Therefore, in order to maintain the proper physical and functional condition of female lyceum students, and at the same time fulfill the requirements of the departmental order in this regard, we propose to include in the training elements of the program of special physical training based on the modular education system [17-20].

Conclusion

Summarizing the above, it should be noted that in the implementation of the results of monitoring of physical development there are two main areas: 1. Correction of abnormalities identified during the monitoring in the state of development of physical condition. 2. The use of monitoring of students as a basis for creating a system of sports selection. Based on this, we can conclude that an important component and subject of monitoring is the physical health of lyceum students, mostly in educational institutions, which facilitates monitoring and management decisions to make adjustments to the educational process.

Conflict of interest

The authors declare that there is no conflict of interest.

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